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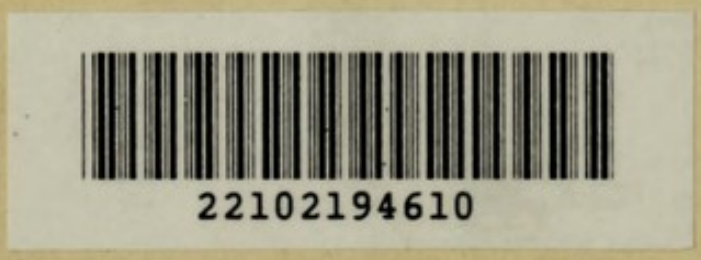
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MODERN SURGERY

GENERAL AND OPERATIVE

BY

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MODERN SURGERY

MODERN SURGERY

I. INFLAMMATION

Definition.—When the tissues are injured they react or respond, and this reaction or response is known as inflammation. The process of inflammation was defined by the late Sir John Burdon-Sanderson as "the succession of changes which occur in a living tissue when it is injured, provided that the injury is not of such a degree as at once to destroy its structure and vitality." Professor Adami, in his article upon inflammation in Allbutt's "System of Medicine," points out that this definition really includes too much. He alludes to the hemorrhage which occurs in the liver after a traumatism, and the subsequent changes in the extravasated corpuscles, and points out that these changes are not inflammatory phenomena. This definition, however, includes all inflammatory conditions, is largely employed, is very useful, indicates the cause, and, as Burdon-Sanderson says, makes clear that inflammation is a process and not a state (Adami). Adami's definition is as follows: "The series of changes constituting the local manifestation of the attempt at repair of actual or referred injury to a part, or, briefly, the local attempt at repair of actual or referred injury." The changes alluded to in Burdon-Sanderson's definition comprise (1) changes in the vessels and the circulation, (2) departure of fluids and solids from the vessels, and (3) changes in the perivascular tissues.

Vascular and **circulatory changes** were formerly thought to be absolutely essential to inflammation in both vascular and non-vascular tissues. In the former they occur in the inflamed tissues; in the latter (cornea and cartilage) they are manifest in neighboring tissues from which the non-vascular area derives its nutritive material. As a matter of fact, in inflammation vascular changes are almost always present; but in a rather trivial corneal inflammation the episcleral vessels may not dilate, and the only white corpuscles which gather in the damaged area are those which come from the lymph-spaces of the cornea. Inflammation in any tissue will not be accompanied by vascular dilatation unless the process reaches a certain stage of severity.

Active Hyperemia.—When an irritant is applied to tissue there may be a momentary arterial contraction due to irritation of the nerves, but this contraction is transitory, and is not an inflammatory phenomenon. The first vascular phenomenon is dilatation of all the vessels—capillaries, venules, and arterioles—appearing first and being most pronounced in the small arteries. As a result of the dilatation there are increased rapidity of circulation and increased determination of blood to the part, and the area of hyperemia becomes warmer than is normal. This condition of increased circulatory activity is known as "active hyperemia" (Fig. 2).

Active hyperemia is an increase in the amount of moving blood in a part. Passive hyperemia is an increase in the amount of blood in a part, but not of moving blood, as passive hyperemia or congestion is due to venous obstruction, and the blood is stagnated. Diminution in the amount of blood in a part is *ischemia*. Local anemia is the complete cutting off of the blood-supply of a part.

In active hyperemia more blood goes to the part and more blood passes through it, an increased amount of venous blood comes from the hyperemic area, the venous tension is increased, and the veins may even pulsate. The capillaries, which under ordinary circumstances contain but few blood-cells (Fig. 1), become filled with corpuscles (Fig. 2), and even the smallest capillaries pulsate. The blood in the veins adjacent to the area of inflammation is of a much lighter red than in health. Many capillaries which were invisible under normal conditions become visible when active hyperemia exists. The capillaries contain no muscle-fiber, and hence these tubes cannot actively contract, except so far as the caliber of the tubes is altered by the contraction or expansion of the endothelial cells of the capillary wall. Contraction and dilatation of the capillaries depend chiefly on the amount of blood sent to or retained in them. In active hyperemia the increased amount of blood sent to the part

causes capillary dilatation. As a result of the dilatation the endothelial cells become thinner than before, the cells in consequence of irritation lose some of their power to restrain exudation, and some observers assert that openings are formed between the cells or that previously existing openings enlarge (pages 20 and 21). Fluid elements rarely leave the blood-vessels during active hyperemia, but they occasionally do. The wheals of urticaria are thus formed (Warren). Active hyperemia is often the first stage of an inflammation, but it is not of necessity followed by other inflammatory changes, and it can be caused by nerve section or nerve stimulation.

The duration of active hyperemia is variable. If the irritation has been brief, the hyperemia is very transitory. In some cases dilatation with accelerated circulation is scarcely more than momentary, giving way almost immediately to dilatation with retardation. If the irritation is prolonged, hyperemia may last some time before giving way to retardation. In the web of a frog's foot, if an irritant is applied, hyperemia lasts from one-half hour to two hours before it is replaced by retardation.

Clinical Signs of Active Hyperemia.—A hyperemic part, if on or near the surface, is red in color, imparts a sense of heat to the examining hand, the color quickly disappearing on pressure and quickly returning when pressure is released. In a congested part the temperature is diminished, the surface is purple, the congested veins



FIG. 1.—Normal vessels and blood-stream.

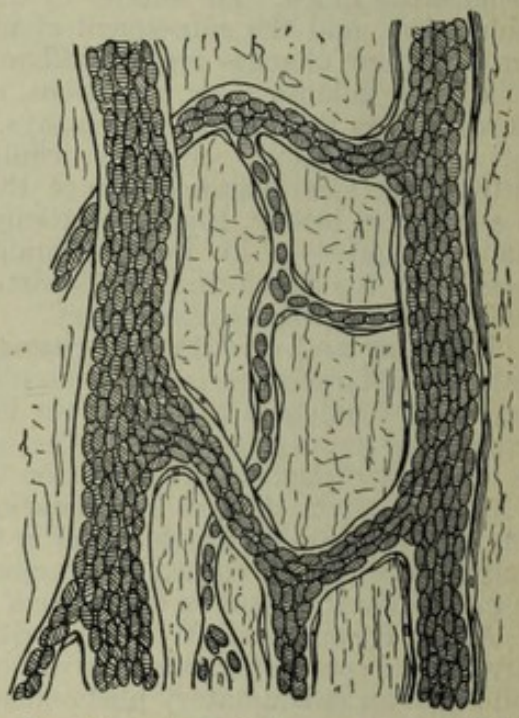


FIG. 2.—Dilatation of the vessels in inflammation.

are visible, there are edema and a sensation of coldness and numbness. When congestion is purely local the lividity disappears quickly when pressure is applied and returns quickly when pressure is removed. When due to disease of the heart or lungs, lividity disappears and returns slowly. When a local congestion is about to give way to gangrene the lividity disappears very slowly on pressure and crawls back very slowly when pressure is released.

Retardation.—After active hyperemia has existed for a variable time the blood-current begins to lessen in velocity, until it becomes more tardy than in health. This is known as "retardation of the circulation." Retardation is first noted in the venules, next in the capillaries, and last in the arterioles; but arterial pulsation continues. The red cells take the center of the blood-stream, which is known as the axial current. The white corpuscles settle out of the central stream, separate from the red cells, and float lazily along near the vessel wall (margination), and they are accompanied by many third corpuscles. The white cells show a strong tendency to adhere to the venule walls, and, as a result, accumulate against the inside of, and stick to, these walls and to one another, until the venules are entirely lined with layers of *leukocytes* (Fig. 3). The third corpuscles act in a similar manner and take the peripheral current. In the capillaries some leukocytes gather, but not so many. In the arterioles they adhere during cardiac dilatations, but are swept away by the force of the heart's contrac-

tions. Retardation is believed to be chiefly due to paresis of the muscular walls of the arterioles. This causation seems probable when we recall Lord Lister's experiments upon the pigment-cells of the frog's foot. Lister proved that inflammation paralyzes the pigment-cells, and concluded that dilatation at the focus of an inflammation is due to the paralyzing action of an irritant. Dilatation at a distance from the focus is a reflex phenomenon (Sir Watson Cheyne). When the vessels are weakened or paralyzed the contractions of the arterioles are feeble or absent, and the blood is no longer urged forward by arterial power. The endothelial cells of the small vessels enlarge distinctly during retardation and develop a condition of stickiness, which leads the white cells to adhere to them, and thus increases resistance to the current of blood and adds to retardation. Fluids pass through the wall of a vessel in this condition more readily than through a healthy vessel, and white corpuscles leave the vessel in large numbers.

Oscillation and Stagnation.—By the accumulation of leukocytes the blood-stream is progressively narrowed and the axial current is impeded. The red blood-cells begin to stick to one another, forming aggregations like *rouleaux* of coin, which increases the difficulty the axial current has to contend with, until progressive movement ceases and the contents of the vessels sway to and fro with each heart-beat. This is the stage of *oscillation*. In a short time oscillation ceases and the vessels are filled with blood which does not move, and the vessel walls become irregular in outline or even pouched. This stage is known as "*stasis*" or "*stagnation*." Stasis is chiefly due to paralysis and damage of the vessel walls. Migration ceases when stasis takes place. If stasis persists, coagulation occurs, because the vessel walls have been so injured by the irritant as to be practically dead material, and they are no longer able to prevent clotting of their contents. Finally, in persisting stasis the vessel walls rupture or are entirely destroyed.

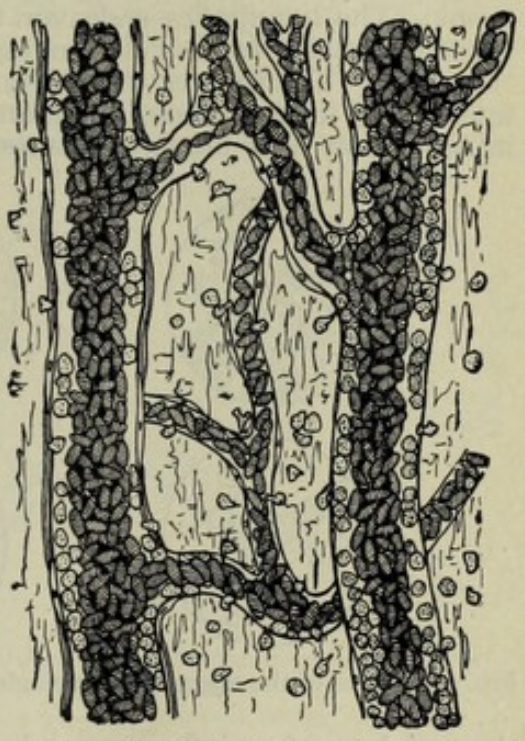


FIG. 3.—Retardation of blood and migration of white corpuscles in inflammation.

Résumé of the Vascular Changes of Inflammation.—We can sum up the vascular changes of inflammation by stating that they consist in a dilatation of the small vessels and a primary acceleration, a secondary retardation, and a subsequent stagnation of the blood-current, exudation of blood-liquor, adhesion of leukocytes to the walls of veins and capillaries, migration of leukocytes, the aggregation of the blood-cells into intravascular masses, and coagulation of the material remaining in the vessel.

Exudation of Fluids.—It is to be remembered that in the process of nutrition blood-liquor and also white cells pass into the tissues through the walls of veins and capillaries, and during this process certain other materials are passing from the tissues into the vessels. Hence, a diffusible irritant in the vessels may pass into the tissues and a diffusible irritant in the tissues may pass into the vessels. Whenever retardation of the circulation arises there is an increase in the amount of plasma which passes out of the vessels, but in inflammation the exudation into the lymph-spaces is vastly greater in amount and is different in composition. In a slight inflammation, and in the early stage of any inflammation, there is an increase in the fluid exudate, and we speak of the condition as "*serous inflammation*." This fluid is really not serum, but is liquor sanguinis. We find true serum in passive congestion, not in active inflammation. The fluid of a serous exudation contains very few white cells, and hence little or no fibrin can form in it, and coagulation does not take place in the perivascular tissues; and if the inflammation goes no further, the exudate is absorbed by the lymphatics. A blister is an example of serous inflammation. If the inflammation continues to intensify, the exudation is altered in character—it becomes thicker, turbid and very coagulable, and exhibits a greatly increased bactericidal power. It contains many white cells and coagulates in the tissues. Coagulation results from fibrin formation. Kinase, from the tissues and blood-cells, combines with calcium which is contained in all

cells, and they act on prothrombin, which is derived from the blood-plaques. The thrombin formed acts on fibrinogen, which is formed in the liver, and the result of the action is fibrin (Howell's theory). This fluid exudate is known as "*lymph*," or *plastic exudation*, and when it is present we speak of the condition as "*plastic inflammation*." Lymph can be seen in the anterior chamber of the eye in cases of plastic iritis. Coagulated fibrin in a recent wound causes the edges to adhere or glazes the raw surface. In inflammation of a mucous surface it may appear as a false membrane. In inflammation of serous surfaces it may glue the surfaces together and lessen motion, the fibrinous masses which effect the gluing being called fibrinous or plastic adhesions. Such adhesions within the abdomen may seal a perforation, may cover a raw spot, or may encompass an area of infection and prevent fatal diffusion. Further, fibrin surrounds and entangles bacteria and retards their diffusion. Pyogenic cocci lessen, retard, or prevent fibrin formation or destroy fibrin previously formed. Fibrinous adhesions may, of course, do harm. They may retard or prevent the absorption of exudate; they may narrow and obstruct important structures (bowel, urethra, larynx); they may bind up and cripple an important viscus (liver, heart, or brain). Fibrinous adhesions may be succeeded by dense contracting and constricting bands of fibrous tissue. The lymphatics endeavor to absorb the fluid exudate in inflammation, but become occluded by coagulation, and the area they drain becomes swollen, hard, and "brawny." The slighter the inflammation, the less albuminous is the fluid; the more intense the inflammation, the more albuminous is the fluid. The focus of a severe inflammation feels brawny because of coagulation of a highly albuminous exudate;

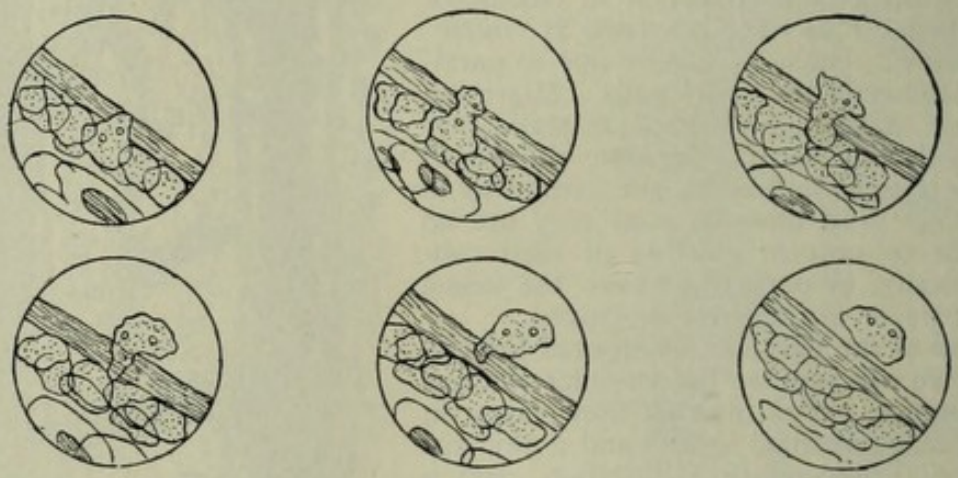


FIG. 4.—Stages of the migration of a single white blood-corpuscle through the wall of a vein (Caton).

the periphery of an inflammation is soft and edematous because of the presence there of thin and non-coagulated exudate. Inflammatory lymph contains proteins and other substances. "Of these the more important are ferments, the results of proteolysis (notably fibrin and its precursors and peptones), and in many cases mucin, together with bactericidal substances, and, where bacteria are present, the products of their growth."[1] The amount of the exudation varies with the violence of the irritation, the nature of the irritant, the general condition of the organism, and the state of the tissues which are involved. In dense tissue (bone, periosteum, etc.) the exudation is scanty. In loose tissue (subcutaneous tissue) it is profuse. Profuse exudation may take place into a joint, the pleural sac, the peritoneal cavity, or the pericardium. In such cases the exudation is profuse because the serous membrane has a thin covering of endothelium, contains quantities of vessels, and the vessels own but a thin covering and obtain but a scant support on the side of the cavity.

Does the plasma leave the vessels as a simple filtrate? Some maintain that it does. Heidenhain and others claim that it does not, and believe that the endothelial cells play an active part in the process. Heidenhain likens exudation to secretion, because some materials from the plasma pass out and others do not. Adami is inclined to agree with Heidenhain, that the endothelium plays "not a passive but an active rôle." Are there spaces between the endothelial cells of the capillary? It was long taught positively that there were no open spaces between the endothelial cells of the vessel wall and that these cells were held close together by a cement substance. It was then believed by some observers that spaces existed between the protoplasmic

[1] Adami, in Allbutt's "System of Medicine."

strands which hold the cells together, these spaces being closed when the vessel was contracted and open when the vessel was dilated. When these spaces were open it was thought that fluid passed, and through these doorways leukocytes were thought to emerge. It now seems certain that spaces do not exist.

Migration and Diapedesis.—Even early in an inflammation a number of white corpuscles pass through the vessel walls; but when the inflammation is well established, large numbers, and when it is severe vast hordes, pass into the perivascular tissues. This process is known as "*migration*" (Figs. 3 and 4). The leukocytes throw out protoplasmic arms, insert themselves between the cells of the walls of the vessel, and pull themselves through by their power of ameboid movement (Fig. 5). Some observers claim that they do not pass through existing open doors, but force openings which close after them. This is readily accomplished, because the vessel wall is itself damaged, weakened, and convoluted. Others claim that stomata exist between the endothelial cells, the vessel wall being porous like a filter (see above). It seems to have been proved that no spaces exist. The escape of leukocytes takes place chiefly from the venules, though some migrate through the capillaries and even the arterioles (Fig. 3).

The leukocytes are influenced to move toward the damaged tissue by the attractive force known as *positive "chemiotaxis,"* a force which draws them toward invading bacteria, to regions of irritation, and to areas of tissue death. Leukocytes may move from very virulent organisms, influenced by what is known as *negative "chemiotaxis."* The migration of a leukocyte requires but a short time. Figure 4 shows the migration of a white blood-cell through a vein wall, the process requiring one hour and fifty minutes. In very acute inflammations red corpuscles also pass into the tissues. Red corpuscles are not capable of ameboid movements, and if they do escape from the vessels the process is passive on their part and not active. This passive escape happens because the capillary walls have been destroyed or because openings have been formed by vascular dilatation. If red corpuscles do pass into the exudate, as happens in pneumonia, the inflammation is a very severe one, and is called a hemorrhagic inflammation. The escape of corpuscles by a passive process is known as "*diapedesis,*" in contradistinction to the escape of leukocytes by active ameboid movements, a process known as "*migration.*" The white corpuscles usually greatly increase in number in the blood of a person who has an acute inflammation, and the blood-making organs, such as the spleen and lymphatic glands, are often enlarged. An increase of white corpuscles in the blood of an individual is called *leukocytosis* (see page 28).

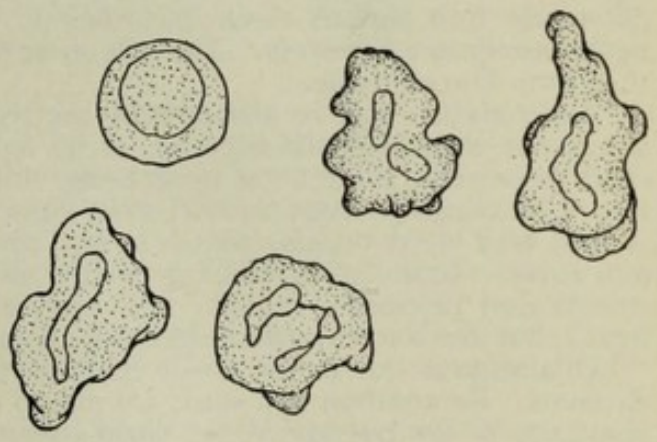


FIG. 5.—Ameboid movements of a leukocyte (Warner).

Blood-plaques.—*Blood-plates, blood-plaques,* or *third corpuscles,* may be discovered in freshly drawn blood, but unless they are present in unusual numbers they will rarely be seen in specimens prepared in the usual way. The third corpuscles can be seen by a high-power microscope in the moving blood of the web of a frog's foot. In blood outside of the body they are destroyed as soon as coagulation begins, and in order to see them coagulation must be prevented. Some observers maintain that the third corpuscles are the real fibrin formers. The blood-plaques, or third corpuscles, are found to be present in increased numbers in inflammation. In health their usual proportion to red cells is as 1 to 20. They are especially numerous at the height of fever processes and during convalescence from extensive abscesses.

Changes in the Perivascular Tissues.—The cells of the perivascular tissue are phagocytes, and when stimulated they enlarge, become more actively phagocytic, and undergo reproduction. The liquor sanguinis which exudes during an acute inflammation coagulates unless prevented by virulent bacteria. It has often been asserted that exudation is Nature's method of supplying nutriment to the cells of the damaged region. Adami points out the apparently contradictory observation that the amount of exudate is in direct proportion to the rapidity of cell destruction, but, nevertheless, concludes that exudation stands in close relation to cell proliferation.[1] From whatever cause, tissue-cells multiply. This process is known as "*cell proliferation.*"

[1] Adami, in Allbutt's "System of Medicine."

When a tissue is injured it inflames, and, as Adami points out, the reaction we call inflammation is an attempt to repair injury.

Irritation may lead to degeneration and death of cells; it may lead to growth and multiplication. In many cases both processes are active in the acute stage, the cells at the focus of the inflammation undergoing degeneration and destruction, and those at the boundary undergoing growth and proliferation.

If tissue-cells have been seriously damaged they perish, and new cells are required to replace them. The inflammatory process has led to exudation of plasma and migration of leukocytes into the perivascular tissues. The connective-tissue cells multiply and produce young cells, which are known as "*fibroblasts*," and which eat up many leukocytes. Early in an inflammation polynuclear leukocytes preponderate, later mononuclear phagocytic cells predominate (Opie). The leukocytes contain two enzymes. One is derived from bone-marrow and digests protein in an alkaline medium; the other is derived from lymph-glands and digests protein in an acid medium (Opie). The migrated leukocytes in part surround the inflamed region and retard diffusion of the process. Many enter the diseased area and attack bacteria. Some undergo degenerative changes and liberate material which aids the clotting of the exudate. Some move out of the inflamed area, each one carrying within it tissue débris or a dead bacterium, and many are eaten up by the fibroblasts. There is no real proof that leukocytes proliferate and help directly to form new tissue. This mass of young cells, taking origin from the fixed cells, has been called *embryonic tissue*, because of a fancied resemblance to the cells of the embryo. John Hunter called it *juvenile tissue*. It has also been called *indifferent tissue*, because of the belief that it could be converted indifferently into various tissue according to circumstances. It is also spoken of as *inflammatory new formation*. The cells of embryonic tissue are called *fibroblasts* because they form fibrous tissue.

An exudation may be absorbed by the lymphatics. It may be converted into pus if infected with pyogenic bacteria, or be replaced by cells from the proliferation of fixed tissue-cells, the cellular mass being subsequently vascularized by the extension into it of capillary loops derived from adjacent capillaries. When embryonic tissue is filled with blood-vessels—that is to say, when it is vascularized—it is called *granulation tissue*. Granulation tissue is finally converted into fibrous tissue. The above complicated processes, vascular and perivascular, are not accidents nor haphazard freaks, but are Nature's efforts to bring about a cure.

Dilatation is due to the direct effect of the irritant upon the muscle or its nerve elements. Retardation and stasis are due to paralysis of the vessel wall, which causes resistance to the passage of the blood-stream and adhesion of the leukocytes to the vessel wall. The blood-liquor exudes and the leukocytes migrate. Often these efforts of Nature succeed. Acceleration of the circulation may succeed in washing away an irritant from the vessel wall. By bringing quantities of blood to the part copious exudation of plasma is rendered certain. The exudation may wash and remove irritants from the tissues, and the germicidal blood-liquor may destroy bacteria in the damaged area. The migration of corpuscles may prove of great service. The leukocytes surround an area of infection and tend to limit its spread. Leukocytes have phagocytic properties, and energetically attack and often destroy bacteria, and they furnish enzymes which may digest proteins, and antitoxins, which antagonize and may neutralize the poisons produced by micro-organisms. Leukocytes aid in forming fibrin. Fibrin formation is of service by helping immobilization and by hindering the spread of bacteria. Leukocytes also aid in separating dead tissue from living, and they remove tissue débris from the area of inflammation. The multiplication of the fixed connective-tissue cells leads to the formation of fibroblasts, and fibroblasts are converted into fibrous tissue; which effects permanent repair (these changes will be alluded to again in the section on Repair).

Nature may fail in her efforts. For instance, an enormous exudate increases stasis and may cause such tension that gangrene results.

Inflammation in Non-vascular Tissue.—A type of non-vascular tissue is the cornea, and the cornea can inflame. The healthy cornea contains no blood-vessels. It is formed of many layers of fibers, each layer running in general parallel with the corneal surface but at places forming angles with the fibers of the adjacent layers. Between the layers are communicating lymph-spaces containing connective-tissue cells known as corneal corpuscles. It obtains its nourishment in part from the vessels of the conjunctiva, but chiefly from the vessels of the ciliary body and sclera. When the cornea inflames definitely the episcleral, conjunctival, and ciliary vessels usually

dilate and pour out exudate, and the fluid exudate and the leukocytes enter into the corneal lymph-spaces. The exudate coagulates and cell multiplication ensues as in inflammation in a vascular structure. In mild inflammations the vessels about the cornea may not dilate. Leukocytes, from the lymph-spaces, reach the seat of injury in small numbers, and the fixed cells multiply. De Nancrede points out that in trivial inflammation, which injures but does not destroy the epithelium, leukocytes may not go to the seat of inflammation, the only change being enlargement and multiplication of corneal corpuscles. If new formation takes place, a permanent opacity mars the cornea as a consequence.

Cartilage has no blood-vessels except in regions where growth is very active or where ossification is taking place. Cartilage has no spaces, like the cornea, for a free circulation of lymph. In man canals have not been demonstrated and it is thought that fibrils conduct nutritive fluids, the nutritive plasma flowing between the cells, but there is no direct connection with blood-vessels. The plasma is furnished by the vessels at the margin of the perichondrium. Cartilage can inflame, and an inflammation of this structure is of slow evolution and of long duration. When inflammation occurs the cartilage cells enlarge and their nuclei proliferate, the intercellular substance softens and cartilage cells may be cast off. After a long time vessels may invade the inflamed cartilage and fibrous tissue may form from the perichondrium, but in some cases a loss of substance is not repaired.

Inflammation of Mucous Membrane.—It may be catarrhal, suppurative, croupous, or diphtheritic. In a *catarrhal inflammation* the increased blood-supply causes an excessive flow of mucus. The submucous tissues present the ordinary changes of inflammation and quantities of epithelial cells are cast off from the surface. Fibrous tissues may form in the submucous tissue and thus cause permanent thickening (strictures, etc.).

Suppurative inflammation is usually preceded by catarrhal inflammation. In this condition there is a discharge of mucopurulent fluid and ulcers are apt to form. A trivial loss of substance permits of regeneration, but a considerable loss is repaired by fibrous tissue, which by its bulk and by contracting may interfere greatly with the functional usefulness of an organ or a canal.

A *croupous inflammation* is one in which quantities of epithelial cells are cast upon the surface and there form a highly fibrinous exudate (false membrane).

In *diphtheritic inflammation* the mucous membrane is destroyed and the false membrane invades the submucous tissue. Diphtheritic inflammation is due to a specific bacillus.

Classification of Inflammations.—The various forms of inflammations are: (1) *Simple* or *common*, that which is due to any ordinary traumatic, chemical, thermal, or actinic cause, and not to bacteria. An instance of simple inflammation is traumatic periostitis or sun dermatitis. It does not tend particularly to spread. Often the cause of a simple inflammation is momentary in action; (2) *infective* or *specific*, that which is due to micro-organisms, as the streptococcus of erysipelas. An unsuccessful attempt has been made to charge all inflammations to bacteria. It is true that bacteria can generally be found in inflammatory areas, but that they are the only causes of inflammation is not proved. Infective inflammations often tend to spread widely; (3) *traumatic*, which is due to a blow or an injury; (4) *idiopathic*, which is without an ascertainable cause. There is certainly a cause, even if it cannot be pointed out, and the term "idiopathic" means that we do not know the cause; (5) *acute*, which is rapid in course and violent in action; (6) *chronic*, which follows a prolonged course; (7) *subacute*, which is intermediate in violence and duration between acute and chronic; (8) *sthenic*, characterized by high action; it occurs in strong young subjects; (9) *asthenic* or *adynamic*, occurring in the old, the debilitated, and the broken down. In such an inflammation there is no certain limitation of the inflammation by leukocytes, and there is an indisposition on the part of the tissue-cells to form fibroblasts; (10) *parenchymatous*, affecting the "parenchyma," or active cells of an organ; (11) *interstitial*, affecting the connective-tissue stroma of an organ; (12) *serous*, characterized by profuse non-coagulating exudation (as in pleuritis) or by marked inflammatory edema; (13) *plastic*, *adhesive*, or *fibrinous*, characterized by an exudation which glues together adjacent surfaces, as in peritonitis; (14) *purulent*, *phlegmonous*, or *suppurative*, when pyogenic cocci are present and multiply; (15) *hemorrhagic*, when the exudate contains many red blood-cells, as in strangulated hernia and in the pustules of black small-pox; (16) *croupous*, when an inflammation produces upon the surface of a tissue a fibrinous exudate which cannot be organized into tissue, and which is due to the action

of micro-organisms. An exudate of this character was called by the older surgeons "*aplastic lymph.*" It occurs most usually on mucous membrane; (17) *diphtheritic*, which differs from croupous in the fact that the false membrane is in the tissue as well as upon it; (18) *gangrenous*, an inflammation resulting in death of the part, the gangrene being due to the tension of the exudate or the virulence of the poison; (19) *healthy*, when the tendency is to repair; (20) *unhealthy*, when the tendency is to destruction; (21) *latent*, an inflammation which for some time does not announce itself by any obvious symptoms, as the inflammation of Peyer's patches in typhoid fever; (22) *contagious*, when its own secretions can propagate it; (23) *dry*, without exudation; (24) *hypostatic*, arising in a region of passive congestion (as a bed-sore); 25 *malignant*, due to a malignant growth; (26) *catarrhal*, affecting a mucous membrane; (27) *neuropathic*, due to impairment of the trophic functions of the nervous system, as in perforating ulcer; and (28) *sympathetic* or *reflex*, due to disease or injury of a distant part, as when orchitis follows mumps.

Extension of Inflammation.—Inflammation extends by continuity of structure, by contiguity of structure, by the blood, and by the lymphatics. Extension by continuity is seen in phlebitis. Extension by contiguity is seen when a cutaneous inflammation advances and attacks deeper structures. Extension by the blood is seen in the formation of the smallpox exanthem. Extension by the lymphatics is witnessed in a bubo following chancroid.

Terminations of Inflammation.—Inflammation may be followed by a return of the tissues to health, and this return may take place by delitescence, by resolution, or by new growth. By *delitescence* is meant abrupt termination at an early stage, as when quinsy is aborted by the administration of quinin and morphin, and the production of a sweat; *resolution* means the gradual disappearance of the symptoms when inflammation has passed through its regular stages; and *new growth* means that an inflammation has lasted a considerable time, with ample blood-supply and without suppuration, and has gone on to the formation of fibroblasts, granulation tissue, and fibrous tissue. Inflammation may be followed by death of the inflamed part or necrosis. Death of the part may be due to suppuration, ulceration, or gangrene.

The **causes of inflammation** are: *predisposing*, or those residing in the tissues, and rendering them liable to inflame; and *exciting*, or those which directly awake the process into activity. The first may be thought of as making material inflammable; the second may be regarded as sparks of fire.

Predisposing causes are those which impair the general vigor, injure the blood, weaken the tissues, or lower nutritive activities. Among these causes are shock, hemorrhage, nervous irritation, gout, rheumatism, diabetes, Bright's disease, alcoholism, and syphilis. Plethora renders a person liable to sthenic inflammations (those characterized by high action). Tissue debility renders one prone to adynamic or asthenic inflammations. Nerve injury predisposes to inflammation, either from damage to trophic nerves and consequent failure in tissue nutrition and resistance or because analgesia exists and irritants which reach the region are not recognized and are allowed to remain. For instance, if the conjunctiva is in a condition of analgesia, the presence of foreign bodies is not noticed and destructive inflammation may result from their non-removal.

After removal of the Gasserian ganglion the cornea is devoid of sensation, the flow of tears is lessened, dust gathers in the eye, and if not removed by irrigation or kept out by a shield, inflammation and disastrous ulceration will ensue.

Exciting Causes.—The exciting causes of inflammation are: *traumatic*, as blows and mechanical irritation; *chemical*, as the stings of insects, the rubefacient effects of mustard, venom of serpents, products of bacteria, ivy poison, etc.; *thermal*, heat and cold; *actinic*, certain solar and electric rays; *specific*, the micro-organisms, causing, for instance, tuberculous peritonitis or erysipelas; and *nervous*, nerve stimulation certainly being capable of producing hyperemia and sometimes even inflammation. Inflammation due to nerve stimulation is seen in herpes zoster and in the swollen and discolored skin over an inflamed joint (Adami). Inflammation may also be induced by electric currents, by the *x*-rays, and by radium rays.

Some writers insist that every inflammation is due to the action of micro-organisms, but this statement lacks proof. They maintain that inflammation is a destructive microbic process which cannot bring about repair, and that repair begins only when inflammation ends. As Adami points out, the advocates of this view argue that swelling, pain, and discoloration point to the existence of inflammation; that repair can take place when these phenomena are absent, hence inflammation is not present when repair

begins. As a matter of fact, swelling, discoloration, and pain are phenomena often but not invariably associated with inflammation; and in inflammation one or all of these phenomena may be absent. Because these signs are not discovered is no proof that inflammation does not exist. I believe that inflammation is not always due to microbes and is not always a destructive process, but may be from the start conservative and reparative. It is always the reaction of the tissue to injury and however caused is the first step on the road to repair.[1]

Symptoms of Acute Inflammation.—Inflammation, if at all severe, announces its presence by symptoms which are both *local* and *constitutional.*

Local Symptoms of Acute Inflammation.—The most prominent local symptoms were known in the first century, A. D., to the famous Roman, Celsus, who stated them as "*rubor, calor cum tumore et dolore*"—redness and heat with swelling and pain. As set forth today, the local symptoms are: (1) heat; (2) pain; (3) discoloration; (4) swelling; (5) disordered function; and (6) muscular rigidity, which is noted in inflammation of certain regions and structures.

Heat is due to the passage of an increased quantity of blood through the damaged area and to the arrival at the surface of the body of warm blood from internal parts. Although an inflamed part may be, and usually is, warmer than the surrounding parts, its temperature is never greater than the temperature of the blood. This increase of heat is especially noticeable when we, for instance, touch an arm affected with erysipelas and contrast the sensation obtained with that obtained by placing the hand on the sound arm. The diseased arm feels much warmer to the examining hand than does the sound arm, but its temperature is not above the general body temperature. An extremity in health, as is well known, shows on the surface a temperature below that of the blood; in an inflamed state the temperature may nearly equal that of the blood. Heat is always present in inflammation of a superficial part. The surgeon examines for heat by placing his hand upon the suspected area and then placing the same hand upon a corresponding portion of the opposite side of the patient in order to note the contrast. If great accuracy is desired, a surface thermometer is used.

Pain is a constant and conspicuous symptom. It is due to stretching of or pressure upon nerves from exudate; to irritation of nerves; or to inflammation of the nerves themselves, producing cellular changes. Pain is associated with *tenderness* (pain on pressure), it is aggravated by motion and by a dependent position of the part, and it varies in degree and in character. In serous membranes it is acute and lancinating, like dagger-thrusts; in connective tissue it is acute and throbbing; in large organs it is dull and heavy; in the bone it is gnawing or boring; in the skin and mucous membrane it is itching, burning, smarting, or stinging; in the urethra it is scalding; in the testicle it is sickening or nauseating; in the teeth it is throbbing; and in inflammation under dense fascia it is pulsatile. Pain in inflammation after presenting itself in one form may change in character. If a pain becomes markedly throbbing, suppuration may be anticipated. Pain does not always occur at the seat of trouble only, but may be felt also at some distant point. Usually there is also pain at the seat of disease. Sometimes no pain is complained of in this region. I have seen pain in the right sciatic nerve dependent upon a chronically inflamed, posteriorly placed appendix, no complaint having been made of pain in the abdomen. This is known as a "*sympathetic*" or *referred pain*, and is due to the fact that the area to which pain is referred receives its nerve supply from the same spinal segment as does the inflamed area; in other words, there is a nervous communication between the inflamed part and a distant area. When appendicitis causes sciatic pain the appendix has caused trouble in the sciatic plexus or sciatic nerve. In many cases of sympathetic pain a nerve trunk refers the sense of pain to its peripheral distribution, but sometimes pain is referred to an adjacent nerve, a distant nerve, or even, perhaps, to a nerve on the opposite side of the body. Tenderness, however, is detected at the seat of trouble, whether or not it exists at the seat of referred pain.

Pain of hepatitis is often felt in the right shoulder. Pain at the point of the right shoulder or in the shoulder-blade is felt also in gall-stones, cholecystitis, and in cancer of the liver. It is held by some that pain arises in filaments of the pneumogastric from the hepatic plexus. Others maintain that it is referred from the phrenic nerve to the cervical nerves by the sympathetic (Mackenzie). Pain in the shoulder (see Löffelmann Abstract in "Surgery, Gynecology, and Obstetrics," Sept., 1915) as a result of acute abdominal conditions may be above the clavicle, at the point of the shoulder, in the nape of the neck, or in the upper part of the arm. It is due to irritation

[1] See Adami's masterly article in Allbutt's "System of Medicine."

of the diaphragm. If the right side of the diaphragm is irritated the pain is felt in the right shoulder, if the left side it is felt in the left shoulder. In splenic injuries and inflammations the pain is in the left shoulder. Pain in the right shoulder is a common but not invariable symptom after perforation of the stomach, in appendicitis with a high appendix, in abscess of the dome of the liver, in subphrenic abscess, and in hepatitis.

Pain of coxalgia is often felt on the inside of the knee, because the obturator nerve, which sends a branch to the ligamentum teres, also sends a branch to the interior and to the inner side of the knee-joint.

Inflammation of an eye with increased tension causes browache. *Inflammation of the anus, uterus, tubes,* or *ovaries* may cause sacral backache. *Pain of rectal inflammation* may be referred to the back of the sacrum, down the thighs, to the penis, and to the perineum. I have seen pain in the heel as a symptom of rectal cancer. *Pain of inflammation of the sacro-iliac joint* may be referred to the sciatic nerve and its branches. *Inflammation of the prostate* and *neck of the bladder* causes pain in the head of the penis, and often pain in the lower abdomen and loin. *Inflammation of a testicle* or *epididymis* causes pain in the groin, and often also in the abdomen, back, and thighs. *Renal calculus* and *pyelitis* cause pain in and retraction of the testicle, and pain in the loin, groin, or thigh. Pain is sometimes felt in the renal region of the opposite side.

If the covering of an organ is involved, pain becomes more violent; for instance, hepatitis becomes much more painful when the perihepatic structures are attacked. Inflammation without pain is known as "latent" (as the inflammation of Peyer's patches in typhoid). The sudden disappearance of inflammatory pain, when not due to the administration of opiates, suggests the possibility of gangrene, because analgesia exists in gangrene. The characteristics of inflammatory pain are that it comes on gradually, has a fixed seat, is continuous, is attended by other inflammatory symptoms, and is increased by motion, by pressure, and by a dependent position of the part. If there be no tenderness in a part, the source of the pain is not local inflammation; but tenderness may exist when there is no local inflammation, as in an area to which pain is referred from a distant part. Pain of an inflammation which does not involve a nerve does not correspond to an exact nervous distribution. If pain corresponds exactly to the area of a nerve's distribution, the cause of it is acting on the nerve trunk or on its roots. If the cutaneous surface is involved, the lightest touch causes pain. The surface may be extremely hyperesthetic even when it is not inflamed, the condition resulting from deep-seated or distant inflammation. Areas of hyperesthesia (hyperalgesia) of the skin of the abdomen are noted in various visceral inflammations. Such hyperesthesia is due to referred impressions. Sir James Mackenzie set forth the significance of this symptom. Ligat ("Practitioner," 1916, xcvii) tests for hyperesthesia by taking a portion of skin between the thumb and index-finger and lifting it away from the deeper parts. He finds that in gastric ulcer and duodenal ulcer the maximum point of sensitiveness is in the midline and midway between the umbilicus and the ensiform. If a line is drawn from the middle of Poupart's ligament to the umbilicus the junction of the middle and lower thirds of this line is the fallopian tube point. The appendix point is at the meeting place of the upper and middle thirds of a line drawn to the anterior superior spine of the right side to the umbilicus. The gall-bladder point is found at the junction of a line drawn horizontally from the tip of the tenth rib and a vertical line drawn midway between the middle of the abdomen and the nipple line. If touching the skin produces no pain, but deep pressure does produce it, the deeper structures are the source. Pain in muscle and ligament is developed by motion; in muscle, by contraction, but not by passive movements with the muscle relaxed; in ligament pain is developed by active or passive movements which stretch the ligament. If, for example, a man with a stiff neck has pain on the right side of the back of his neck on voluntarily turning his face toward the left shoulder, but is without pain when his face is turned by the surgeon, who, conversely, induces pain by turning the patient's face far to the right, this condition indicates the trouble to be muscular. If, however, no pain arises on turning the face to the right, but it is manifest on turning the face actively or passively to the left, the pain is in those ligaments which stretch when the face is turned to the left.[1] In inflammation of the synovial membrane even gentle passive motion in any direction causes pain.

The pain of colic differs from that of inflammation. It is sudden in onset, intermits, recurs in paroxysms, and is relieved by pressure. The pain of inflammation is gradual in onset, is continuous, and is made worse by pressure. The pain of neuralgia is often preceded by cutaneous anesthesia of the skin of the part, is very paroxysmal, comes on

[1] "Surgical Diagnosis," by A. Pearce Gould.

suddenly, darts through recognized nerve areas, the attack lasts some hours, and is apt to recur at a certain hour. It presents no general tenderness, as does inflammation, but there may be several points which are acutely sensitive to pressure (Valleix's *points douloureux*). The tender spots of Valleix are met with in *inveterate* neuralgia, and occur at points where nerves "pass from a deeper to a more superficial level, and particularly where they emerge from bony canals or pierce fibrous fasciæ."[1]

Pain is often of great value by calling attention to parts diseased; but it may be a terrible evil, racking the organism and even causing death. If pain continues long, it becomes in itself formidable: it prevents sleep, it destroys appetite, and it deteriorates the mind, and one of the surgeon's highest duties is to relieve it. The *physiognomy, or expression of persistent physical pain*, presents the following characteristics: Heavy fulness about the eyes, drooping of the angles of the mouth, contraction of the brows, and the aspect of fatigue. The victim of pain may be restless, but in severe inflammation he is apt to assume some fixed posture. He may be anemic. There may be wide-spread tremor, muscular twitches, or muscular rigidity. Agony is made evident by various signs and is often associated with fear. The absence of the physiognomy of pain in a person who complains of great pain is a strong indication that the patient exaggerates the gravity of his sufferings or deliberately deceives. Spartans are few.

Discoloration arises from determination of blood to the part; hence the more vascular the tissue, the greater the discoloration. A non-vascular tissue presents no discoloration, though we usually find discoloration adjacent in the zone of blood-vessels which furnish the tissue with nutriment. Discoloration in vascular tissue is most intense at the focus or center of the inflammation. Discoloration varies in tint and in character according to the tissue implicated and the nature of the inflammation. It may be circumscribed or diffuse. Arborescent redness means a distribution in dendritic lines. Linear discoloration signifies redness running in straight lines, as in phlebitis. Punctiform discoloration occurs in points, and is due to vascular rupture. Maculiform redness resembles an ecchymosis or blotch. Dusky discoloration points to suppuration.

Inflammation of the throat and skin produces scarlet discoloration; inflammation of the sclerotic coat of the eye and of the fibrous coat of muscle produces lilac or bluish discoloration; inflammation of the iris produces brick-dust, grayish, or brown discoloration; erysipelas causes a yellowish-red discoloration; secondary syphilis causes a copper-hued discoloration; and tonsillitis causes a livid discoloration. A tuberculous ulcer is of a purple color on the edge. Gangrene is shown by a black discoloration. A scorbutic ulcer is surrounded by an area of violet color.

Redness as a sign of inflammation must be permanent and joined with other symptoms. Redness due to inflammation disappears on pressure, but returns when the pressure has been removed. If redness is due to staining of the surface by dye, pigmentation, or extravasation of blood, pressure will not blanch the spot. If on taking off pressure the redness of inflammation rapidly returns, the circulation is active; if, on the contrary, it very slowly reappears, the circulation is very sluggish and gangrene is threatened. Subcutaneous hemorrhage gives rise to a purplish-red color which does not fade when subjected to pressure. Stains of the surface by dyes not only fail to disappear on pressure, but are distributed over a considerable surface, show a hue which is uniform throughout, are obviously superficial, are not associated with other signs of inflammation, and can be washed away.

A. Pearce Gould, in his excellent little work upon "Surgical Diagnosis," tells us that the color of a hyperemic surface may furnish important information. Lividity may mean failure of the heart and lungs, or simply venous congestion in the part. In lividity from obstruction of the lungs or heart the color slowly returns after pressure has driven it out. In lividity due to local congestion the color quickly returns when pressure is released and the dilated veins are often distinctly visible. Of course, in a local trouble, when the circulation becomes impaired to such a degree that gangrene is threatened, the lividity fades very slowly on pressure and reappears very slowly on the release of pressure.

Swelling or *tumefaction* is due in small part to vascular distention, but chiefly to effusion and cell multiplication. The more loose cellular material a part contains, the more it swells; hence the eyelids, scrotum, vulva, tonsils, glottis, and conjunctivæ swell very greatly when inflamed. A swelling is soft or edematous when due to uncoagulated effusion; is brawny and doughy when due to coagulated effusion; is hard and elastic when produced by proliferating cells. Swelling may do good by unloading

[1] Anstie, "Neuralgia and Diseases which Resemble It."

the vessels and acting like a blister or local bleeding, or it may do great harm by pressing upon the vessels and cutting off the blood-supply. Swelling of the conjunctiva, or chemosis, may cause sloughing of the cornea, and swelling of the prepuce may cause gangrene. A swelling may do harm by obstructing an aperture, as in edema of the glottis, when the larynx becomes blocked; or by compression of a normal channel, as in the swelling of the perineum when the urethra is compressed. The cutaneous surface over a swollen area may become covered with blisters or blebs. This condition is noted particularly after burns and fractures.

Disordered function is always present in inflammation. It may be manifested by *increased tenderness* or sensibility; a slight touch, it may be, producing torturing pain. This condition is called *hyperesthesia.* Healthy parts almost or entirely destitute of feeling (as tendons, ligaments, and bones) become highly sensitive when inflamed. It may be manifested by *increased irritability.* In dysentery the colon repeatedly contracts and expels its contents; the stomach does likewise in gastritis; and the bladder acts similarly in cystitis. Spasmodic twitching of the eyelids occurs in conjunctivitis, and twitchings of the muscles of a limb are common after fracture and amputation.

Impairment of Special Function.—In inflammation of the eye, when an attempt is made to look at objects the lids close spasmodically, and even a little light causes great pain and lacrimation (photophobia). In inflammation of the ear noises cause great suffering, and even when in a quiet room the patient has subjective buzzing and roaring in his ears (tinnitus aurium). In coryza the sense of smell, in glossitis the sense of taste, in dermatitis the sense of touch, and in laryngitis the voice may be lost. In inflammation of the brain the mind is disordered; in arthritis the joints can scarcely be moved; and in myositis it is difficult and painful to employ the muscles.

Derangement of Secretions.—In dermatitis the sweat is not thrown off; in hepatitis bile is not properly secreted; and in nephritis nitrogenous elements are not satisfactorily removed. The secretions may undergo important changes of composition. The sputum in pneumonia is rusty, and dysentery causes a discharge of bloody mucus.

Derangement of Absorbents.—In the height of an inflammation the absorbents are blocked and clogged by coagulated exudate, and they cannot perform their offices.

Muscular rigidity is sometimes an important sign of inflammation. If a joint is inflamed, the muscles which move the joint are rigid and the joint is more or less immobile. In inflammation of the peritoneum the abdominal muscles are rigid, and the respirations become shallow, frequent, and thoracic. In pleuritis the intercostal muscles of the inflamed side become rigid and the respiratory excursions of the chest are limited. Rigidity serves to lessen motion, prevent pain, protect the part, and so gives physiologic rest.

Constitutional Symptoms of Acute Inflammation.—The chief constitutional symptoms of acute inflammation are elevated temperature and leukocytosis. Constitutional symptoms may be absent, and often are in moderate or limited inflammations; but in severe, extensive, or infective inflammations the symptom group known as *fever* is certain to exist. This is known as *symptomatic*, or *inflammatory fever*, and it arises in non-septic cases from the absorption of aseptic pyrogenous exudate, and in microbic inflammations from the absorption of pyrogenous toxic products of bacterial action. In young and robust individuals an acute non-microbic inflammation causes a fever characterized by full, strong pulse, flushed face, coated tongue, dry skin, nausea, constipation, and possible acute delirium (the *sthenic type* of the older authors). In broken-down and exhausted individuals an ordinary inflammation, and in any individual a bacterial inflammation, may cause a fever with typhoid symptoms (the *typhoid, asthenic*, or *adynamic type*). The absorption of aseptic pyogenous material causes aseptic fever (see page 59). Inflammatory blood contains an increased amount of albumin and salts. If a person with inflammatory fever is bled, the blood coagulates rapidly, the clot sinks, and there is found on the surface a cup-shaped coat, made up of liquor sanguinis and white cells, known as the *"buffy coat"*; but this is not really proof of inflammation, and occurs normally in the blood of the horse. The buffy coat forms when blood contains a great number of leukocytes, because these leukocytes sink more slowly than do the red corpuscles. Cupping occurs because the white corpuscles sink more slowly at the wall of the tube than in the center.

Leukocytosis.—In many inflammatory and infectious diseases leukocytosis is noted. It probably indicates an attempt on the part of the organism to protect itself from

noxious materials. Leukocytosis is usually much more marked if pus exists than if the exudation is serous or fibrinous.

"The degree of leukocytosis may be considered a general index to the intensity of the infection and to the strength of the individual's resisting powers in reacting against it. It follows, therefore, that intense infections occurring in individuals whose resisting powers are strong, produce a decided increase; but the presence of an infection of like intensity in one whose resisting powers are greatly crippled fails to cause leukocytosis, for in such an instance the organism is so overpowered by the effects of the morbid process that it is incapable of reacting" ("Clinical Hematology," by J. C. DaCosta, Jr.). We see from the above that gangrene or any other virulent infection may be accompanied by a low leukocyte count, and when pus is surrounded by a thick wall the leukocytes may be normal or nearly normal in number. An increased proportion of polymorphonuclear leukocytes strongly suggests body reaction against infection, and an increase of eosinophils aids us in recognizing deep-seated pus when the leukocyte count is normal or but slightly increased.

The introduction of salt solution into the peritoneal cavity leads to the gathering of numbers of white cells, and the resistance of the serous membrane to infection is increased. Horse-serum that has been boiled is said by Petit to be a valuable material to draw polynuclear leukocytes to a part ("Med. Record," June 22, 1907). It has been injected into the peritoneal cavity the evening before an operation (30 c.c.); it has been poured into the cavity at the termination of an operation; the gauze used for drainage after an appendicitis operation has been soaked in it.

There is no fixed number of leukocytes which causes us to affirm the presence or absence of gangrene or pus. A normal count shows from 50 to 60 per cent. of polymorphonuclear leukocytes and from 25 to 40 per cent. of lymphocytes. Most serious inflammations show marked inflammatory leukocytosis and an increase in the relative proportion of polynuclear cells. Typhoid and tuberculosis show no inflammatory leukocytosis and even a mixed infection may cause comparatively little increase of polynuclear cells. In tuberculosis the proportion of lymphocytes is increased. The same man should make all the counts on one patient; at least 500 cells should be counted at each examination and several examinations ought to be made.

Chronic Inflammation.—This condition results from the action on the tissues of some mild but long-acting irritant. It progresses slowly and does not produce symptoms of severity either in the part or the body at large.

Causes.—Blood diseases, as rheumatism and gout; infective diseases, as tuberculosis and syphilis; retained pus in an ill-drained abscess; blocking of the duct of a gland; the retention of a foreign body in a part; the flow of an irritant secretion (as saliva from a fistula); repeated identical traumatisms of an occupation, etc. Sir Watson Cheyne tells us that chronic inflammation is not due to the ordinary pyogenic organisms (see Cheyne's article in Treves's "System of Surgery").

Tissue Changes.—These changes are practically the same as in acute inflammation, but take place far less rapidly. Vascular dilatation, exudation, and leukocytic migration are often trivial. Cell proliferation is always conspicuously marked. It is maintained by Cheyne and others that typical granulation tissue does not form, the tissues of the part being replaced directly by fibrous tissue. The amount of fibrous tissue produced is relatively very great. This tissue may cause permanent thickening, or may contract and thus diminish the size of a part. Contraction is very considerable in cirrhosis of the liver and in interstitial nephritis.

Symptoms.—Pain varying in intensity and character; tenderness; great swelling, which in some cases is followed by shrinking, and is usually indurated or brawny. As a matter of fact, great swelling is the most usual symptom. Sometimes there is a trivial amount of heat. There is rarely discoloration unless the skin is itself inflamed, but usually the surface veins are distinctly, and sometimes they are greatly, distended. There are no constitutional symptoms attributable purely to the inflammation. If there are such symptoms, they are due to the disease which induced the inflammation or to interference with the function of an organ because of the fibrous mass. (For the treatment of chronic inflammation see articles upon special regions and particular structures.)

Treatment of Acute Inflammation.—The first rule in treating an inflammation must be to remove the exciting cause. If this cause is a splinter in the part, take out the splinter; if it is a foreign body in the eye, remove the foreign body; if urine is extravasated, open and drain; take off pressure from a corn; remove an ingrown nail and its matrix; and eject microbes from an infected area by draining, irrigating, and

perhaps by applying antiseptics. The rule, remove the cause, applies to a chronic as well as to an acute inflammation. If the cause of an inflammation was momentary in action (as a blow), we cannot remove it, for it has already ceased to exist. After removing the cause, endeavor to bring about a cure by local and constitutional treatment.

Local Treatment of Inflammation.—It must be remembered that the division of inflammation into stages is natural, and not artificial, and that a remedy which does good in one stage may do harm in another. Certain agents are suited to all stages of an acute inflammation, namely, *rest* and *elevation*. In many inflammatory conditions nature seeks to immobilize, protect, and rest the part by increasing the tension of adjacent muscles. By this muscular rigidity inflamed joints are fixed and rested. Rigidity of the intercostal muscles in pleuritis limits chest motion and pain; rigidity of the abdominal muscles in peritonitis limits abdominal movements and lessens suffering.

Rest.—Physiologic rest is of infinite importance, and is always indicated in acute inflammation. In the exercise of function blood is taken to a part and an existing inflammation is aggravated. Further, as Billroth has pointed out, rest prevents the dissemination of infection, because motion exposes fresh surfaces to inoculation and breaks down protective barriers of leukocytes. Its principles were first thoroughly studied by Hilton.[1] Baron Larrey, the celebrated military surgeon of the Napoleonic Empire, anticipated many modern views on this subject. He insisted on the necessity of rest in the treatment of wounds; he believed that rest permitted Nature to perform her work unhampered; he was accustomed to leave a "first dressing," if properly applied, undisturbed for several or even for many days. He believed it advisable to associate with rest well adjusted and judicious compression made by bandages, especially flannel bandages. (The author, on Baron Larrey, in "Johns Hopkins Hospital Bulletin," July, 1906.) The means of securing rest differ with the structure or the part diseased. When rest is used, do not employ it too long. *Rest in bed* diminishes the amount of blood sent to an inflamed part and lessens the force of the circulation; hence it antagonizes stasis. It has been shown that the heart beats at least fifteen times per minute less when the patient is recumbent than when he is erect. The saving of strength and the benefit of the local condition are thus seen to be enormous. In fact, the heart saves at least 21,000 beats a day. In every severe inflammation insist on the patient going to bed.

In *cerebral concussion* rest must be secured by quiet, by darkness, by the avoidance of stimulants and meat, by the application of ice to the head, and by the use of purgatives to prevent reflex disturbance and the circulation of poisons in the blood. In *inflamed joints* rest must be obtained by proper position, associated in many cases with the adjustment of splints or plaster of Paris, or the employment of extension.

In *pleuritis* partial rest can be secured by strapping the affected side with adhesive plaster, or by using a bandage or a binder to limit respiratory movements. In *fractures* Nature procures rest by her splints—the *callus*—and the surgeon procures rest by his splints—firm dressings or extension. In *cancer of the rectum* and *intractable rectitis* a colostomy secures rest for the inflamed and damaged bowel. In *enteritis* opium gives rest to the bowel by stopping peristalsis. In *cystitis* rest is obtained by the administration of opium and belladonna, which paralyze the muscular fibers of the bladder. The use of the catheter gives rest to the bladder by removing urine. A cystostomy allows complete rest by permitting the bladder to suspend its function as a reservoir of urine. In cystitis from *vesical calculus* rest is obtained by incising the bladder, removing the stone, and draining, or by crushing and evacuating the stone. In *inflamed mucous membrane* rest from the contact of irritants is secured by touching the membrane with silver nitrate, which forms a protective coat of coagulated albumin. Opening an *abscess* gives its walls rest from tension. In *inflammation of the eye* light must be excluded to obtain complete rest, but tolerably satisfactory rest is given in some mild cases by the use of glasses of a peacock-blue tint. In *aneurysm* the operation of ligation cuts off the blood-current and gives rest to the sac. In *hernia* the operation gives rest from pressure. Instances of the value of rest could be multiplied indefinitely.

Relaxation is in reality a form of rest, and consists in placing the part in an easy position. In *synovitis of the knee* semiflexion of the knee-joint lessens the pain. In *muscular inflammation* relaxation relieves the pain.

Elevation partly restores circulatory equilibrium. A *felon* is less painful when the

[1] "Lectures upon Rest and Pain."

hand is held up in a sling than when it is dependent. A *congestive headache* is worse during recumbency. A *gouty inflammation* in the great toe is more painful with the foot lowered than when it is raised. A *toothache* becomes worse on lying down.

Certain agents are suited to the stage of vascular engorgement, increased arterial tension, and beginning effusion. These agents are: (1) local bleeding or depletion; (2) cold.

Local bleeding, or *depletion*, is the abstraction of blood from the inflamed area. This abstraction relieves circulatory retardation and causes the blood to move rapidly onward. The corpuscles clinging to the vessel walls are washed away, the capillaries shrink to their natural size, and the exudate is absorbed. In other words, local blood-letting increases the rate of the circulation, though not its force.

The *methods of bleeding locally* are: (*a*) puncture; (*b*) scarification; (*c*) leeching; (*d*) cupping.

Puncture is recommended in inflammation, not only because it abstracts blood locally, but also because it gives an exit to effusion under fibrous membranes. It is very useful in relieving tension—for instance, in epididymitis. It is performed with a tenotome and with aseptic precautions. If numerous punctures are made, the procedure is termed "multiple puncture." This is very useful when applied to the inflamed area around a leg ulcer. The late Prof. Joseph Pancoast was very fond of employing multiple punctures, and he designated the operation "the antiphlogistic touch of the therapeutic knife."

Scarification or Incision.—By means of scarification we bleed locally, evacuate exudate, and relieve tension. One cut or many cuts may be made, and these cuts may be deep or may not go entirely through the skin, according to circumstances. Multiple incisions are useful when applied to inflamed ulcers, tissues in danger of gangrene, and almost any condition of great tension. Scarification is of notable value when edema of the glottis exists. Free incision is of great benefit in periostitis and in threatened gangrene. In osteomyelitis the medullary canal must be promptly opened.

Leeching.—Leeches must not be applied to a region plentifully endowed with loose cellular tissue, as great swelling and discoloration would certainly ensue. These regions are the prepuce, labia majora, scrotum, and eyelids. Leeches should never be applied to the face (because of the scar), near specific sores or inflammations, nor over a superficial artery, vein, or nerve. A leech is best applied at the periphery of an inflammation and between an inflammation and the heart. To leech at the inflammatory focus only aggravates the trouble. Before applying leeches, wash the part and shave it if hairy. Place the leech in a test-tube or an inverted wine-glass, inserting the tail or thick end first, and invert the tube so that the leech's head will come in contact with the prepared skin. The leech is restrained in the tube until it "takes hold" and begins to feed, when the tube is removed. If the leech will not bite, smear the part with milk or a little blood. Never pull off a leech; let it drop off. It will usually drop off when full, but if it refuses to do so, sprinkle it with salt. After removing a leech, employ warm fomentations if continued bleeding is desired. Sometimes the bleeding persists or recurs. Weill and Mouriquand ("Press. Médicale," Paris, No. 1, 1911) report 6 cases of severe bleeding. Bleeding can usually be arrested by styptic cotton and pressure. In some rare cases the bleeding continues in spite of pressure. This is due to the fact that the tissue contains a considerable quantity of a material secreted from the throat of the leech, which material prevents coagulation of blood. In such a case excise the bite and the area of tissue adjacent to it, and suture the wound. Leeching leaves permanent triangular scars. The Swedish leech, which is preferred to the American, draws 2 to 4 drams of blood. After a leech has been removed, if we desire to use it again, place it in salt water. This causes it to vomit the blood which it has taken up. Leeching has both a constitutional and a local effect. It is at present used comparatively rarely, but it is employed by some practitioners over the spermatic cord in epididymitis, and on the temple in ocular inflammation.

Cupping.—Dry cups deviate blood from a deeply placed inflamed area to the surface. Wet cups actually remove blood.

Dry cups are applied without first incising the skin. One or more may be applied. A special instrument is sold in the shops for the performance of dry cupping. It consists of a glass bell, with a globular and hollow top of rubber (Fig. 6). The rubber is emptied of air by squeezing. The glass bulb, the edges of which have been greased, is pushed upon the skin, and the compression is relaxed upon the rubber bulb. A partial vaccum is created, and an area of skin and subcutaneous tissue full of blood rises into the glass bell.

Cupping can be easily performed by means of a tumbler. The edge of the glass is greased; a bit of blotting-paper wet with alcohol is placed in the bottom of the tumbler and lighted. After a brief period the glass is inverted and placed upon the skin, which has been dampened with warm water. As the air in the glass cools the tissues rise into the partial vacuum.

Wet cups draw blood, and the skin should be cleansed before they are applied. In wet cupping apply a dry cup for a moment, remove it, incise or puncture the skin, and replace the cup to draw the requisite amount of blood. Incisions may be made by an ordinary scalpel, a lancet, or a scarificator, a cup being then applied. A once popular scarificator is shown in Fig. 7. Unfortunately, it cannot be sterilized easily. In this instrument concealed blades are thrown out by touching a spring. Baron Heurteloup devised an instrument (Fig. 8) in which the incision is made by a scarificator. The blood is drawn out by a pump, the tube being placed upon the cut area and the withdrawal of the piston creating a vacuum. This instrument is known as the "artificial leech." After scarification and the application of the cup, the partial vacuum draws blood into the cup; when the wounds cease to bleed the cup is removed, and if further bleeding is thought desirable, the clots are wiped away and the cup is again applied, and after its removal warm fomentations are used. Wet cupping is of value in pleuritis, pericarditis, and nephritis.

Cold is a very powerful and useful agent if used judiciously and applied at the proper time. It is valuable because of its reflex effect upon the vessels of the inflamed area rather than because of direct action upon the cells of a part. It should only be used early in the case, that is, before stasis occurs. It is not to be used in the later

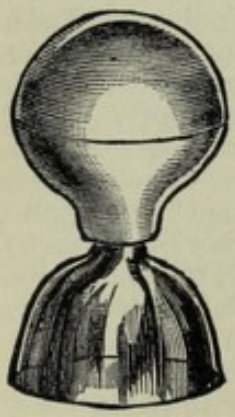


FIG. 6.—Rubber bulb cupper.

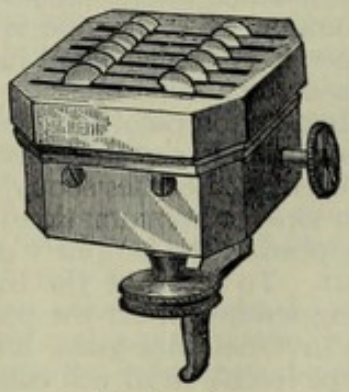


FIG. 7.—Scarificator.

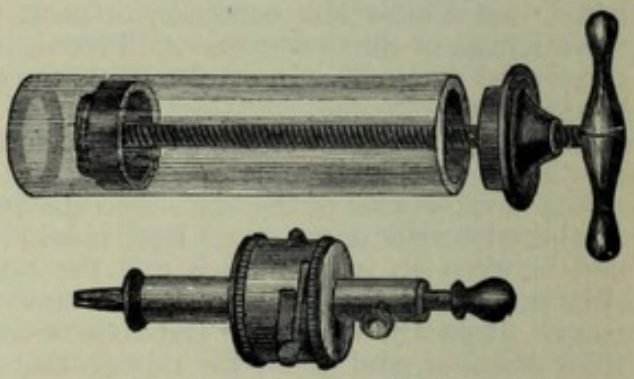


FIG. 8.—Heurteloup's artificial leech.

stages of inflammation, for it will then only aggravate the existing state; in fact, when there is considerable exudation cold does actual harm.

Cold acts by constricting the vessels of a hyperemic area, thus lessening the amount of blood sent to the part, and preventing the evolution of the process into the stages of retardation. exudation, and stasis. Further, it prevents the migration of leukocytes, retards cell-proliferation, relieves pain and tension, and lowers temperature. If cold is too intense, if it is kept too long applied, if it is used too late in an inflammation, if it is used upon an old or feeble patient, or if it is employed when there is much exudation or a condition of tissue strangulation, it does actual harm. It lessens the nutritive activity of cells, constricts the lymph-spaces and channels, increases existing stasis, hence lowers the vitality of the tissues, and may cause gangrene. If the parts are constricted, as in strangulated hernia, or if they are compressed by a large exudate or fed by diseased blood-vessels, or if the patient is old or exhausted, cold is particularly apt to cause gangrene. Cold should not be used in a bacterial inflammation. In such an inflammation it is desirable that quantities of active leukocytes and germicidal materials should come to the part. Phagocytes destroy bacteria and circumscribe the inflammatory focus. Cold keeps much blood and hence many leukocytes out of the part, lessens the ameboid activity, and prevents migration of the leukocytes which do succeed in arriving. Hence, cold actually favors the spread of a microbic process. Furthermore, it lessens leukocytosis and thus lessens the protective reaction of the tissues. De Nancrede, in his "Principles of Surgery," points out that in an inflammation stasis soon arises at the focus of the inflammation, and there is an area of stasis surrounded by a zone of hyperemia. Cold benefits the hyperemic zone, but

aggravates the stasis. De Nancrede cautions us as follows: "Judgment is, therefore, requisite to decide whether the evil at the focus will not outweigh the good exerted at the periphery."[1] De Nancrede further points out that cold must not be used intermittently; but if employed at all, must be continuously applied. If cold is applied intermittently, there will be a reaction whenever it is removed, and this reaction causes increased hyperemia. Hence, cold must be "continued in action to prevent reaction." If during the employment of cold the skin becomes purple and congested and the circulation feeble, at once discontinue the use of it, as its continuance would be dangerous.

Cold may be used as wet cold or as dry cold.

Wet cold is easily applied, but it is much more depressing than dry cold, is likely to produce discomfort, macerates the skin, and may lead to the formation of excoriations, etc. A part can be subjected to wet cold by the application of evaporating fluids or the use of a siphon. When wet cold is used inspect the part at frequent intervals, and discontinue the treatment if evidences of stasis become positive. Evaporating fluids are extensively employed. If such a fluid is used, never cover the part with a thick dressing. If this should be done, the fluid will not evaporate with sufficient rapidity to produce cold. A piece of thin muslin or flannel should be moistened with the fluid and laid upon the part, and be kept constantly moist by the application from time to time of small quantities of the liquid. Lead-water and laudanum is used extensively, and probably owes its chief value to the fact that it produces cold on evaporation. Lead-water and laudanum is composed of 1 oz. of laudanum, 1 oz. of liquor plumbi subacetatis, 1 pint of water. Liquor plumbi subacetatis dilutus may be used without laudanum. It is thought that the addition of laudanum tends to allay pain. Coplin demonstrated by a series of laboratory experiments that lead-water and laudanum is a germicide. A solution of ammonium chlorid may be used in the strength of 1 oz. of the drug to 2 quarts of water. If ammonium chlorid is used for more than a short period of time, it is prone to cause the formation of blisters, which are irritable and painful. Cheyne and Burghard use the following formula: ½ oz. of ammonium chlorid, 1 oz. of alcohol, and 7 oz. of water. Plain spring-water, iced water, or a mixture of alcohol and water may be used. The *siphon* is occasionally used. If there is a wound, the fluid which comes in contact with it must be aseptic or antiseptic. We may use sterile water, sterile salt solution, a solution of boric acid, or a solution of acetate of aluminum. In conjunctivitis, cold is applied to the eye by means of linen or muslin soaked in iced water, laid upon the closed lids, and changed frequently.

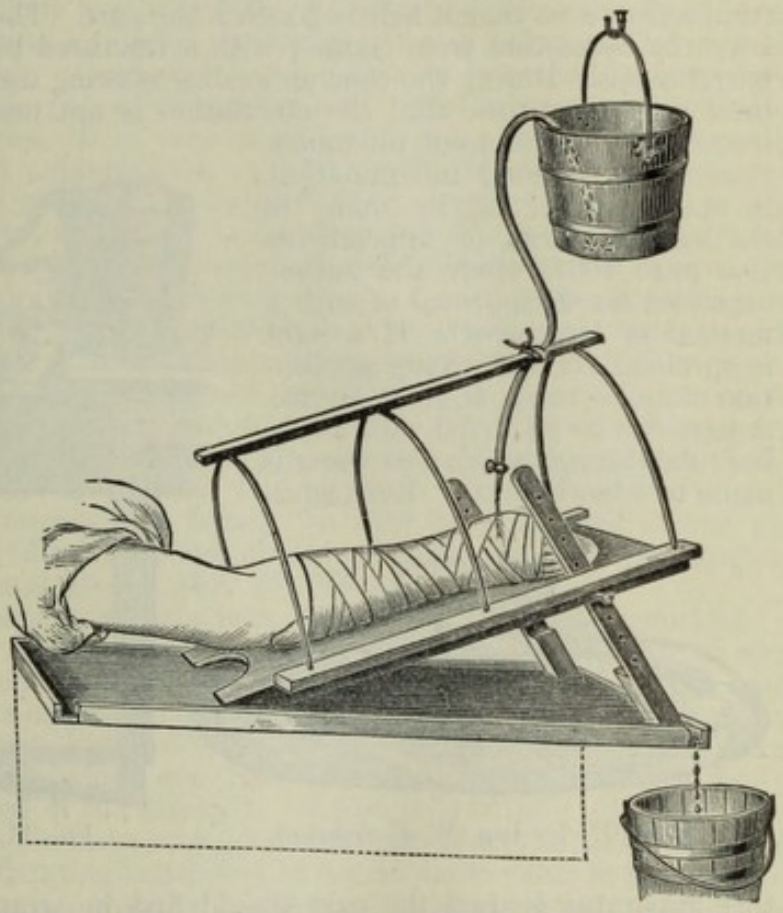


FIG. 9.—Siphon (Esmarch).

To apply wet cold by means of a siphon, the part is covered with one layer of wet linen or muslin, and is laid upon a rubber sheet folded like a trough and emptying into a bucket. A vessel filled with cold water is placed upon a higher level than the bed. A wet lamp-wick is now taken, one end is inserted into the water of the vessel, and the other end is laid upon the part. Capillary action and gravity combine to keep the

[1] "Principles of Surgery."

part moist. A rubber tube may be used instead of a wick. If a tube is employed, tie it in a knot or clamp it so that the fluid is delivered drop by drop (Fig. 9). Ordinary water or iced water can be used. If the water be too warm, it can be reduced to about 45° F. by adding 1 part of alcohol to every 4 parts of water, but such a degree of moist cold is too intense for safety. A mixture of 5 parts of nitrate of potassium, 5 parts of chlorid of ammonium, and 16 parts of water produces great cold, but such a degree of cold is not useful surgically, in fact it is dangerous.

Dry cold is more manageable and more generally useful than wet cold. It is applied by means of a rubber bag or a bladder filled with ground or finely cracked ice, several folds of flannel being first laid over the part. The flannel collects the moisture from the "sweating" bag and thus prevents maceration of the skin. Further, it saves the tissue from being subjected to too much direct cold and enables us to obtain the beneficial reflex effect. The ice-bag of India-rubber is widely used. We can venture to apply by means of the ice-bag a greater degree of cold than it is proper to apply by the use of fluids, as dry cold is not so likely to induce gangrene as is moist cold. If there is much tenderness, the weight of an ice-bag causes pain, and it is best to suspend it from a frame, so that it lightly touches the part. The frame is the same as is used to keep the bedclothes from contact with a fractured leg, and can be easily made from barrel-hoops. During the time an ice-bag is being used the part must be inspected at brief intervals to see that the circulation is not unduly depressed. The ice-bag is frequently used in joint inflammation, in intracranial inflammation, in epididymitis, and by many in the earliest stage of appendicitis (see page 1001, where the author expresses his disapproval of such a method of treatment). If a joint is sprained, the immediate application of an ice-bag is of great service. A part can be encircled with a rubber tube through which iced water is made to flow (Fig. 11). Even when this apparatus is used the part should first be wrapped in flannel. Leiter's tubes, which are tubes of lead made to fit various regions and which carry a stream of cold water, can also be used. A piece of flannel must be placed between the tube and the skin. The temperature of these tubes can be lowered to any desired degree by lowering the temperature of the circulating fluid. Cheyne and Burghard wisely caution us to use a fluid at a temperature not under 50° or 60° F., to inspect the part every three or four hours, and not to employ the tubes longer than twenty-four hours.

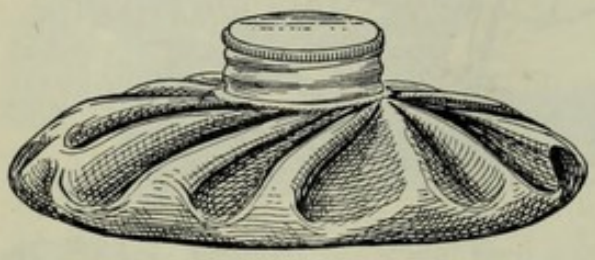


FIG. 10.—Ice-bag (W. E. Ashton).

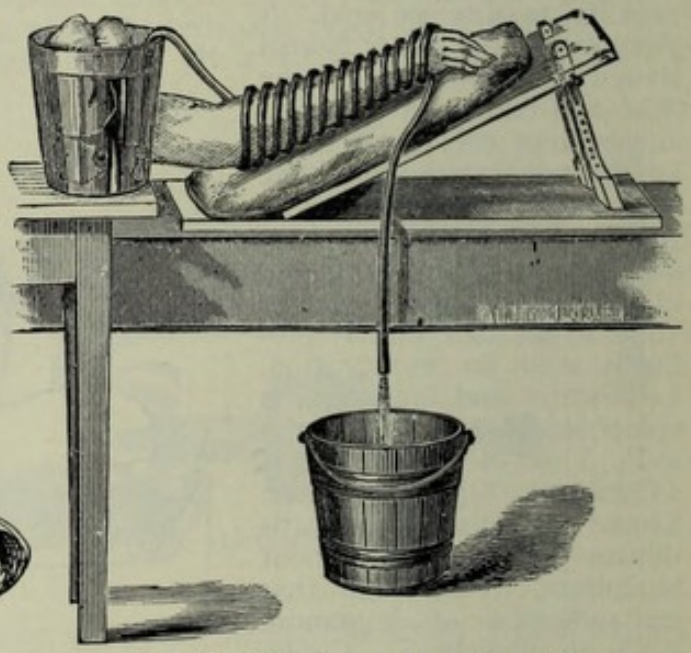


FIG. 11.—The Esmarch cooling coil.

Heat is employed by some early in an inflammation. It is rarely beneficial at this stage, except when applied by a hot-air apparatus for the treatment of an injured joint. It is true that a degree of heat which does not actually destroy the tissues will contract the vessels as does cold; but this degree of heat will not be borne by the patient unless but a limited portion of a superficial part is involved.

Certain agents are suited to the stage of fully developed inflammation, when there is a great deal of swelling due to effusion and cell-proliferation. The indication in this stage is to abate swelling by promoting absorption. This is accomplished by (1) compression; (2) local use of astringents and sorbefacients; (3) the douche; (4) massage; (5) heat.

Compression is especially beneficial in fully developed or in chronic inflammation, but it will do good even in the early stages. Compression is of great usefulness; it

supports the vessels and causes them to drink up effusion, and it strongly rouses the absorbents. This agent is valuable in most external inflammations with marked swelling, and is particularly beneficial in chronic inflammation. In *erysipelas* of an extremity the part should be elevated and the extremity bandaged from the periphery to the body. In *ulcers*, especially those with hard and blue edges, the use of Martin's elastic bandage or of straps of adhesive plaster gives decided relief. In *chronic inflammation of a joint* elastic compression is of great value. In *epididymitis*, after the acute stage, the testicle may be strapped with adhesive plaster. In *lymphadenitis* compression by a weight or by a bandage is very generally employed. In *fractures* compression not only antagonizes spasm, but also combats the swelling and pain of inflammation. Compression must be judicious; it must never be forcible, and it must not be applied to a limb without including the distal portion of the extremity (never, for instance, strongly compress the elbow without including the hand, nor the palm without bandaging the fingers). Injudicious compression causes severe pain and great edema, and may produce gangrene.

Astringents and Sorbefacients.—Astringents may have direct value in inflammation of the skin, but it is not likely that they have any effect on deep-seated inflammation. When used in evaporating lotions in an earlier stage of inflammation the cold does good rather than the drug. Lead-water and laudanum is extensively employed and it is thought to allay somewhat inflammatory pain. The mixture certainly gives comfort in cutaneous erysipelas. It is very doubtful if lead-water is of any service at any stage of a deep-seated inflammation or in any fully developed inflammation. If used after the first stage it must not be applied as an evaporating lotion, because cold will do harm. Pieces of lint are soaked in the fluid and placed upon the part, and a bandage is applied. The wet lint which has been placed upon the part is covered with oiled silk or a rubber-dam before the bandage is applied. If used in the latter manner, the body heat is retained in the part. If greater heat is required, a hot-water bag can be placed outside of the bandage. Lead-water, though germicidal, is seldom used in treating wounds, and hot lead-water should not be applied to an area of cutaneous inflammation, as heat increases congestion and does harm to a cutaneous inflammation.

Saturated watery solution of Epsom salt is of real value in inflammation. It is applied as a wet compress covered with rubber-dam. The compress is moistened every two or three hours and renewed in twenty-four hours, the skin being washed at the time of renewal. In many cases it allays pain and abates swelling. Its use was suggested by Tucker ("Jour. Experimental Med.," May 25, 1907).

Tincture of iodin is astringent, sorbefacient, counterirritant, and germicidal. It must not be used pure. For application to adults it should be diluted with an equal amount of alcohol, and for children with 3 parts of alcohol. In using iodin, paint it upon the part with a camel's-hair brush and fan in order to dry, applying one or more coats. The repeated application of iodin to the skin is of great benefit in inflammation of the glands, muscles, tendons, joints, and periosteum. Iodin is apt, after a time, to vesicate, and must not be used in full strength because it is irritant. It is of special value in chronic inflammation. In deep-seated inflammation it acts as a counterirritant.

Nitrate of silver is a non-irritating astringent of considerable value in inflammation of mucous membranes. It forms a protective coat of coagulated albumin, and is much used in treating the throat, mouth, and genital organs. In urethral inflammation a protein compound of silver known as protargol may be used.

Ichthyol is a drug of decided efficiency in reducing inflammatory swelling. It is usually employed in ointments, the strength being from 25 to 50 per cent. It is best exhibited with lanolin. When rubbed in over inflamed glands, joints, and lymphatic enlargements, it is of great value. In children a 25 per cent., and in adults a 50 per cent., ointment should be rubbed in thoroughly twice a day. In inflammatory skin disease, synovitis, thecitis, frost-bite, bubo, chilblain, and in many other conditions, acute or chronic, the use of ichthyol is indicated. The odor of ichthyol is highly disagreeable, and when ordered for a refined person it had better be deodorized. For this purpose Hare uses oil of citronella, 20 minims to 1 oz. of ointment.

Mercurials.—Blue ointment, pure or diluted to various strengths, is extremely valuable. It is spread upon lint and kept applied over areas of fully developed inflammation. It is especially useful in periostitis and in acutely or chronically inflamed joints, glands, tendons, etc. Blue ointment is strongly irritant, and will soon blister or excoriate a tender skin.

The **douche** consists of a stream of water falling upon a part from a height. The water may be poured from a receptacle or may run through a tube, and may be either

hot or cold. Alternating hot and cold streams are very popular in inflammations of joints and tendons, especially in chronic inflammation. This mode of application is known as the "Scotch douche." It restores the tone of the blood-vessels and plasma-channels and promotes the absorption of inflammatory exudate. If the part is very tender, the water should be squeezed upon it from sponges. In a sprain of a joint, after a time, when thickening has occurred, pour upon the part daily from a height, first a pitcherful of very warm water, then a pitcherful of very cold water; then dry the part and use friction with a hand greased with cosmolin. Hot vaginal douches are generally employed in the pelvic inflammations of women.

Massage is a procedure not employed frequently enough. It is very useful in some acute inflammations, though in these it must be gentle. It is of great service in the treatment of sprains of joints and fractures of bones. It is influential for good in chronic inflammations at the period when rest is abandoned. It acts by promoting the movements of tissue-fluids (blood, lymph, and areolar fluid), stimulating the absorbents, strengthening local nervous control, and thus improving nutrition. Passive motion in joints acts as massage.

Heat may be used continuously or intermittently, and may be either moist or dry. A considerable degree of heat will act like cold and contract the vessels. The degree necessary to cause vascular contraction would not destroy the tissue, but would produce discomfort, which would become unbearable discomfort during the continuance of the application. Therefore, heat is rarely used in the earliest stage of an acute inflammation. It is hard to state exactly when heat should be substituted for cold. Certainly when retardation and stasis are manifest it is to be preferred. Heat should be used when inflammation is not very superficial. In a cutaneous inflammation heat usually does harm, because it increases the congestion of an inflamed superficial part. In deep-seated inflammations heat to the surface acts as a revulsive or counterirritant. Thus a poultice to the chest may do good in the first stage of pneumonia and cauterization of the skin near a joint may benefit an acute synovitis. The use of heat for purposes of counterirritation will be discussed under the head of Counterirritants. A moderate degree of heat applied over a fully developed and not too superficial, inflamed area dilates the vessels, especially the veins, of the skin and superficial tissues. Thus circulation is re-established in an area filled with stagnant blood or blood which is scarcely moving and the inflamed region is drained, fluid exudate is absorbed, tension is lessened, the lymph-spaces and vessels distend, and lymphatic absorption becomes active. The application of heat increases the ameboid activity and the migratory tendency of the leukocytes, phagocytes gather in great numbers and surround an area of infection, and those which have taken up bacteria or tissue débris hurry away. Heat also, in all probability, causes antibodies to escape from the leukocytes and enter the blood-serum. Furthermore, heat favors leukocytosis. Thus, we see, that heat tends to help the building of protective barriers about an area of infection and aids the protective reactions of the body. Heat notably lessens the pain of inflammation. It is often used purely to relieve pain.

The *forms of heat* are: (1) fomentations; (2) poultices; (3) water-bath; (4) dry heat.

Fomentation is the application to the skin of a piece of flannel containing a hot liquid. A basin is warmed and over the top of the basin a towel is placed. A piece of flannel folded in two or three thicknesses is laid upon the towel and boiling water is poured upon it. By twisting the towel the water is squeezed out of the flannel. Great care must be taken to squeeze the water thoroughly out of the flannel, otherwise the skin may be scalded. The hot flannel is laid upon the skin over the disordered part. A rubber-dam larger than the flannel is placed over it, a mass of cotton is laid upon the rubber-dam, and a bandage is applied. The fomentation must be changed within an hour unless a hot-water bag has been placed outside the bandage, in which case it need not be changed for two hours or more. The flannel which is dipped into the hot liquid is known as a "stupe." The turpentine stupe is made by wringing out the flannel as above and then putting upon it from 10 to 20 drops of turpentine. Instead of fomenting the part, steam may be thrown upon it. Fomentations are used chiefly for their reflex influence over deep congestions or inflammations. The liquid of a fomentation may, if desired, contain corrosive sublimate, carbolic acid, or other agents. A fomentation containing an antiseptic is known as an antiseptic fomentation. An *antiseptic fomentation* or, as it is often called, an *antiseptic poultice* is made and applied as follows: Sterile gauze is used instead of flannel, and is laid upon the towel over the basin as previously described. A very warm solution of corrosive sublimate (1 : 1000), of concentrated boric acid solution, or a 2 per cent. solution of acetate of

aluminum, is poured upon the gauze, the material is partly wrung out, placed upon the part, covered with a rubber-dam, and upon it a hot-water bag is placed. Fomentations are very useful in relieving pain in any stage of an inflammation and act also as counterirritants. Fomentations are used in preference to ordinary poultices if there is any probability of a surgical operation becoming necessary, because skin to which an old-fashioned poultice has been applied cannot be satisfactorily sterilized. The antiseptic fomentation is of great service in removing sloughs from foul wounds and ulcers. It is the only form of poultice which is admissible when the skin is broken.

Poultice or Cataplasm.—A poultice is a soft mass applied to a part to bring heat and moisture to bear upon it. Poultices can be made of gound flaxseed, of slippery-elm bark, of arrowroot, starch, bread and milk, potatoes, turnips, etc. The poultice should be placed upon the part and be covered outside with oiled silk, a rubber-dam, or waxed paper. A mass of cotton is applied outside of the rubber and the poultice is held in place by a bandage or binder. It can be kept very warm for a considerable period by placing upon it a bag filled with hot water. If a hot-water bag is not employed, a poultice should be changed every two hours. Spongiopilin, when moistened with hot water, is a good substitute poultice. Lint soaked with hot water and covered with some impermeable material does very well. A poultice containing opium is known as a "sedative" poultice. About 2 gr. of opium to the ounce of poultice-mass may relieve pain. Flaxseed is a vegetable material, adheres to the skin, enters the mouths of glands and follicles, undergoes decay, can be removed only with great difficulty, and is a very objectionable material to use if there is any breach of surface continuity or if it is possible that an incision will be required. The preparation of an antiseptic *poultice* or fomentation is described above. Poultices must not be kept on the part too long, as they will cause vesication, especially in adynamic conditions. If a poultice is causing vesication, remove it and do not replace it, or replace it after sprinkling the part and the poultice with powdered oxid of zinc. If suppuration exists or is seriously threatened, do not waste time by using poultices, but incise at once. Incision may prevent suppuration by relieving tension, affording drainage, and permitting the local use of antiseptics. If pus exists, it cannot be evacuated too soon. To use poultices and delay incision is often productive of irreparable harm. After incision of a purulent focus it is common practice to apply an antiseptic fomentation in order to draw quantities of leukocytes to the part and thus limit the spread of infection and stimulate granulation.

Hot-water Bath.—The immersion of a part in a continuous warm bath is now rarely advised except in burns and cases of phagedena. In such cases it often proves curative. An antiseptic agent may be dissolved in the water. Continuous immersion in a warm bath is regarded favorably by some surgeons for the treatment of sloughing wounds and large purulent areas. The immersion of a part from time to time in water as hot as can be tolerated is useful in fully developed and in chronic inflammation. Such immersion benefits an inflamed joint, lessening the pain, swelling, and stiffness.

Dry heat is applied by a metallic object dipped in hot water and laid upon the part; by Leiter's tubes, through which hot water flows; by the hot-water bag or by the hot-air apparatus. Some practitioners use the hot-water bag in cases of mild appendicitis in order to favor the limitation of the area of infection. The hot-water bag is often soothing and beneficial when laid upon an inflamed joint, or on the perineum or the hypogastric region in cystitis. A bag of hot sand, a hot brick, or a bottle or can of hot water may be used instead of the water-bag. The hot-air apparatus is of very great service in the treatment of chronic inflammation, and particularly of inflamed joints (*vide* dry hot-air apparatus).

Treatment When Suppuration is Threatened.—When suppuration is threatened, ordinarily hot fomentations or antiseptic fomentations must be used, and the part must be kept at rest. As previously explained, the flaxseed poultice is inadmissible. When suppuration is threatened, the use of heat causes the collection of multitudes of leukocytes, which tend to limit the area of infection and destroy bacteria. Even when suppuration is not prevented, heat aids in the rapid breaking down of the diseased tissue at the focus of the inflammation and causes hordes of leukocytes to gather and encompass the suppurating tissue, and these leukocytes prevent the spread of the infection.

In most cases, when suppuration is obviously inevitable or seriously threatened, a *free incision* will be of greatest benefit.

Irritants and Counterirritants in Inflammation.—*Irritants* attract an increased supply of blood to the part whereon they are applied, and are used for their local

effects. *Counterirritants* are used to affect by reflex influence some distant part. In chronic inflammation irritants may do good by promoting the blood-supply, thus favoring the removal of exudates (nitrate of silver for indolent ulcers). Counter-irritants are powerful pain-relievers when used over an inflamed structure; they bring blood to the surface, and are thought by many writers to cause anemia of internal parts, the site and area of anemia depending on the site, the area, and the duration of the surface irritation. Some careful studies seem to suggest that counterirritation produces hyperemia of the superficial part, compensatory anemia of surrounding regions, and anemic edema of the subcutaneous tissue and muscles (W. Wecksberg, "Zeit. f. klin. Med.," Bd. xxxvii, H. 3 u. 4). De Nancrede dissents from the statement that counterirritants cause anemia of internal parts; and he maintains that they irritate deeper parts and cause more external blood to be taken to them. He claims that a blister applied to the chest produces a hyperemic area in the pleura, and refers to Furneaux Jordan's opinion that direct irritation to the surface over a joint adds to synovial hyperemia, and that consequently in joint inflammation counterirritants should be applied above and below a joint, but not directly over it. As a matter of fact, we know clinically that powerful counterirritation directly over an inflamed superficial joint is occasionally followed by an aggravation of the trouble, and that in pericarditis blistering directly over the pericardium may, as pointed out by Sir Lauder Brunton, make the condition worse. Counterirritants not only relieve pain in the earlier stages of inflammation, but they also promote absorption of exudate in the later stages, and are particularly valuable in chronic inflammations. Great benefit is obtained by blistering old thickened ulcers, and by painting the chest with iodin to relieve pleuritic effusion. Frictions, besides their pressure effects, act as counterirritants. Frictions may relieve skin pain, and are associated with the application of stimulating liniments in the treatment of stiff joints. A mustard plaster is a valuable counter-irritant in an acute deeply seated inflammation. Tincture of iodin is extensively used in chronic inflammation.

There is no more efficient non-operative method of relieving pleural effusion than by the application of a succession of blisters. Blisters are also used in the treatment of inflamed joints, pericarditis, pneumonic consolidation of the lung, acute and chronic rheumatism, etc.; and are applied back of the ears or at the nape of the neck in congestive coma or meningitis. A blister can be produced in a few minutes by soaking a bit of lint in chloroform, and after applying it to the surface, covering it with oiled silk or with a watch-glass. Equal parts of lard and ammonia will blister in five minutes. It is easier to blister with cantharidal collodion or blistering paper. Before applying a blister, shave the part if it be hairy; then grease the plaster with olive oil and apply it. Blistering plaster is left in place six hours in the case of an adult, but only two hours in the case of an old person or a child; the plaster is then removed, and if a blister has not formed, the part must be poulticed for a few hours. When a blister is obtained, open it with a needle which has been dipped in boiling water. If the surgeon wishes the blister to heal, it should be covered with a piece of lint smeared with cosmolin or with zinc ointment. If it is to be kept open for a time, cut away the stratum corneum and dress with cosmolin, each ounce of which contains 6 drops of nitric acid.

Pustulation can be effected with tartar-emetic ointment or with Vienna paste. Tartar-emetic ointment was formerly used on the shaven scalp in meningitis. It consists of 1 part of tartar emetic to 5 parts of simple ointment. Vienna paste consists of 5 parts of caustic potash and 6 parts of lime made into a paste with alcohol. It is applied for five minutes, and is then washed off with vinegar.

The actual cautery is the most powerful of counterirritants. It is chiefly used in chronic inflammation of joints, bones, nerves, and the spinal cord. The application is, of course, very painful, and it is best to give an anesthetic before using the cautery. The electric cautery is most convenient. The Paquelin cautery is often used. This is a hollow platinum point which, after being heated in the flame of an alcohol lamp, is kept hot by forcing through it the vapor of gasolene (Fig. 241). The point of a cautery is used at a white heat. One area or several areas may be seared. The cautery is drawn lightly two or three times over each spot we wish to burn. The object is to destroy only the superficial layers of the skin. After the cauterization is completed, lint wet with iced water is applied for several hours to allay pain, and then hot antiseptic fomentations are used until the slough separates.

If the wish is to prevent healing after separation of the slough, dress the sore with cosmolin, each ounce of which contains 6 drops of nitric acid. It is not wise to cauterize deeply directly over a superficial joint.

Constitutional Treatment of Inflammation.—Certain remedies are used in inflammation for their general or constitutional effects; these remedies are: (1) general bleeding; (2) arterial sedatives; (3) cathartics; (4) diaphoretics; (5) diuretics; (6) anodynes; (7) antipyretics; (8) emetics; (9) mercury and iodids; (10) stimulants; (11) tonics.

General Bleeding, Venesection, or Phlebotomy.—Venesection is suited to the early stages of an acute inflammation in a young and robust subject. The indication for its employment is increased arterial tension, as shown by a strong, full, rapid, and incompressible pulse in a vigorous young patient. General blood-letting diminishes blood-pressure and increases the speed of the blood-current, thus amends stasis, causes the absorption of exudate, and the washing of adherent white corpuscles from the vessel wall; furthermore, it reduces the whole amount of body blood and thus forces a greater rapidity of circulation, decreases the amount of fibrin formers, lowers the temperature, arrests cell-proliferation, and stops effusion.

This procedure was in former days so highly esteemed that it settled into a routine formula to be applied to every condition from yellow fever to dislocation. The terrible mortality of the cholera epidemics from 1830 to 1835 led practitioners to question the belief that bleeding was a general panacea, and from this doubt there was born in the next generation violent opposition to blood-letting in any disease. Like most reactions, opposition has gone too far, the pendulum of condemnation has swung beyond the line of truth and sense, and thus a powerful and valuable resource is neglected universally and condemned unsparingly. Many physicians of long experience have never seen a person bled; its performance is not demonstrated in most schools, and few patients and families will permit it to be done; but when properly used it may be very beneficial. It is applicable, however, only to the young, strong, and robust, and not to the old, weak, or feeble. It is used for violent acute inflammations of important organs or tissues, and not for low inflammations or for slight affections of unimportant parts. It is used in the early, but not in the late, stages of an inflammation. It is used when the pulse is frequent, full, hard, and incompressible, but not when it is slow, small, soft, compressible, and irregular. It is used when the face is flushed, but not when it is pallid. It is not used in fat persons, drunkards, very nervous people, or the sufferers from adynamic, septic, or epidemic diseases. It is of value in some few cases of congestion of the lungs, pneumonitis, pleuritis, meningitis, nephritis, prostatitis, cystitis, and other acute inflammatory conditions. It is particularly valuable in any subject when uremia exists, or when there is distention of the right side of the heart. The method of bleeding is described on page 410.

After bleeding the patient should be put on arterial sedatives, diuretics, diaphoretics, anodynes, and, if necessary, purgatives. A favorite mixture of Prof. S. D. Gross was the antimonial and saline, 40 gr. of Epsom salt, 1/10 gr. of tartar emetic, 2 drops of tincture of aconite, and 1 dram of sweet spirits of niter, in enough ginger syrup and water to make ½ oz.; given every four hours.

Arterial Sedatives.—Drugs of this character are of great use before stasis is pronounced; but if used after stasis is established they will increase it. If stasis exists it may be relieved by blood-letting, local or general, and then arterial sedatives can be given. Either local bleeding or venesection abolishes stasis and lowers tension, and arterial sedatives maintain the effect and hold the ground which is gained. The arterial sedatives employed are aconite, veratrum viride, gelsemium, and tartar emetic. These sedatives lessen the force and the frequency of the heart-beats, and thus slow and soften the pulse, and are suited to a robust person with an acute inflammation, but are not suited to a weak individual in an adynamic state.

Aconite is given in small doses, never in large amounts. One drop of the tincture in a little water is given every half hour until its effect is manifest on the pulse, when it may be given every two or three hours. Large doses of aconite produce pronounced depression, and are dangerous. Aconite lowers the temperature, slows the pulse, and produces diaphoresis.

Veratrum viride is a powerful agent to slow the pulse and to lower blood-pressure; it produces moisture of the skin, and often nausea. It is given in 1-drop doses of the tincture every half hour until its physiologic effects are manifested, when the period between doses is extended to two or three hours. Ten drops of laudanum given a quarter of an hour before each dose of veratrum viride will prevent nausea.

Gelsemium is an arterial sedative. It is given in doses of 5 to 10 drops of the tincture every three or four hours.

Tartar emetic lowers arterial tension and lessens the pulse-rate. This drug is not generally employed; if it is used with the greatest care it is no better than some other

agents, and if it is not so used it will cause dangerous depression. The dose is from 1/20 to 1/10 gr., given in water every three hours until the physiologic effects are manifest.

Cathartics.—Purgation is of great value in inflammation. By it putrid material is removed from the intestine, fluid containing poisonous elements is drawn from the blood, and the liability to infection of the tissues is lessened. Purgation is a powerful aid in removing serous effusions and other exudates. The administration of purgatives is, of course, not to be a routine procedure in inflammatory states. The bowels may be acting so freely that no cathartic is required. Treatment in an inflammation should be inaugurated, if constipation exists, by giving a cathartic. The tongue affords important indications as to the necessity for purgation. Castor oil can be given in capsules, or in the froth of beer, or the juice of half a lemon is squeezed into a tumbler, 1 oz. of oil poured in, and the rest of the lemon is squeezed on top, thus making a not unpalatable mixture. Aloin, podophyllum, the salines, and calomel in 3- or 5-gr. doses, followed by a saline, have their advocates. In threatened peritonitis the salines were formerly used by some surgeons, a teaspoonful of Epsom salt and a teaspoonful of Rochelle salt were given hourly until a movement occurred. In this condition, however, purging may prove disastrous. In the course of inflammation, from time to time, if there be constipation, a coated tongue, and foulness of the breath, there should be ordered 1 gr. of calomel with 24 gr. of bicarbonate of sodium, made into twelve powders, one being given every hour; if the bowels are not moved by the time the powders are all taken, a saline should be given. If a violent purgative effect is desired, as in meningitis, croton oil or elaterium may be ordered. If constipation is persistent, give fluidextract of cascara sagrada daily (20 to 40 drops), or a pill at night containing $\frac{1}{4}$ gr. of extract of belladonna, $\frac{1}{4}$ gr. of extract of nux vomica, $\frac{1}{10}$ gr. of aloin, $\frac{1}{4}$ gr. of extract of physostigma, and $\frac{1}{2}$ drop of oil of cajuput. Enemas or clysters may be used in some cases. A very useful enema is composed of 1 fl.oz. of oil of turpentine, $1\frac{1}{2}$ fl.oz. of olive oil, $\frac{1}{2}$ fl.oz. of mucilage of acacia, in 10 fl.oz. of water. Soap and turpentine is very satisfactory. Soapsuds and vinegar in equal parts make a serviceable clyster. A combination of oil of turpentine, castor oil, the yolk of an egg, and water can be used. Asafetida, 30 gr. to the yolk of 1 egg, makes a good enema to abate gas pains in the abdomen. An ounce of alum in 1 quart of water is valuable for the same purpose, and so is an enema of equal parts of milk and New Orleans molasses.

Diaphoretics.—These agents are very useful. A profuse sweat removes much toxic material from the blood and in the beginning of an acute inflammation, such as tonsillitis, may abort the disease. Dover's powder is commonly used, but pilocarpin is preferred by some. Camphor in doses of from 1 to 5 gr. is diaphoretic, and so are antimony and ipecac. Acetate and citrate of ammonium, opium, alcohol, hot drinks, heat to the surface (baths, hot bricks, hot-water bags), serpentaria, and guaiac are diaphoretic agents.

Diuretics are useful in fevers when the urine is scanty and high-colored, and are valuable aids in removing serous effusions and other exudates. Among the diuretics may be mentioned calomel in repeated large doses, cocain, alcohol, infusion of digitalis, the nitrites, squill, turpentine, copaiba, and cantharides. The liquor potassæ and the acetate of potassium are the best agents to increase the solids in the urine. The liquor potassi citratis in doses of 1 to 4 fl.dr. is efficient. Large drafts of water wash out the kidneys. If the heart is weak, citrate of caffein is a good stimulant diuretic, and hot coffee is very serviceable in promoting the secretion of urine. The injection of hot salt solution into the rectum and under the skin favors diuresis, and the intravenous infusion of salt solution is a very powerful diuretic if the kidneys are not seriously damaged (see page 421). The application of heat to the loins promotes the secretion of urine. Sodio-theobromin salicylate (diuretin) is an uncertain but sometimes valuable diuretic, in doses of 10 gr., every two or three hours.

Anodynes and Hypnotics.—Drugs may be required to allay pain or procure sleep. Dover's powder, besides being diaphoretic, is anodyne. Opium acts well after bleeding or purgation. If it causes nausea, it should be preceded one hour by the administration of 30 gr. of bromid of potassium. Opium is given by the mouth or by the rectum. Morphin is given by the mouth or hypodermically. Opium is used when there is pain, but its use is not to be long persisted in if it can be avoided. It is given in doses measured purely by the necessities of the case. If opium disagrees, try the combination of morphin with atropin. After an operation antipyrin or phenacetin will often quiet pain and secure sleep. When a person feels "so tired he can't sleep," alcohol in the form

of whisky or brandy must be given. Sleeplessness not due to pain is met by chloral, trional, veronal, the bromids, chlorotone, chloramid, paraldehyd, or sulphonal. Chloral is dangerous in conditions of weak heart or exhaustion. Bromids must be given in large doses to be efficient. Sulphonal must be given about four or five hours before sleep is expected, in doses of from 10 to 20 gr. in hot milk or hot mint-water. Trional is safe and very satisfactory. It is given in doses of 15 to 25 gr. in hot water.

Antipyretics.—Arterial sedatives, diaphoretics, and purgatives lower temperature, and have previously been alluded to (see page 39). There are two great classes of febrifuges—those which lessen heat production and those which increase heat elimination. In the first group we find quinin, salicylic acid and the salicylates, kairin, alcohol, antimony, aconite, digitalis, cupping, and bleeding. In the second group we find alcohol, nitrous ether, antipyrin, acetanilid, phenacetin, opium, ipecac, cold to the surface, and cold drinks. In surgical inflammations it is rarely necessary to employ heroic means to lower temperature. Quinin is but a feeble antipyretic for non-malarial fevers, and that it shall be one at all requires a dose of 20 gr. or more. Salicylic acid is not advisable unless there is hyperpyrexia or unless the patient has acute rheumatism. If 30 or 40 minims of guaiacol are painted on the skin of the abdomen, it may cause a brief drop in a febrile temperature. After a short period of lowered temperature has been obtained by guaiacol there is commonly a chill and a rapid rise. Cardiac depression may arise after giving an antipyretic, and such an agent as antipyrin is dangerous to the weak and adynamic. In truth, all of the coal-tar derivatives are dangerous when used as antipyretics. As a matter of fact, fever is a condition in which the animal organism is endeavoring to oxidize and render inert certain poisonous materials, and antipyretic drugs lessen oxidation and actually make the patient worse. It is a suggestive fact that bacteria are said to multiply more rapidly when kept at about the normal body temperature than when kept at fever heat (102° F. or more). The mere discomfort of fever may be much mitigated by antipyretic drugs, but the fever process is not benefited by them. No attempt should be made to lower temperature by cold or antipyretic drugs, unless with the high temperature there are the nervous phenomena of hyperpyrexia.

Emetics may do good when the patient suffers from a parched, coated tongue, a dry and hot skin, nausea, and gastric oppression, but it is very rarely in these days that we employ them.

Mercury and the Iodids.—Mercury is an alterative, that is, an agent which favorably affects body nutrition without causing any recognizable change in the fluids or the solids of the body. Mercury lessens blood plasticity, hinders the exudation of liquor sanguinis—thus furnishing less food to the cells in the perivascular tissues—and retards cell-proliferation. Further, by a stimulant action on the absorbents it promotes the breaking up of an existing inflammatory exudation, and hence limits damage from excess of new formation. The time at which mercury is best given is when violent symptoms have abated, the guides being a reduced temperature and a moist skin. Mercury is often given in conjunction with local use of sorbefacients (ichthyol or mercurial ointment). When possible, the administration of mercury is associated with compression of the inflamed part. Mercury is sometimes given until the gums are slightly touched, but it is not given to the point of salivation. When the breath becomes offensive and the gums tender on snapping the teeth, or when griping and diarrhea begin, the dose should be reduced or the drug should be stopped (see Ptyalism). In iritis mercury is used to get rid of the plastic effusion which is causing pupillary fixation and opacity. In keratitis the gums should be touched *slightly*. In orchitis, after the subsidence of the acute symptoms, mercury should be employed. In pericarditis, meningitis, and in many chronic and lingering, and in all syphilitic inflammations, this drug can be used.

Some persons will be salivated by very minute doses of mercury, either because of idiosyncrasy or previous saturation. Others can take enormous doses without any appreciable constitutional effect. The action of mercurials can be favored by a combination with ipecac or with tartar emetic.

In giving mercury, if a prompt effect is desired, give 3 gr. of calomel every three hours until a metallic taste is noted in the mouth. If the case is not so urgent, mercury and chalk (gray powder) is a good combination. Children are given calomel and sugar or mercury and chalk. If it is desired to give the drug for some time, corrosive sublimate is a suitable form, and small doses will actually increase the number of red blood-corpuscles. Corrosive sublimate is to be given alone or combined only with iodid of potassium. The green iodid of mercury is a drug suitable for prolonged ad-

ministration. During a prolonged course of mercury it will often be necessary to give at the same time a little opium to prevent diarrhea and griping. A rapid effect can be obtained by rubbing daily with a gloved hand 1 dr. of the oleate of mercury or ½ dr. of the ointment into the groins, the axillæ, or the inside of the thighs. Suppositories of mercurial ointment induce rapid ptyalism. Hypodermic injections of corrosive sublimate or gray oil, etc., may be used, and must be thrown deeply into the muscles of the buttock or back. Old people, those who are exhausted, anemic, and broken down, and the tuberculous bear mercury badly. If it be given to them at all, it must only be in small amounts and for a brief time.

Alkaline iodids are useful in removing the products of inflammation; they can be given for a long time, and admirably supplement mercurials. Iodid of potassium can be prescribed in combination with corrosive sublimate as follows:

℞. Hydrarg. chlor. corros. ..... gr. ij;
Potass. iodidi ..... ʒv et ℈j;
Syr. sarsaparillæ comp. ..... q. s. ad. fʒviij.—M.
Sig.—Two fluidrams in water, after meals.

Iodid of potassium, well diluted, is given on a full stomach; it is never given concentrated or before meals. A convenient mode of administration is to procure a concentrated solution of the iodid of potassium, remembering that every drop equals about 1 gr. of the drug, and give as many drops as may be desired in half a glass of water after meals. If the medicine causes nausea, add to each dose, after it is put in water, 1 dr. of the aromatic spirit of ammonia. Extract of licorice is a good vehicle for the iodid. If the mixture in water causes nausea, the drug should be given in milk. Capsules are satisfactory, but a drink of water should be taken just before and again just after taking a capsule, to protect the stomach from the concentrated drug. Iodid of sodium may agree when iodid of potassium does not. When the iodids disagree systemically they produce *iodism*. The first indications of iodism are a bad taste in the mouth, running of the eyes and nose and sneezing, followed by a feeling of exhaustion, absolute loss of appetite, nausea, tremor, and skin eruptions (acne, hemorrhages, blebs, hydroa, etc.). If iodism occurs, stop the drug and give the patient Fowler's solution in increasing doses, laxatives, diuretic waters and also nutritious food, and stimulants if depression is great. Sometimes belladonna does good in obstinate cutaneous disorders induced by the iodids.

Remedies Directed Against Special Morbid States.—If inflammation is associated with rheumatism, gout, scurvy, syphilis, tuberculosis, or any other constitutional disease or predisposition, appropriate treatment should be instituted to control the disease or combat the predisposition, and at the same time the area of inflammation should be locally treated. Syphilis is treated by the internal use of mercury and perhaps an occasional injection of salvarsan; in some cases the iodids are also given; scurvy, by fresh vegetable juices; rheumatism, by the alkalis or salicylates; gout, by colchicum or alkalis; tuberculosis, by fats, tonics, and open-air life.

Stimulants.—The chief stimulants used are hot black coffee by the stomach or bowel; hot normal salt solution by the bowel, beneath the skin, or in a vein, alcohol by the mouth or rectum; and strychnin or atropin hypodermatically. The use of *alcoholic stimulants* is called for by conditions rather than by diseases, being indicated by the state of the patient rather than by the name of the malady. For a brief acute inflammation in a robust young person alcohol is not needed; but all who are weak or exhausted, be they young or old, all who are aged, those who are accustomed to alcoholic beverages, those who have high temperatures or failure of circulation, and those who labor under septic inflammations or adynamic processes require alcohol, and it should be given with a free hand. In an acute malady, a feeble, compressible, rapid, or irregular pulse, and great weakness of the first sound of the heart are indications that alcohol is required. Low, muttering delirium is a strong indication for stimulation. There is no *dose* of alcohol for these states; it is given for its effect. Two ounces of brandy or whisky may be needed in a day, or perhaps many ounces. If the breath of the patient smells strongly of the alcohol, he is getting too much. If delirium increases after each dose, alcohol is doing harm. Alcohol is contraindicated in acute meningitis. In acute illness use whisky, brandy, champagne, or alcohol and water. During convalescence, if outside of the borders of the United States, there may be used a little port, claret, or sherry wine, or malt liquor. These agents will promote appetite, digestion, and sleep.

Strychnin is a very valuable stimulant. It can be given by the mouth in doses of 1/30 to 1/20 gr. three times a day, but after a few days seems to lose its stimulant effect.

Atropin is one of the best remedies for exhaustion of the vasomotor system. The dose is 1/100 gr. hypodermically.

Tonics.—The use of tonics is indicated during convalescence from acute and throughout the course of chronic inflammations. There may be used iron, quinin, and strychnin in the form of elixir; iron alone, as in the tincture of the chlorid; quinin in tonic doses (6 to 8 gr. daily); or Fowler's solution of arsenic. An excellent pill consists of—

℞. Acid. arsenos..... gr. j;
Strychnini..... gr. ss;
Quinini..... gr. xlviij;
Ferri reduct..... gr. vj.—M.
Ft. in pil. No. xxiv.
Sig.—One after each meal.

Bitter tonics before meals improve the appetite. One of the best tonics is tincture of nux vomica in gradually increasing doses.

Antiphlogistic Regimen.—This term comprises the necessary directions relating to diet, ventilation, cleanliness, etc.

Diet.—When, in the early stages of an acute inflammation, the patient cannot eat, there must be administered a cathartic before food is given. Nausea is combated by calomel and soda, drop-doses of a 6 per cent. solution of cocain, iced champagne, iced brandy, chloroform-water, hot water, and counterirritation of the epigastric region. Sucking ice may check nausea, but it often makes the patient uncomfortable, because he sucks in air with the melted ice. Sucking ice does not quench thirst. When the process is depressive from the start, and in any case after the earliest stage, feeding is of vital moment. The great tissue waste calls for large quantities of nutritive material, but the impaired digestion demands that the food shall be easily assimilable; hence it is taken in liquid form, small quantities being frequently given. Albumin-water is an agreeable beverage of some nutritive value. Milk contains all the elements required by the body, and is the food of foods. It contains carbohydrates (milk sugar), protein (casein and albumin), fat and mineral salts. Carbohydrate and fat are fuel to furnish body heat and protein repairs and reconstitutes destroyed tissue. If it disagrees, it should be mixed with lime-water, or to each dose an equal amount of Vichy or soda-water may be added. Peptonized milk is a valuable agent. Some people can take boiled milk who cannot take cold unboiled milk. Some patients, however, digest raw better than boiled milk. Peptonized milk has been to a great extent superseded by pancreatinized milk. It is given cold, either alone or mixed with a carbonated water. Koumiss is retained in some cases when the stomach rejects all other foods. This fermented milk is nutritious, stimulant, and very useful. One part of milk, 2 parts of cream, and 2 parts of lime-water make a nutritious and digestible mixture. Milk punch is largely used. Whey may be used when plain milk cannot be taken. Eggs are highly nutritious, but are apt to disturb the stomach; they may be given as egg-nog, or simply soft-boiled, or the yolk can be beaten up in a cup of tea, or raw eggs may be given in sherry or brandy. When considerable nausea exists the yolk of an egg may be added to 1 oz. of lemon-juice and 2 dr. of sugar, the glass filled with carbonated water. Beef-tea is certainly a stimulant, but it is not a food. It contains the excrementitious elements of the beef. It is prepared by cutting up 1 pound of lean beef, adding to it a quart of water, and then simmering, but not boiling, down to a pint, finally filtering and skimming the liquid. The dose is a wineglassful seasoned to taste. Beef juice is nutritious. It is prepared as follows: A thick and tender beefsteak is partly broiled over a hot fire, the outside is browned and the juice is retained within the meat. The steak is cut into pieces to fit a lemon squeezer or meat-press (the instrument having been warmed by previously dipping it in hot water). The juice is expressed into a warmed glass by squeezing and may be given warm, seasoned with salt and pepper. Some patients prefer it frozen. Fresh meat juice may be used plain or pancreatinized. The meat juices obtained in the shops have little nutritive value. Bouillon and beef extracts have slight nutritive value. Meat jellies (calf's foot being the one commonly used) have some though little nutritive value by producing a certain amount of energy which, were they not given, would of necessity be furnished by protein. Hence, meat jelly saves or spares protein (Bauer).

Clam-juice and clam-broth are palatable and slightly nutritious. They are retained in many cases when any other food would be rejected. The broth is to be given hot and the juice either hot or cold. Coffee is a valuable stimulant in febrile conditions. When the stomach entirely rejects food day after day, nutritive enemata are given. There is dispute as to their value, because it is certain that the large intestine does not digest by juices of its own manufacture, and no protein matter can be absorbed without previous digestion. If undigested protein matter is introduced it undergoes putrefaction, causes irritation, and liberates toxins which may be absorbed. It seems equally certain, however, that the large bowel does absorb water as part of its physiologic duty and that it can absorb alcohol, saline fluid, glucose, certain drugs, and perhaps digested albumin and fat. Undigested albumin and fat should never be given by enema. These materials should be pancreatinized before injection or should be mixed with pancreas and then injected, the peptones being formed in the bowel. Nutritive enemata are given at a temperature of 90° to 95° F. They should not be bulky (not over 7 or 8 oz.), because a large enema is usually quickly expelled. They should not be given oftener than three or perhaps four times a day, because too frequent administration irritates the rectum and enemas will not be retained by an irritated rectum. During the period that rectal enemata constitute the method of feeding the rectum should be washed out once a day by a high enema of warm salt solution: this cleansing enema is given one hour before a nutritive enema. A popular enema is Leube's meat and pancreas—3 oz. of pancreas and 8 oz. of meat are rubbed together in a mortar by a pestle, tepid water is added, and the mixture is injected. It undergoes digestion in the large bowel. Bidwell's formula is as follows: 2 oz. of milk, 2 oz. of strong beef-tea, yolk of 1 egg, 1 dr. of pancreatic solution, prepared one hour before using and kept during the interim at a temperature of 100° F. Brandy can be added just before using. Enemata of salt solution greatly relieve thirst. When the sufferer feels able to eat a little, any good soup, strained and skimmed, should be ordered. As the patient gets better he may be fed on scraped meat, broth containing crumbs, tapioca with cream, custard, milk-toast, sweetbreads, chops, oysters, chicken, etc., until he gradually reaches ordinary diet.

The *temperature* should be taken at regular intervals, and the condition of the gastro-intestinal tract should be observed. The *urine* must be examined at intervals, and the daily amount passed must be known. If insufficient urine is being passed, increase the amount of fluid, particularly of water, given by the mouth. If the urine is scanty and the patient is nauseated by drinking-water, give enemata of hot saline fluid or employ hypodermoclysis. The *pulse* and *heart* must be frequently observed, and cardiac weakness must be combated by suitable stimulants. Blood examinations may be necessary.

Ventilation and Cleanliness.—The ventilation of the apartment is of the greatest importance. Every day the windows should be opened widely for a time, the patient, of course, being protected from chilling and kept out of a draft. When the windows are open the air of a room can be quickly changed by swinging the door to and fro. A constant access of fresh air must be secured, and the temperature kept as near as possible to 68° F. If high fever exists, the sick man must be cleaned and be sponged off with alcohol and water every day. It is important that the bed-clothing be clean and that the sheet be unwrinkled, as otherwise bed-sores may form.

Treatment of Chronic Inflammation.—The subject of chronic inflammation has been referred to previously. The local treatment comprises rest, relaxation, elevation, counterirritation, massage, passive movements, the douche, the application of sorbefacients, the use of compression, incision, and, perhaps, certain special methods, as the induction of passive hyperemia by Bier's method, or baking the part in a hot-air oven. The patient should be placed under proper hygienic and climatic conditions; the diet must be judiciously regulated; drugs are given symptomatically or to combat some constitutional tendency or disease (see articles upon Special Regions and Diseases).

Bier's Hyperemic Treatment of Inflammation.—Years ago Laennec asserted that cyanosis was antagonistic to tubercle. Rokitansky emphatically supported the contention that people with marked valvular disease of the heart were seldom attacked by pulmonary tuberculosis. Such lesions, of course, dam back the blood in the lungs. Farre and Travers pointed out the great liability to pulmonary tuberculosis of patients with anemic lungs because of stenosis of the pulmonary artery (Edward Adams, in "N. Y. Med. Jour.," February 26, 1910). The discovery of how to utilize this knowledge in treatment was made by Professor Bier, of Berlin. Bier believes that

hyperemia in inflammation is a reaction on the part of the body; that it is Nature's effort to remove an irritant and to supply increased nutritive material, hence that it is desirable and should not be combated by cold, but should be favored by every means in our power. Bier endeavors to increase the hyperemia of an inflamed region, or to produce hyperemia in an area of disease. He regards hyperemia as beneficial, stasis as harmful; hence he causes or increases hyperemia and combats stasis. Stasis lowers tissue resistance and may cause gangrene. The increase in the amount of moving blood in a part means an increase in the number of phagocytes and the amount of germicidal blood liquor. By the method of treatment recommended by Bier the surgeon induces venous, passive, or obstructive hyperemia by means of an elastic band or a cupping glass, active or arterial hyperemia by means of hot air.

Obstructive Hyperemia by Means of the Elastic Bandage.—The constrictor should be the soft broad bandage of an Esmarch apparatus. Figure 12 shows it applied around the arm. The bandage must not be so tight as to cut off the pulse at the wrist or to cause unpleasant sensations, pain, or very rapid distention of the subcutaneous veins (Meyer and Schmieden). When edematous swelling arises we may be unable to feel the pulse. Then our guide must be the sensations of the patient. If the treatment causes pain or increases existing pain, at once discontinue it (Waterhouse, "Brit. Med. Jour.," Dec. 16, 1911). The part below the band should become bluish red and warm, but never white under the influence of the constriction. When the bandage is in place an area of inflammation shows an increase of redness, heat and swelling, and a diminution of pain. If pain was not present before, the bandage must not produce it. Should it do so it is too tight. In chronic conditions the bandage is usually employed daily and for two, three, or four hours at a séance. When used for three hours or longer temporary edema may arise. In acute cases it is used for twelve, fifteen, or twenty hours a day. Prolonged application may make the skin sore unless a flannel bandage is applied before the band is used, unless the site of application is shifted daily, and unless the skin during each intermission is well rubbed with alcohol. The bandage is always applied well above the inflamed region, and that region is exposed free from dressings in order that its condition during treatment may be observed. If edema occurs, the band must be removed and the edema relieved by elevation and massage. If the inflammation is accompanied by marked edema, incisions are required. Treatment by the bandage may prevent pus formation. If pus forms it must, of course, be evacuated.

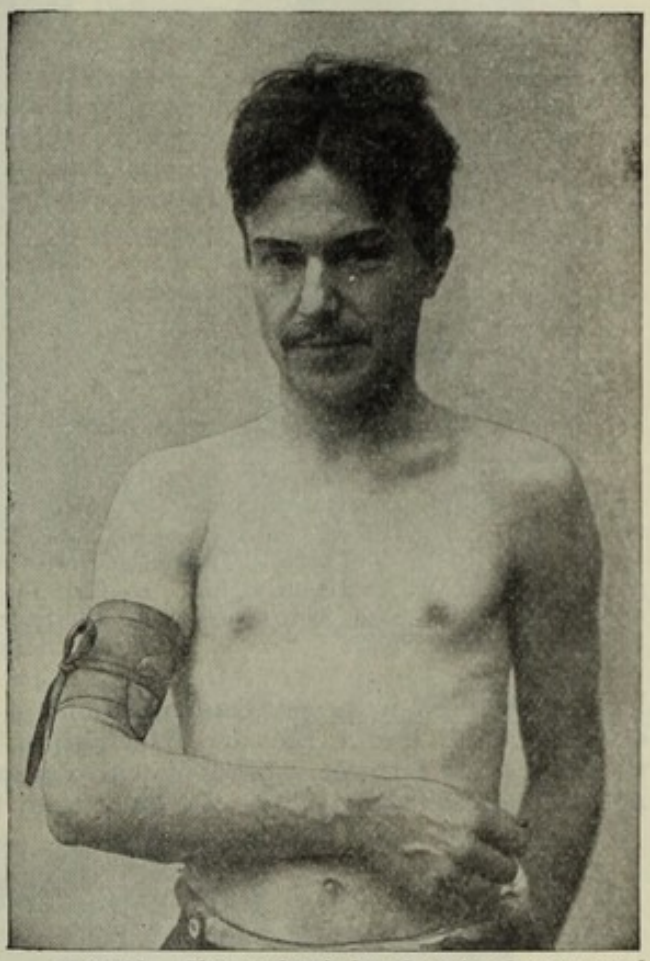


FIG. 12.—Shows elastic bandage in place around the arm, its ends tied with tapes which are attached to the bandage. This is the style of bandage usually found upon the market. If the bandage is to remain on for a number of hours, it is advisable to apply a strip of adhesive plaster, to guard against the tapes becoming undone. Note the engorgement of the subcutaneous veins of the forearm, showing the effect it is desired to produce by the bandage (Meyer and Schmieden).

Obstructive Hyperemia by Means of the Cupping Glass.—Endeavor to make the skin bluish red, but not white. Cupping glasses are used not only to treat areas of inflammation, but to aid in emptying sinuses and abscesses which have ruptured or have been incised. Figures 13 to 16 show cupping glasses.

I am satisfied from personal experience that Bier's method of treatment is of decided

value in some acute inflammations as well as in chronic inflammation, and that it is not used as often as it should be. I have used it with success in several cases of ununited fracture. It is an improvement on the method of Thomas, of Liverpool, for inducing hyperemia about the ends of the fragments. He did it by repeated percussion with a mallet. Barker has warmly advocated Bier's treatment for ununited fracture. I

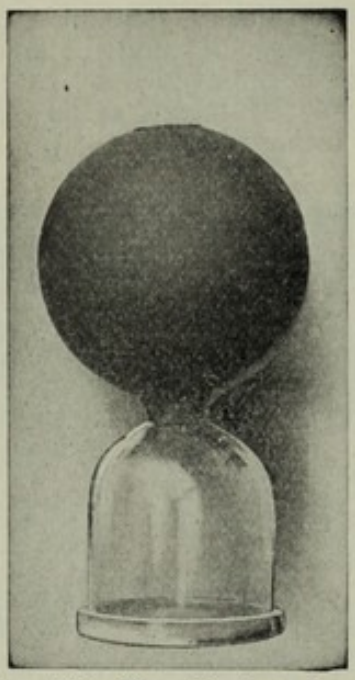


FIG. 13.—The simplest form of suction glass. The rubber bulb is attached directly to the glass. This glass is used in the treatment of furuncles of smaller size and sinuses (Meyer and Schmieden).

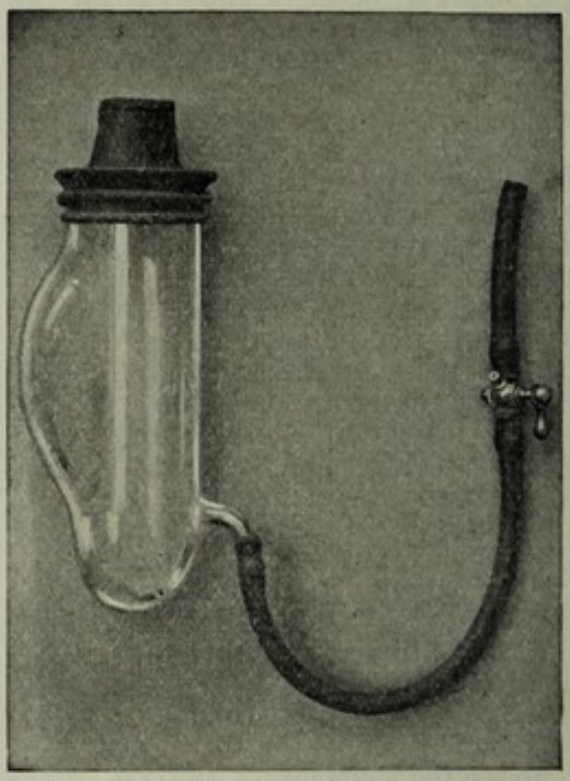


FIG. 14.—Illustrating an ordinary suction apparatus for the finger (felon, etc.) with a convexity at the lower surface, designed to receive the pus (Meyer and Schmieden).

have never used it for purulent affections of large joints, a condition in which Bier claims it highly useful (Bier and Baetzner, in "Practitioner," Jan., 1912). He empties the joint with a trocar, washes it with carbolic solution, puts on dressing, but does not immobilize. Bier retains the band from twenty to twenty-two hours a day. As

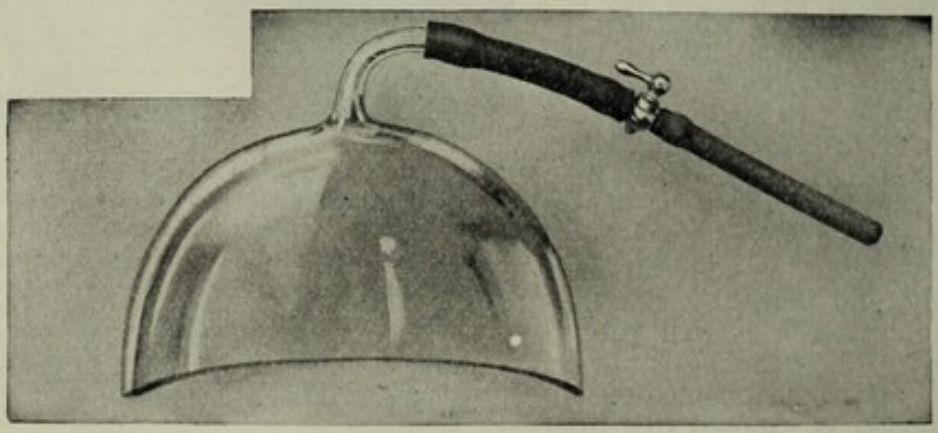


FIG. 15.—Shows glass of simpler configuration; a rubber tube connects glass with bulb; the same can be readily detached, thus rendering easy the sterilization of the glass by boiling. In the tube a three-way stop-cock is inserted. This cup is used for treating furuncles of larger dimensions, etc. (Meyer and Schmieden).

soon as acute symptoms subside he uses hot air. The reduction of the daily period of hyperemia is brought about gradually before substituting hot air. I have seen very gratifying results from the Bier treatment of gonorrheal joints. I believe that this treatment gives the best chance of cure without deformity and with retained function. It is valuable for joint tuberculosis, although very numerous brief applications are

necessary. It is beneficial for thecitis, areas of suppuration after incision, and chilblains. Waterhouse suggests its use to prevent suppuration in a crushed limb. The treatment is contraindicated in spreading inflammation—for instance, erysipelas.

Bier claims that arterial hyperemia induced by hot air is particularly useful in chronic inflammation, as it favors the absorption of exudates and of adhesions. It will hasten the separation of sequestra. Venous hyperemia produced by the elastic band or the cupping glass is claimed to be of great value in infections. It may abolish the infection, prevent suppuration, and hasten the process to a conclusion. It does certainly lessen pain and favor absorption. The elastic band may be used upon an extremity, a testicle, the scrotum, and the head. In other regions cupping glasses are used, a partial vacuum being established in the glass by means of a pump or a rubber bulb.

Sir Almroth Wright's Views Upon Inflammation and Its Treatment.—Wright maintains that a free supply of blood and lymph is necessary for repair, that both the blood and lymph should contain a sufficiency of protective materials, and that it is essential that numerous active leukocytes enter the area of disease.

When there is a large serous effusion and few leukocytes, a condition met with often in tuberculous pleurisy, repair does not take place.

In abscess the leukocytes are dead and the material obtained from dead leukocytes retards healing. If the fluid exudate does not contain protective material the process extends.

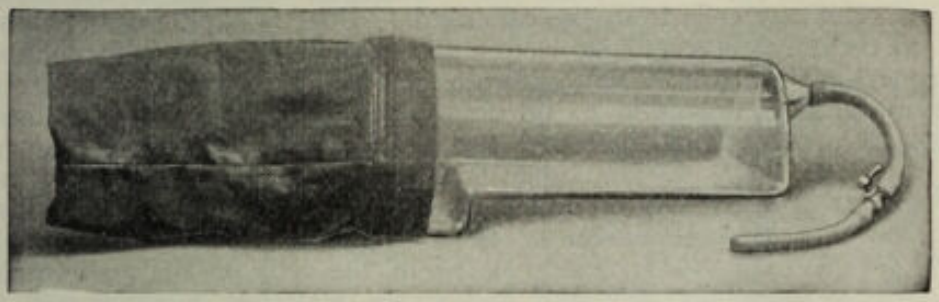


FIG. 16.—Constructed for the treatment of the hand. A soft-rubber band wound around the cuff makes it fit air-tight around the arm (Meyer and Schmieden).

Repair is retarded by induration, or by the formation of a fistula or a sinus.

If there is a small amount of fluid exudate, there is little protective substance thrown into the inflamed part and repair is retarded.

If there be a large effusion and few leukocytes, cure is favored by removing the fluid. This is done in abscess and in serous effusion. If there is too little lymph in the part salt solution and citric acid should be used locally, and citric acid should be administered internally. The administration of proper bacterial vaccines will increase the protective qualities of the lymph. (See Wright, "The Pathology of Inflammation," and the résumé of his views in "Progressive Medicine," Sept. 1, 1908, p. 31.)

II. REPAIR

A damaged tissue reacts to the injury and Nature attempts to effect repair. It is held by many that inflammation is a destructive process and repair is a constructive process; that repair is constantly effected in an aseptic wound without many of the evidences of inflammation; that repair does not proceed from inflammation, but is retarded or prevented if inflammation occurs. As before stated, we agree with Adami, that inflammation is reaction to injury and the effort of Nature to repair the injury. As Adami points out, the attempt to repair may fail, the reaction to injury being excessive or not powerful enough; but even should the attempt fail, the conservative intention exists. "What is the development of cicatrical tissue but an attempt at repair? What other meaning can be ascribed to the increased bactericidal power of the inflammatory exudate as compared with that of ordinary lymph and blood-serum? Why do leukocytes accumulate in a region of injury? Why do some of them incorporate bacteria and irritant particles, and others bring about the destruction of these without necessarily ingesting them? All these are means whereby irritants are antagonized or removed, and reparation and return to the normal sought after."[1]

Repair is favored by good general health, asepsis of the wound, coaptation of

[1] Adami, in Allbutt's "System of Medicine."

wound edges, and rest. It is retarded or prevented by infection, gaping of the wound, frequent or forcible motion, and impairment of the general health.

Albuminuria and *diabetes* particularly obstruct repair. R. T. Morris points out that sugar in the blood is hygroscopic, removes water from the tissues, and thus obstructs repair; and also that the wound fluids contain sugar and are good culture-media ("Med. News," June 29, 1901).

Healing by First Intention.—A wound may "heal by first intention." This mode of healing, which is known as "primary union," occurs without suppuration, and is observed in the healing of an aseptic wound. If infection occurs, primary union will not take place. The phrase "by first intention" comes down to us from the past. It was properly thought that Nature intends to repair a wound, and first intention signifies the first, the best, the most desirable way in which it can be accomplished. In a small aseptic incision, in which no considerable vessels are cut, repair will take place very rapidly after the edges have been approximated and the wound dressed. In fact, the wound edges may be held firmly together in twenty-four hours. In such a wound a small amount of blood flows from the capillaries between the edges of the wound, and this blood clots. A trivial amount of exudate and some few migrated corpuscles pass into the clot and into the tissues. The fixed connective-tissue cells and the endothelial cells of the vessels multiply, and form embryonic or juvenile tissue. The cells are epithelioid cells and are known as fibroblasts. The fibroblasts eat up many of the leukocytes and multiply, so that the new cells from one side of the wound finally interlace with the new cells from the other side. Nearby capillaries become irregular in outline; at certain points bulging occurs, and at these points new capillaries develop, extend into the mass of fibroblasts, and join new capillaries of the opposite side. The reparative material is now said to be organized; it has become granulation tissue. The fibroblasts become spindle shaped and develop into interlacing fibers (Fig. 17).

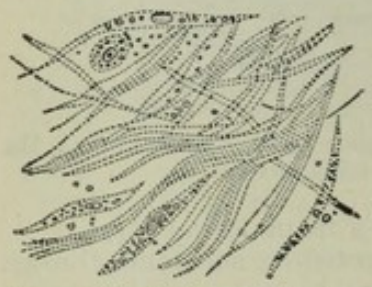


FIG. 17.—Cells developing into fibers (Bennett).

The tissue is now fibrous tissue; it contracts strongly, and finally most of the capillaries are obliterated by pressure. In a slight wound the reaction to injury is chiefly noted in the cells of the part, and the vessels and leukocytes play but a small part in repair. The exudation is so scanty that there is practically no swelling unless it arises from venous obstruction. The vessels are so slightly affected that there is no redness. The final step in healing is contraction of the fibrous tissue and the covering of the surface with epithelium, which springs from the epithelial cells upon the edges. This final process is called "*cicatrization*," and consists in the formation from fibroblasts of new fibrous tissue and the contraction of the new tissue. The "immediate union" of some writers never occurs. This term means the union of microscopic parts to their counterparts without any effort at repair. A first union is effected always by clotted blood and coagulated exudate, next by proliferating cells, and finally by fibrous tissue. A wound healing by first intention exhibits no evidence of inflammation. There is some slight tenderness, but no actual pain. A certain amount of swelling arises because of exudation of fluid from the blood, and the coagulation of this fluid makes the wound edges hard. Venous obstruction leads in some cases to a considerable fluid swelling. A wound may heal by first intention even though some bacteria are present, if the part has a good blood-supply and the patient is in good health. Active leukocytes and germicidal blood liquor may prevent infection. In a more extensive incised wound many vessels are cut. After oozing ceases the vessels are closed by clots continuous with the clot between the sides of the wound. An exudation of plasma from the blood-vessels and of lymph from the lymph-spaces takes place. Leukocytes in great numbers invade the wound edges and the exudate, and the exudate clots. Thus, an infection may be surrounded and limited. This mass of blood-clot, plasma-clot, and leukocytes used to be known as "coagulable lymph." The leukocytes actively eat up the clot, and by the end of the third day occupy the space formerly occupied by the clot. Embryonic tissue is formed by multiplication of the fixed connective-tissue cells and endothelial cells. These cells are called fibroblasts. They multiply and grow into the mass of leukocytes, eating up many of the leukocytes, and finally join the fibroblasts of the other side of the wound. Some leukocytes enter into the lymph-spaces. New capillaries form from the capillaries at the wound margins. By the end of the first week the fibroblasts begin to assume various outlines, sending out poles or branches

or becoming spindle shaped. These spindle-shaped cells become fibers, and the fibers of the new tissue interlace and strongly contract. Thus the edges are pulled firmly together. Finally, new epithelium, derived from epithelium at the wound edges, forms and grows over the wound (Figs. 18–20). In order to obtain primary union the surgeon ought to cleanse the wound, and all his procedures must be thoroughly aseptic and bleeding should be carefully arrested. The parts are then accurately coaptated by sutures, aseptic or antiseptic dressings are applied, and special care is taken to secure *rest*. In a large wound special methods to secure drainage are required. In a small wound the spaces between the stitches give exit to the trivial quantity of wound fluid. The use of irritant germicides in a wound greatly increases the amount of discharge and renders necessary the introduction of material for drainage. Even a comparatively small wound so treated requires drainage for the first twenty-four hours. During the first twenty-four hours after a large wound begins to heal by first intention the discharge of bloody serum is most plentiful, but after this period it becomes very scanty and soon ceases entirely, and can be much diminished in quantity on the first day by the application of pressure. Warren says that after a hip-joint amputation over a pint of bloody serum flows out during the first twenty-four hours. In an aseptic wound, as a rule, one-half of the stitches are removed on the sixth or seventh day and the remainder on the eighth day, but for two weeks more the wound should be rested and supported, as the new tissue is not very resistant to infection. *Aseptic fever* always arises when much exudation is poured out and is slowly and imperfectly drained. Aseptic fever is due to the absorption of aseptic pyrogenous material (see page 59). If an incised wound becomes infected, the pyogenic organisms, by liquefying the intercellular substance, destroy the bond of union which is forming between the wound edges. As a consequence, the wound edges are soon widely separated by pus.

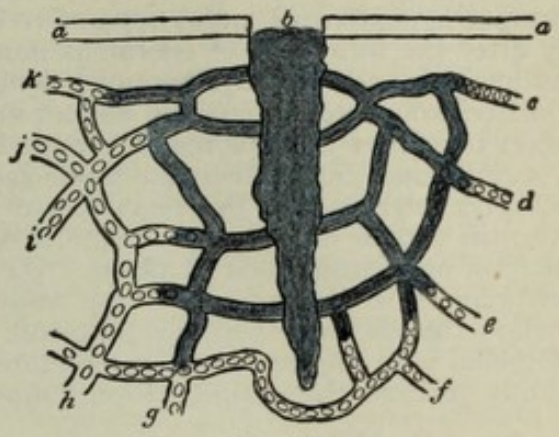


FIG. 18.

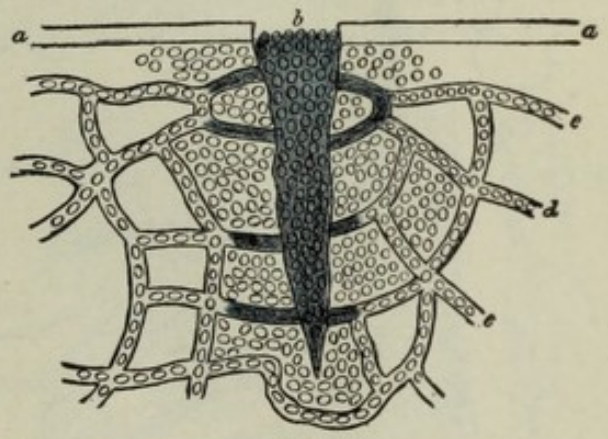


FIG. 19.

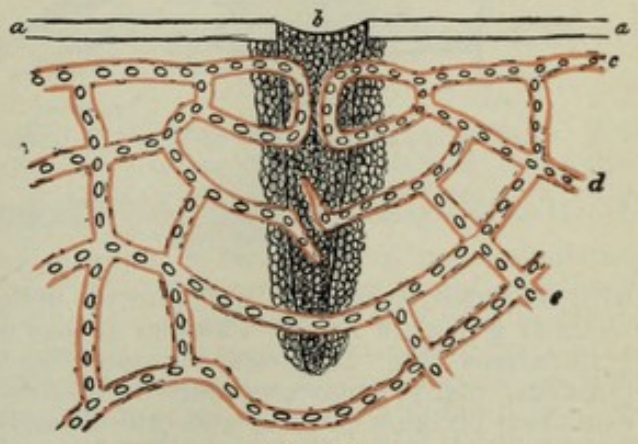


FIG. 20.

FIGS. 18–20.—Healing by first intention: *a*, Skin; *b*, fibroblasts; *c*, *d*, *e*, capillaries. Fig. 18, Clot in the vessels continuous with clot between the edges of the wound. Fig. 19, Migration of leukocytes into the perivascular tissues and into the clot between the edges of the wound. Fig. 20, Formation of new capillaries (after Pick).

What used to be known as "*healing by blood-clot*" is healing by first intention. If there is a considerable gap between the edges of an aseptic wound, and the gap is filled with a blood-clot, healing goes on in the same manner as when the gap is narrow, although more corpuscles, more exudate, and more fibroblasts are required to effect repair.

Healing by Second Intention.—Healing of a wound in which there is a large cavity in the tissue or in which the edges have gaped apart is known as healing by

granulation, or "healing by second intention." It is called healing by granulation because the granulations (areas of vascularized embryonic tissue) are visible. It is effected in the same manner as "healing by first intention," the processes in the two cases being practically identical if pus is absent. As a matter of fact, in healing by granulation there is usually wound infection. As a result of infection intercellular substance is peptonized, many reparative cells are cast off, and repair can be effected only after the formation of enormous numbers of fibroblasts and the expenditure of considerable time. It requires much longer for an infected wound to heal than for an incised wound to be repaired, and an infected wound can heal by granulation only. A short time after the infliction of a wound the oozing ceases, because thrombi form in the vessels and clot gathers in tissue-gaps and interstices. Exudation begins and leukocytes migrate into the exudate and into the walls of the wound. In an hour or two the surface of the wound becomes distinctly glazed or glistening, because of the formation and coagulation of fibrin. The exudation is at first thin and red, and it soon becomes so profuse as to wash away the discolored fibrin coat. Usually, in a few days the discharge becomes purulent. The connective-tissue cells, especially the endothelial cells of the vessels, proliferate and form fibroblasts, and the fibroblasts multiply to close the wound. From adjacent capillaries new capillaries form. This formation takes place as follows: A portion of a capillary thickens and a whip-like process comes off from the thickened part. This process fuses with a second filament budded from another or from the same capillary, or runs straight out as a terminal vessel. The filaments after a time are hollowed out from within, protoplasmic tubes are formed, and endothelial cells develop from the protoplasm. In some cases a tubular prolongation comes off from a capillary directly. Figures 20 and 21 show the formation of a capillary. In a wound healing by granulation these newly formed capillaries run among the fibroblasts, and some of them run perpendicularly to the surface, or a loop forms and reaches the surface. The surface of a granulating wound is covered with migrated leukocytes, and directly under these are fibroblasts covering the new vascular strings or loops. Vascular strings or loops coated with fibroblasts are called granulations (Fig. 22 shows a granulating surface). When the discharge becomes purulent, many leukocytes and fibroblasts are destroyed, inflammation increases, exudation becomes profuse, and cellular multiplication wide-spread and rapid in order to make up for the cells lost by microbic action. Gradually the gap is filled. As it is being filled the older fibroblasts in the deeper layers of the edges and base of the wound are converted into *cicatricial, fibrous*, or *scar tissue* (Fig. 23). As the granulations rise to a higher level at the surface the area of fibrous tissue becomes broader at the base and margins, and this young fibrous tissue contracts. By contracting it draws the edges of the wound into closer approximation, and thus lessens the area of the surface which must be covered with epithelium. When the granulations reach the level of the cutaneous surface the epithelial cells at the margin of the wound proliferate, and young epithelial cells, constituting a bluish or opalescent film, grow over the granulations. Epithelium comes only from epithelium. Granulations are never converted into epithelium. The epithelial covering comes only from the epithelium at the wound margins, unless there be epithelial remains in the wound; for instance, an undestroyed papilla, sweat-duct, or hair-follicle. The process of covering the surface with epithe-

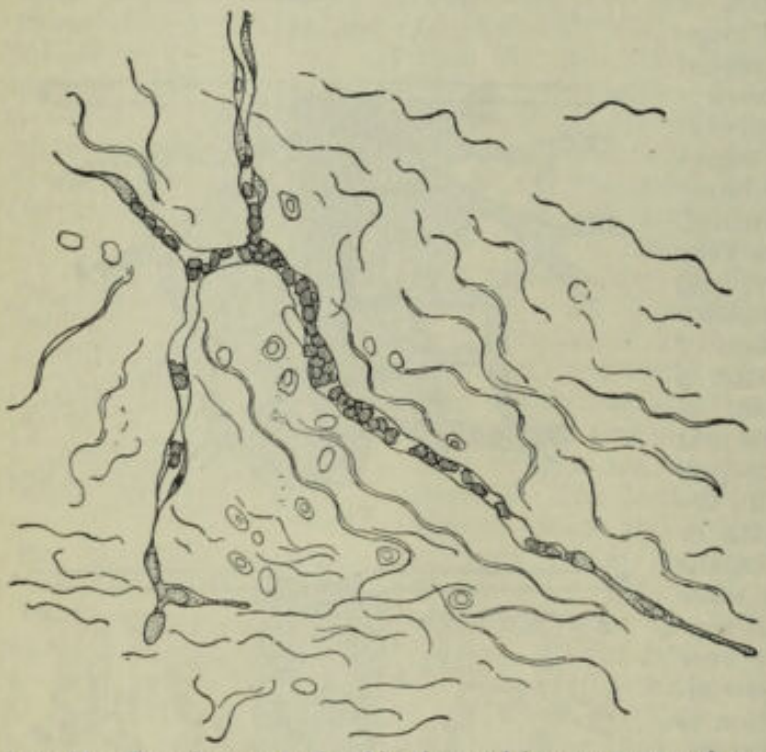


FIG. 21.—Development of a blood-vessel in mesentery of an embryo (Warren).

lium is known as *epidermization*. The epidermization of a large area always consumes considerable time and sometimes Nature fails to accomplish it. In such cases skin-grafting is employed (*q. v.*). Before, during, and for a time after epidermization the fibrous tissue of the walls and base of the wound contracts. Thus the wound margins are pulled and held nearer together, the gap to be bridged is diminished in size, the danger of tearing apart of the epithelial layer is lessened, many capillaries are destroyed by pressure, and the scar becomes firm, white, and puckered. *Cicatrization* consists in the conversion of immature connective tissue into mature fibrous tissue and in the contraction of the new fibrous tissue. The rate of cicatrization is more rapid early in repair than it is later in the process. Carrel says the rate is even more dependent upon the area of the wound than upon its age (Carrel and Hartmann in "Jour. of Exper. Med.," 1916, xxiv). The larger the wound the more rapid the cicatrization. It is sought by these experimenters and others (Du Nouy, "Jour. Exper. Med.," 1916, xxiv) to measure accurately wounds in order to obtain a mathematical formula as to the time for ideal healing of a given wound. Cicatrization is hurried in a healthy granulating wound by the application of an 8 per cent. ointment of scarlet red. The red is kept in place only twenty-four hours. To keep it longer would irritate the wound edges. If infection is severe, destruction will exceed repair and healing will not occur. In such a case there is coagulation necrosis of granulation tissue, and the wound becomes covered with tissue remains (*aplastic lymph*). If granulations rise above the cutaneous level, healing will not take place, because the epithelium cannot then grow over the raw surface. A wound in this condition is said to possess *exuberant granulations*, or *proud flesh*. In some cases the granulations are *pale* from insufficient blood-supply, and in others *edematous* from venous congestion. Contraction of the fibrous tissue may be insufficient because there is adhesion to deep unyielding fascia or to periosteum. Excessive contraction is frequent after burns and often produces terrible deformity. The scars or cicatrices of burns contain much elastic tissue derived from cell protoplasm. Infected wounds and ulcers heal by second intention.



FIG. 22.—Blood-vessels in granulation (Gross).

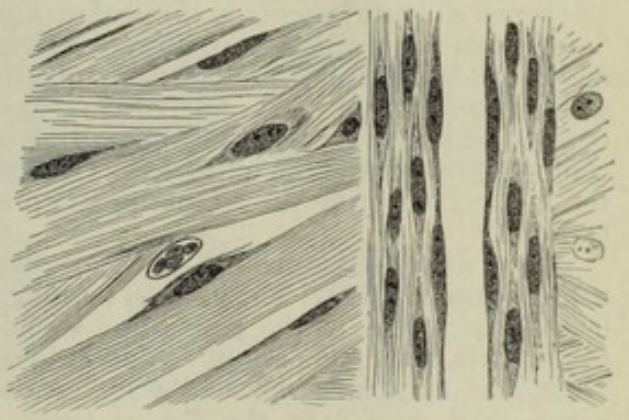


FIG. 23.—Cicatricial tissue; × 670 (Fowler).

Healing by Third Intention.—This consists in the union of two granulating surfaces, the granulations of one side fusing with the granulations of the other side. It is seen in the union of collapsed abscess walls. The surgeon may seek to obtain union of a wound several days old by third intention by approximating two granulating surfaces. If the surfaces are aseptic, he will often succeed. Wounds may be rendered aseptic preparatory to secondary suturing by the use of Dakin's fluid (page 228). The procedure of approximation is known as *secondary suturing*. It is not unusual to pack a wound with iodoform gauze to control oozing. When this is done it is customary to pass the sutures, but not to tie them. After a few days the gauze is removed and the sutures are tied. This plan renders healing much more rapid than would be possible by the process of healing by second intention.

Cicatrices, or Scars.—The newly formed connective tissue which constitutes a scar will be present in large amount if more granulations were formed than were really necessary for repair or if a considerable defect was repaired.

A recent scar contains fibrous tissue, many fibroblasts, and numerous blood-vessels, but no nerves, lymphatics, or elastic fibers. The skin above recent scars is usually red because of the numerous vessels beneath it and the layer of epidermis is well developed. In old scars fibroblasts have disappeared and fibrous tissue really constitutes the cicatrix. Some blood-vessels disappear and the diameters of those

remaining are much reduced. These vascular changes result from contraction of the cicatrix. Delicate elastic fibers appear in old scars. They appear at the end of the second month in wounds healed by first intention, at the end of the third or fourth month in wounds healed by second intention, and they take origin directly from cell protoplasm and not from fibrous tissue (Minervini, in "Virchow's Archiv," vol. clxxv, No. 2). No genuine lymphatics exist in old scars, but occasionally nerve filaments are present. Some dermal papillæ are found after a time, but skin glands, skin muscle, and hair-follicles remain absent.

An old scar is smooth, whiter than the surrounding skin, somewhat creased or wrinkled and deficient in tactile sense. The scar of a healed tuberculous ulcer is irregular, livid, and often actually corrugated. The scar of a healed syphilitic ulcer is at first coppery red and then glistening white and depressed. The scar of an old ulcer of the leg and of the skin about it is often darkened by pigmentation.

A cicatrix may be discolored by retained foreign bodies, for instance, grains of gunpowder.

During scar formation shreds of epidermis may be displaced and included in granulation tissue. Subsequently they are included in fibrous tissue, and may then give rise to transplantation (*implantation*) dermoids or to epithelial tumors (see page 324). A scar may be deformed, for instance, may be greatly depressed and adherent to underlying bone, and in certain situations such a scar will fix the jaws or any other joint. The *vicious cicatrix* is a great excess of scar tissue and results from delayed healing by second intention. Such cicatrices are particularly common after burns and tuberculous ulcerations. In some cases the scar is irregular and lumpy, in other cases it is thickened at certain parts and discolored and resembles keloid.

A cicatrix may block a natural orifice, as the mouth or nostril; may produce great deformity, for instance, the head may be drawn upon the chest or shoulder by a contracting scar in the neck, fingers may have grown together after a burn, a hideous depression may exist on the forehead after an injury, or the face may be fearfully contorted by contracting cicatrices. A scar may produce great disability by blocking the jaws, obstructing the rectum or urethra, or fixing a joint or certain muscles of an extremity.

Most scars are insensitive, some are hypersensitive. The hypersensitive scars are usually thin and pale. The itching, burning, or tingling appreciated in a sensitive scar is located, as a rule, at the junction of sound skin and newly formed epidermis. Some times acute neuralgic pain in and about a scar is due to pressure upon nerve filaments.

A scar may inflame or ulcerate, warts may spring from its cutaneous surface, keloid may arise from the fibrous tissue, carcinoma may come from the epithelial elements (Marjolin's ulcer), sarcoma from the connective-tissue elements.

Healing of Subcutaneous Wounds.—Blood fills the tissue gap and the blood clots. Plasma exudes and corpuscles migrate into the clot and the tissue about it. The clot is eaten up by the leukocytes. The connective-tissue cells and the endothelial cells of the adjacent tissue proliferate and form fibroblasts, and fibroblasts multiply and replace the clot. The area of fibroblasts is vascularized by the formation of new capillaries, fibrous tissue forms and strongly contracts.

Healing of Wounds in the Non-vascular Tissues.—After a trivial injury of the cornea a few leukocytes gather from the lymph-spaces and a few of the fixed cells proliferate. When the cornea is more severely wounded, an increased flow of lymph occurs. The nerves are irritated, vessels adjacent to the cornea distend, and many leukocytes invade the lymph-spaces. The corneal corpuscles multiply and alter in shape. The product of the process may be transparent if fibrin is absorbed and leukocytes pass away, because proliferating corneal corpuscles form transparent tissue. The surface epithelium is replaced by proliferation of the deep layer of corneal epithelium. If the wound has penetrated the posterior portion of the cornea, it becomes filled by proliferating epithelium from the membrane of Descemet. In a severe injury of the cornea endothelial cells and corneal corpuscles proliferate, vessels grow in from the corneal margins toward the seat of inflammation, fibrous tissue forms, and permanent opacity results.

Repair in cartilage, when it occurs at all, is very slow and is accomplished in the same way as repair in the cornea. Any severe injury is repaired by white fibrous tissue, furnished by the cells of the perichondrium, and the scar is permanent.

Cell-division.—The multiplication of connective-tissue cells in repair may be by direct, but usually is by indirect, cell-division. *Direct cell-division* consists in division of the nucleus followed by division of the entire cell.

Indirect cell-division, or *karyokinesis*, takes place after remarkable changes in the nucleus. The membrane of the nucleus disappears; the nuclear net-work becomes first close and then more open; and the cell becomes round, if not so before. The network of the nucleus, now consisting of one long fiber, takes the shape of a rosette; next it takes a star form—the aster stage; two V's next form—the equatorial stage; an equatorial line appears and widens, and each one of the V's retreats toward a pole. Thus two new nuclei are formed, each polar V passing in inverse order through the previous changes of shape, and protoplasm of the original cell collecting about each nucleus (Fig. 24).

Repair of Nerves.—A nerve-fiber consists of a core known as the axis-cylinder, which is the essential element in function. About the axis-cylinder is an almost liquid material, known as the medullary sheath or white substance of Schwann, or myelin. The myelin is surrounded by a firm sheath known as the neurilemma (sheath of Schwann, primitive sheath, neurilemma). On the inner surface of the sheath of Schwann, or between it and the white substance of Schwann, are nuclei which are supposed by some to be peripheral nerve-cells (neuroblasts). The neurilemma is absent in the brain and cord. The continuity of the white substance of Schwann is interrupted at frequent intervals, and these breaks in the myelin are called nodes of Ranvier. Numbers of fibers of the kind just described, bound in bundles by connective tissue and surrounded by a fibrous sheath, constitute a nerve. It is known that a nerve may regenerate and completely regain function after division; that regeneration is strongly favored by suturing the ends together; and that if the ends of a divided nerve are more than 1 inch apart, regeneration will rarely take place unless they are sutured together. The method by which regeneration is effected has been much disputed and is still involved in uncertainty. If a nerve is divided, the peripheral segment at once loses its function and then undergoes degeneration (wallerian degeneration). The degeneration begins within twenty-four to forty-eight hours and affects the entire peripheral segment. The axis-cylinder perishes, the myelin runs into globules and is absorbed, leaving an almost empty sheath; the nuclei of the inner surface of the neurilemma proliferate for a time, but cease to do so before the myelin is completely absorbed. The sheath shrinks and looks empty, but here and there are collected masses of proliferated nuclei and protoplasm. Degeneration takes place in days, but regeneration requires months. Regeneration takes place by the multiplication of pre-existing nerve-fibers, and not by the transformation of connective tissue into nerve structure. The ends of a divided nerve, it is true, become united by connective tissue formed by the proliferation of fibroblasts, but this connective tissue is only a bridge to carry nerve elements across the gap between the proximal and peripheral segments. The common view is that regeneration takes place as follows: The new axis-cylinder of the peripheral segment is a prolongation of the old axis-cylinder of the proximal segment, projected in the following manner: A fiber, which is at first devoid of myelin, is prolonged from a proximal axis-cylinder; it divides into many cylinders, which pierce the granulation tissue between the separated ends and enter into the empty sheaths of Schwann of the distal segment or insinuate themselves between these sheaths (Ranvier, Réclus, Senn). Verga (quoted in "Journal de Chirurgie," April, 1910) opposes the notion that the peripheral end plays any part in regeneration and advocates the view that all regeneration comes from the central end. The above is the view entertained by those who teach that the new axis-cylinders come entirely and only from the prolongation of old axis-cylinders of the proximal segment, that the distal segment is passive in the process until "neurotised" (Vanlair), and that regeneration is impossible in the distal segment unless it is in approximation with the proximal segment or within easy reach of the prolongations of the axis-cylinders from above. Another view is that the axis-cylinders, myelin, and neurilemma are formed from cells which exist in the distal segment, and that juvenile

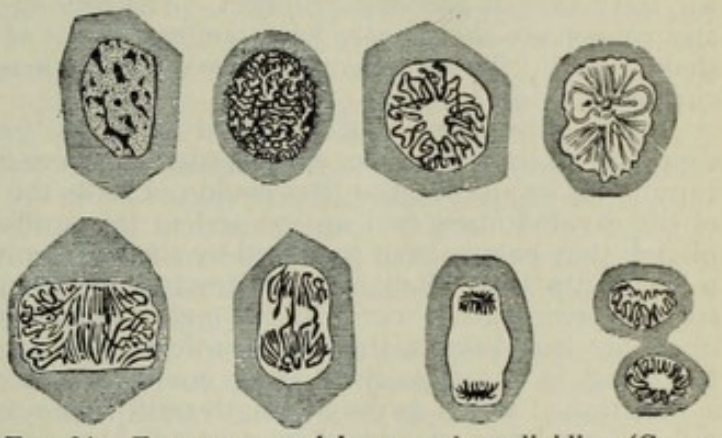


FIG. 24.—Forms assumed by a nucleus dividing (Green, from Flemming).

axis-cylinders and medullary sheaths are formed in the peripheral portion and then effect a junction with like structures of the central segment. The last-mentioned view is advocated by Mayer and Eichhorst, Tizzoni, Cattani, and others, and Ballance and Stewart have published a most valuable monograph advocating it ("The Healing of Nerves"). The nuclei proliferate and form a mass of protoplasm within the old sheath, and this protoplasm subsequently joins the proximal segment. Such a protoplasmic fiber has "conduction and irritability" (Raymond's "Human Physiology"), but there is as yet neither myelin nor axis-cylinder. "The fiber is responsive to mechanical stimuli, but not to induction shocks, which latter property returns only after the axis-cylinder is developed. The medullary substance later appears and forms a tube; and still later the axis-cylinder is formed, having its origin in the central end of the nerve" (Ibid.). The views of Ballance and Stewart may be set forth as follows: When a nerve-trunk is divided, the peripheral segment degenerates whether it has been sutured to the proximal segment or not, and the portion of the proximal segment near the wound also degenerates. The injury produces at once an effusion of blood, migration of leukocytes takes place into and about the wound at the proximal segment, but leukocytic invasion of the entire distal segment is noted. After three days connective-tissue cells begin to replace the leukocytes, and after two weeks the excess of leukocytes is no longer observed, proliferated connective-tissue cells having taken their place (Ballance and Stewart, "Healing of Nerves," page 94). The proximal segment in the neighborhood of the wound and the entire distal segment are invaded by proliferating connective-tissue cells. The connective-tissue cells completely absorb the fatty myelin and axis-cylinders. The cells of the neurilemma actively multiply, and connective-tissue cells lying among chains of neurilemma cells become spindle shaped and "the degenerated nerve-trunk therefore becomes hard, fibrous, and cirrhosed" (Ibid.).

In the proximal end of a divided nerve an "*end-bulb*" is formed. This was long supposed to be due to the prolongation of nerve-fibers from the central fibers and a turning backward because they could not cross the gap. As a matter of fact, the ends of the divided fibers curl up; on and in this scaffold-like arrangement new fibers are placed, they having been produced by the neurilemma cells which have taken on "neuroblastic function" (Ballance and Stewart). When a nerve has been sutured, the earliest signs of regeneration "occur at the end of three weeks" (Ibid.). Short lengths of new fibers are laid down within old neurilemma sheaths. The new axis-cylinder "is seen to consist in the deposition along one side of a spindle-shaped neurilemma cell, of a thin thread which grows in length until it projects beyond the limits of the parent cell and stretches on toward its next neighbor in the same longitudinal row" (Ibid.). The new medullary sheath is "laid down by a process of secretion" (Ibid.) along the sides of the neurilemma cells.

Ballance and Stewart go on to point out that if the central theory of regeneration is true, not a trace of regeneration could occur in the distal segment when the two segments have not been united by sutures, and yet such regeneration *does* occur, although slowly, the new axis-cylinders and medullary sheaths not attaining full size. "Evidently some stimulus afforded by the conduction of impulses is necessary in order to permit of their full development" (Ibid.). In the notable study quoted at such length are some experiments on the "conduct and fate of transplanted nerve." When the gap is wide between the two ends, a portion of fresh nerve-trunk may be inserted to bridge it. The transplanted piece degenerates; it is invaded by leukocytes, and proliferating connective-tissue cells, medullary sheaths, and axis-cylinders are destroyed, but regeneration may subsequently occur; "but when it does occur, it is not from the activity of the cells of the graft itself." Blood-vessels enter the degenerated graft at each end and they are accompanied by chains of neurilemma cells, which form axis-cylinders and medullary sheaths. The graft is merely a scaffold.

The studies of Ballance and Stewart persuade us that regeneration does occur in the distal part independently of the proximal part, although full development does not take place unless there is a junction with the central part. As to the exact method of regeneration we still feel somewhat uncertain. When we remember that the nerve-fibers of the spinal cord are devoid of neurilemma and that the cord can, to some extent at least, regenerate, we must conclude that regeneration can take place in the cord without the aid of neurilemma cells, and must infer that the same may be true in a nerve.

Some have asserted that in suturing together the ends of a divided nerve an effort should be made to place the parts as nearly as possible in the relation they held before

the injury. McKinley apparently proves that such a contention is an error ("Archives of Neurology and Psychiatry," June, 1921).

We do know certainly that the initial step in nerve regeneration is proliferation of the neurilemma nuclei with the formation of protoplasmic bands in both proximal and peripheral segments of the divided nerve (W. E. Lee in "Progressive Medicine," Dec., 1922). There is still debate as to whether each segment forms a neuraxis, that of the lower segment awaiting fusion with that of the upper segment, or whether the neuraxis which appears in the distal segment is a projection of that in the proximal segment. Ranson's studies seem to prove that the neuraxis comes entirely from the proximal segment, bridges the gap between the two segments, and travels down the distal segment guided by the protoplasmic bands (Lee, Ibid.).

Kirk and Lewis ("Bull. of Johns Hopkins Hosp.," Feb., 1917) show that protoplasmic bands bridged a gap of ¾ inch in less than six days and that axis-cylinders from the proximal segment entered the distal segment within three weeks.

Repair of the Spinal Cord and Brain.—Can the spinal cord regenerate? Many observers have doubted it. But there is no doubt of the fact that sometimes, after the subsidence of an acute myelitis or after the relief of a pressure which produced complete and prolonged paralysis, there is a return of functional power. It is usually assumed that restoration is possible in fibers which have not been hopelessly damaged, but is not possible in those which have been destroyed; but, as Gowers says, there are cases in which "we can scarcely believe that the axis-cylinders retain their continuity, although conducting capacity is ultimately restored." Clinical evidence indicates strongly that the pyramidal fibers may regenerate. Mills ("The Nervous System and Its Diseases") says: "Nerve-tracts in the spinal cord and brain have power to regenerate, but this is not so great as in the peripheral nerves, and yet even old cases of compression of the spinal cord may make great improvement after a long time, largely through the regeneration of the columns of the cord." Mills affirms that although nerve-cells sometimes appear to regenerate, the destruction in these cases was not complete. Some years ago I showed in my clinic a man who had had complete paraplegia with paralysis of the bladder and rectum for nineteen years. The condition was due to a bullet lodged within the spinal canal. Removal of the bullet was followed in a few weeks by restoration of control over the bladder and rectum. In a few months spastic paraplegia was substituted for flaccid paralysis.

When axis-cylinders have been destroyed in the cord and yet some power returns, we ask ourselves: Does this occur because new fibers have grown down from above? Gowers says that such a growth has been proved to occur in the lower animals, but has not as yet been demonstrated in man; although specimens have been described which strongly suggest such an occurrence in the human subject. That the cord can regenerate to some extent seems highly probable from the report of a case operated upon by my late colleague, Professor Francis T. Stewart, of Philadelphia. He sutured a completely divided spinal cord and some restoration of function took place (Francis T. Stewart and Richard H. Harte, in "Phila. Med. Journal," June 7, 1902). This case is commented on at some length in the section on Injuries of the Spinal Cord. Another somewhat similar case was reported by George Ryerson Fowler in the "Annals of Surgery," Oct., 1905.

Many claim that a brain injury cannot be followed by repair with restoration of function; some think that complete regeneration can take place; others, that partial regeneration may occur. Vitzon and Tedeschi even believe that nerve-cells in the brain can regenerate. It seems probable that extensive injuries are not repaired, but slighter ones may be, new ganglion-cells and neuroglia being formed. Tedeschi describes the process of repair after a wound of the brain as follows: Degeneration occurs and a limited focus of necrosis forms and then the adjacent tissue shows evidences of repair. Capillaries form from the endothelial cells, glia tissue from the neuroglia, ganglion-cells present karyokinetic changes, and some nerve-fibers appear in the scar (Senn's "Principles of Surgery").

Repair of Muscles.—It has long been taught that the repair of muscle by muscle is impossible, and, as a matter of fact, it does not take place if the ends of a divided muscle are separated to the extent of an inch or more. When a muscle is divided transversely by a cut of considerable extent, the ends of the divided fibers retract and a wide space is left between them. Blood flows into the space between the ends, and also between individual fibers of the injured muscle and the blood-clots. Exudation of plasma occurs and migration of corpuscles takes place. Fibroblasts are produced by proliferation of connective-tissue cells and a mass of fibroblasts soon replaces the

blood-clot. Granulation tissue is formed by vascularization of the mass of fibroblasts, and granulation tissue is converted into scar tissue, but not at all into muscle. After slight injuries a trivial amount of muscular regeneration does occur by the multiplication of living muscle-cells, but not by metamorphosis of fibroblasts. Fibroblasts are incapable of transformation into muscular tissue. When the ends of a divided muscle are separated to a very slight degree or when they have been brought together and sutured, some muscular regeneration occurs. After an injury a number of the muscular fibers always wither, perish, and are absorbed. The process of regeneration arises from the remaining fibers. The nuclei of the muscle-fiber proliferate and so do the nuclei of the perimysium. The muscle-cells are called myoblasts, and the nuclei of the perimysium are called sarcoblasts. About the juvenile muscle-cells a deposit of protoplasm takes place (Weber). The embryonal cells gradually become spindle shaped, and muscular fiber is formed by cellular fusion or by elongation of individual cells.

The above remarks refer to striated muscle. Unstriated muscle-fibers are repaired solely by "indirect multiplication of their nuclei" (Senn).

If a muscle has been divided, it should be sutured. This process insures more rapid repair and secures a better functional result, and is followed by a much greater amount of muscular regeneration.

Repair of Tendon.—When a tendon is divided, the ends retract, and the sheath, as a rule, becomes filled with blood-clot. The blood-clot is rapidly removed, fibroblasts replacing it. This new tissue arises from the sheath, the cut ends of the tendon not participating in its formation. Granulation tissue is formed; this is converted into fibrous tissue, and after a time the fibrous tissue becomes true tendon. If no blood-clot forms in the sheath, the walls of this structure collapse and adhere, and the separated tendon-ends are held together by a flat fibrous band formed from the collapsed sheath (Warren's "Surgical Pathology").

Repair of Bone.—When a bone is broken a blood-clot quickly forms in the medullary cavity, between the broken ends and under and outside the periosteum. Leukocytes invade and destroy the clot. The cells outside the periosteum, the cells of the periosteum and of the medullary tissue, particularly the endothelial cells, proliferate and produce cells which are practically fibroblasts. The osteoblasts in the medullary tissue, and perhaps in the deeper layers of the periosteum, multiply and are distributed through the mass of fibroblasts. The osteoblasts may form bone directly or may form cartilage first. Some teach that fibroblasts can be converted into bone; others positively deny such a conversion. The point is not settled, but it is well to remember that in myositis ossificans a muscle is converted into bone, and hence that it is probable that fibroblasts formed from periosteum and medullary tissue, are more prone to undergo such a development. During regeneration the bone ends soften and are partially absorbed by osteoclasts. Osteoclasts are large osteoblasts which have lost the power of bone production and furnish a secretion which dissolves osseous matter. The excess of callus is finally absorbed by osteoclasts. (For a more extended description see Repair of Fractures.) Sir William Macewen has denied emphatically that the periosteum plays a leading rôle in bone production ("Brit. Med. Jour.," June 22, 1907). He believes that the periosteum is a membrane to limit and control the osteoblasts and that new bone is formed purely from bone cells. There is much experimental evidence to confirm Sir William's assertion. If he is correct, a considerable osseous defect could not be filled up by new bone even if the periosteum were intact. As a clinical fact, we see this very thing occur. For instance, W. R. MacAusland and A. F. Sargent report a successful transplantation of an entire fibula, the tibia having been lost by osteomyelitis ("Annals of Surgery," July, 1922). In an article ("Lancet," Aug. 3, 1912) Sir William Macewen claims that osteoblasts are the essential elements in repair, that they come from cartilage cells, that when growing bone is stripped of periosteum growth continues, that when bone is removed and periosteum is left no growth occurs, and that transplantation of spicules offers the best chance of repair because each fragment furnishes peripheral growth. During the last few years many surgeons have utilized bone transplantation, for instance, transplanting a portion of a rib or the crest of the tibia of the same individual to fix an ununited fracture, to fill a bone gap the result of osteomyelitis, or to anchor vertebræ as in Albee's operation for vertebral caries. Davis and Hunnicult ("Annals of Surgery," 1915, lxi) assert that a transplanted bit of periosteum and a flap of periosteum do not produce new bone unless shavings of bone have been attached, and that removal of periosteum has little effect in bone nutrition. The late Professor John B. Murphy in many respects

disagreed with Macewen. (See "Practical Med. Series," vol. ii, 1912.) He taught that a bit of periosteum completely detached from the bone of a young individual and placed in the fat or muscle of the same individual did make new permanent bone. If one end of the strip were allowed to retain attachment to the bone, the transplanted end practically always made new bone. Bone with or without periosteum transplanted in the same individual and placed in contact with growing bone united to the living bone, acting as a scaffold for blood-vessels and osteogenetic cells, and was eventually absorbed. The periosteum, according to Policard (Lyon, Chirurg., vol. xxix, 1922), is not essential but is helpful, but densely fibrous periosteum is harmful and retards fixation of a graft by opposing the passage of newly formed capillaries and connective tissue into the haversian canals of the transplanted bone. Many cases studied during the World War indicate the frequent high value of bone fragments in aiding repair. Fragments covered with periosteum seem to have been of particular use. Only fragments devoid



FIG. 25.—Fracture one week: blood-clot containing fragment of bone (Warren).

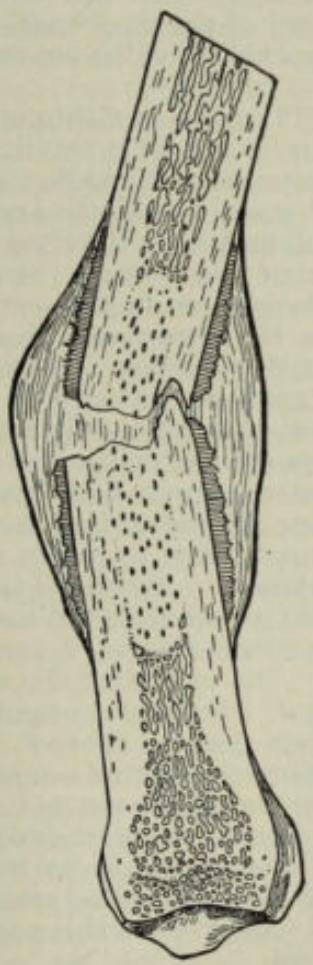


FIG. 26.—Callus of fracture (dog), four weeks: commencing ossification of external callus (Warren).

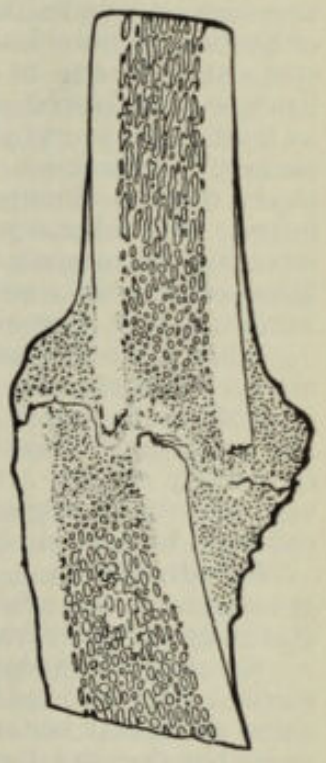


FIG. 27.—Femur of a child fifth week after fracture (Warren).

of periosteum, those seriously infected and those distant from the bone injury should be removed by the surgeon. If these statements are confirmed we must accept Murphy's view as to the value of periosteum. Large pieces of bone can be transplanted successfully. Many hold a transplant of living bone acts as does transplanted dead bone. It first undergoes absorption and then bony new-formation occurs, bone also forming in adjacent connective tissue and in the interior of the bone (Policard, Ibid.).

Many investigators maintain that a transplant of living bone not only stimulates bone production in the bone ends and sides with which it is in contact but that many of its own osteoblasts survive and participate in the process of regeneration. Haas ("Surg., Gynecol., and Obstet.," June, 1923) maintains that a fracture of a transplant of living bone, even if it lies in muscle, unites in the same way and as firmly as a fracture under "normal conditions," whereas a fracture of a boiled bone transplant never shows any evidence of repair.

Repair of Blood-vessels.—If an artery is cut across and ligated, a clot forms within its lumen and about its divided end, and the circulation in the vessel at this point is permanently arrested. The proximal clot, it used to be thought, always reaches the first collateral branch. This statement was true before the days of asepsis; it is not always true now. Often a clot stops far short of the branch above. Exudation of plasma and migration of corpuscles take place from the vasa vasorum. The clot becomes filled with leukocytes, which gradually destroy it, and it plays no active part in repair. Fibroblasts form by the multiplication of the cells of the vessel wall and the clot is soon replaced by fibroblasts. The fibroblasts are converted into granulation tissue, granulation tissue becomes fibrous tissue, the fibrous tissue contracts, and the artery is transformed into a fibrous cord. Warren insists that the muscle-cells of the middle coat play an active part in repair. Usually, when a ligature is applied to an artery in continuity, a deliberate attempt is made to rupture the internal and middle coats, in order to permit of contraction and retraction above and below the seat of ligature, and a turning inward of the inner coat. Such a sequence of events happens also when an artery is completely divided across and not tied, and favors the rapid formation of a clot.

Ballance and Edmunds ("Ligation in Continuity") maintain that repair is obtained most rapidly when the artery is tied with two ligatures, the vessel at this point being deprived of blood, but the internal and middle coats being kept intact. Cell-proliferation forms a spindle-shaped mass of new cells and the lumen is obliterated at the seat of ligation by fibroblasts obtained from the fixed cells of the wall of the artery. Halsted's studies seem to disprove these views. Senn advocates the employment of two ligatures, not placed side by side as in the method of Ballance and Edmunds, but so applied as to include "a bloodless space about ½ inch in length" ("Principles of Surgery"). Professor Halsted ("Surgery, Gynecology, and Obstetrics," Dec., 1918) shows that an aluminum band, no matter how tightly rolled, does not rupture the intima; that intimal surfaces however lightly brought together do not unite by first intention but necrosis always ensues; that a gradual substitution of the necrotic tissue takes place, new vessels entering from both ends, and finally a fibrous cord forms. Sutures lightly approximating intimal surfaces act like a band.

When a lateral ligature is applied to a vein or when a small wound in a vein or artery is sutured, the circulation in the vessel is not completely cut off, a thrombus of small size is formed on the vessel wall, the fixed cells of the vessel wall proliferate, and a scar of fibrous tissue effects repair. A completely divided vein heals as does a completely divided artery. The clot after the aseptic application of a ligature to a vein may be of slight extent, but in some cases the proximal clot reaches the first collateral branch and in others goes far above it.

Repair of Skin.—The fibrous structure is repaired by fibrous tissue. Hair-follicles, sweat-glands, and sebaceous glands are not re-formed. The epithelial layer is regenerated by the proliferation of adjacent epithelial cells.

Repair of Lymphatic Tissue.—Lymphatic tissue may be formed from the fatty tissue, or the divided ends of the lymph-ducts. When a gland has been removed a new gland may be formed. When a gland has been partially removed it heals by scar tissue but does not regenerate.

Repair of the Kidney and Testicle.—These organs when damaged can undergo some regeneration.

Repair of the Liver and Spleen.—Each of these organs, after injury, is capable of considerable regeneration.

III. SURGICAL FEVERS

The surgeon encounters fever as a result of an inflammation or an aseptic wound, in consequence of infection, as a result of poisoning by certain drugs, and in several maladies of the nervous system. It is important to remember that, while elevated temperature is generally taken as a gage of the intensity of fever, it is not a certain index. There may be fever with subnormal temperature (as in the collapse of typhoid or pneumonia), and there may be elevated temperature without true fever (as in certain diseases of the nervous system). It is true, however, that elevation of temperature is almost always noted, and is usually accepted as the measure of the severity of the fever.

Elevated temperature is only a symptom. The elevated temperature caused by an infection may be regarded as evidence that the body is fighting the infection. An acute

infection with a low or subnormal temperature is a far graver condition than an acute infection with a high temperature. The low temperature shows that the body is abandoning the contest; the subnormal temperature shows that it has abandoned it. Exham ("Brit. Med. Jour.," January 27, 1912) points out that the worst cases of pneumonia, peritonitis, and diphtheria are those with subnormal temperature, and that in some of the most malignant cases of scarlet fever the temperature does not rise much above 100° F. As Exham says: elevated temperature is a defense and subnormal temperature means that body resistance is at an end. If in doubt as to the cause of fever, count the leukocytes; make a blood-culture, a Widal test, and a Wassermann test.

The *essential phenomena of fever*, according to T. J. Maclagan ("Fever, A Clinical Study") are: (1) wasting of nitrogenous tissue; (2) increased consumption of water; (3) increased elimination of urea; (4) increased rapidity of circulation; (5) preternatural heat.

Traumatic fevers follow traumatism and attend the healing or infection of a wound. The forms are: (1) benign traumatic fever; (2) malignant traumatic fever.

Benign traumatic fever is divided into two forms—the *aseptic* and the *septic*. There is but one form of aseptic fever, the postoperation rise. The septic benign fevers are surgical fever and suppurative fever. The malignant traumatic fevers are sapremia, septic infection, and pyemia. In this section we discuss the benign fevers only.

Aseptic traumatic fever, or the *postoperative rise*, often, but not always, appears after a thoroughly aseptic operation and after a simple fracture or a contusion. It is not preceded by a chill, by chilliness, or by a feeling of illness. It may appear during the evening of the day of operation or not until the next day, and reaches its highest point by the evening of the second day (100–103° F.). This elevation is spoken of as the "postoperation rise" because it is usually encountered after an operation. Besides the elevated temperature there are no obvious symptoms; the patient feels well, sleeps well, and often wants to sit up; there are no rigors and there is no delirium. The wound is free from pain and appears entirely normal. Blood examination may show moderate leukocytosis. This fever is due to absorption of pyrogenous material from the wound area, the material being obtained from clot or inflammatory exudate, or from both. Observers believe that the pyrogenous element is thrombin, which is absorbed from disintegrating blood-clot and coagulating exudate. Warren regards the fever as due to what we used to call fibrin ferment (probably thrombin) and "also to other substances slightly altered from their original composition during life." Some have asserted that the fever is due to nervous shock.

Schnitzler and Ewald have studied aseptic fever.[1] These observers maintain that aseptic fever can exist when no fibrin ferment is free in the blood, that fibrin ferment can be free in the blood when there is no fever, and, in consequence, that fibrin ferment is not the cause of the elevation of temperature. They rule out of consideration nervous shock as a cause, and assert that a combination of several factors is responsible, nucleins and albumoses which are set free by traumatism being looked upon as the most active causative agents. The presence of nuclein in the blood in aseptic fever is indicated by leukocytosis and by the increase of the alloxur bodies (including uric acid) in the urine. The capacity of nucleins and albumoses to cause elevated temperature is greater in the tuberculous than in the non-tuberculous, and we know clinically that a tuberculous patient is apt to exhibit a more violent postoperation rise than is a non-tuberculous subject. The diagnosis of aseptic traumatic fever is only to be made after a careful examination has assured the surgeon that there is no obscure or hidden area of infection.

In some cases aseptic fever may appear after an operation, and later be replaced by a septic fever. If the temperature remains elevated more than a day or so, if other symptoms appear, or if after the temperature has become normal it again rises, the wound should be examined at once, as trouble almost certainly exists.

True traumatic, or **genuine surgical, fever** is seen as a result of infected wounds in which there is decided inflammation, but as yet no pus. The real cause is the presence of fermentative bacteria in the wound and the absorption of a moderate amount of their toxic products. The most active and commonly present organisms are those of putrefaction. Suppuration occurs later. Surgical fever ceases as soon as free discharge occurs, and the appearance of such a fever is an indication for instant drainage. The condition is ushered in two or three days after the operation by

[1] See "Archiv für klinische Medicin," Bd. liii, H. 3, 1896; also statement of their views in "Medical Record," Dec. 19, 1896.

chilly sensations and general discomfort. The temperature rises pretty sharply, ascends with evening exacerbations and morning remissions, and reaches its height about the third or fourth day, when suppuration sets in; the temperature begins to drop when pus forms, if the pus has free exit, and reaches normal at the end of a week. (See Suppurative Fever.) The temperature may reach 104° F. or more, but rarely rises above 103° F. The patient has the general phenomena of fever, that is to say, thirst, anorexia, nausea, dry and coated tongue, constipation, pain in the back and legs, and headache. The urine is scanty and high colored. Blood examination usually shows decided leukocytosis. The wound is painful, tender, swollen, discolored, and often foul, and stitch-abscesses may form. Some or all of the stitches must be cut, the area should be asepticized, the wound edges separated by iodoform gauze, or the wound drained by a tube. The fact that this fever is apt to cease when discharge of pus begins led the older surgeons to hope for pus and to endeavor to cause it to form. A severe grade of surgical fever, such as arises when there is putrefaction in a large and ill-drained wound, is due to the absorption of a large quantity of the toxic products of putrefactive bacteria, and is known as sapremia (see page 126).

Suppurative Fever.—This fever, which is due to the absorption of the toxins of pyogenic organisms, occurs after suppuration has begun, is found when the pus has not free exit, and is an intoxication rather than an infection, that is to say, toxins enter the blood, but no bacteria. It can follow or be associated with surgical fever, or may arise in cases in which surgical fever has not existed. Suppuration in a wound is indicated by a rapid rise of temperature—possibly by a chill. The temperature rises to a considerable height, shows morning remissions and evening exacerbations, and as it begins to fall toward morning sweating occurs. The patient is much exhausted and presents the phenomena of fever previously described. The skin about the wound becomes swollen, dusky in color, and edematous, pain becomes pulsatile, and much tenderness develops. Blood examination shows very marked leukocytosis. The wound must at once be drained and antisepticized. In a chronic suppuration, such as occurs when there is pyogenic infection of a tuberculous area, there exists a fever with marked morning remissions and vesperal exacerbations, attended with drenching night-sweats, emaciation, diarrhea, and exhaustion. This is known as *hectic fever;* it is really a chronic suppurative fever. The treatment of hectic fever consists in the drainage and disinfection, if possible, the excision of the infected area, the employment of a nutritious diet, stimulants, tonics, remedies for the exhausting sweats, and free access of fresh air.

Some Other Forms of Fever Seen by the Surgeon.—Fever of Tension.—When there is great tension upon the stitches, the spots where the stitches perforate ulcerate and some fever arises. To relieve the fever of tension cut one or several stitches. This fever is in some cases surgical, and in some suppurative, according as to whether the infective organisms cause fermentation or suppuration.

Fever of Iodoform Absorption.—The drug must be used with some caution. Absorption from a wound sometimes happens, producing toxic symptoms. These symptoms are frequently misinterpreted, being usually attributed to infection. R. T. Morris has pointed out that in iodoform-poisoning the wound seems to be in excellent condition, whereas in sepsis the wound appears unhealthy. The symptoms in some cases are acute and arise suddenly, and consist of hallucinatory delirium, nausea, fever, watery eyes, contracted pupils, metallic taste in the mouth, yellowness of the skin and eyes, the odor of iodoform upon the breath, the presence of the drug in the urine, the outbreak of a skin eruption resembling measles or which is erythematous, vesicular, bullous, or petechial. There is often nephritis and always excessive loss of flesh and strength. Patients with such acute symptoms usually pass into coma and die within a week. Such attacks are most apt to arise in those beyond middle life (see Gerster and Lilienthal in Foster's "Practical Therapeutics"). Iodin can be recognized in urine by adding a few drops of commercial nitric acid and a little chloroform. When the mixture is shaken the chloroform will take up the free iodin and become purple, and on standing the purple layer will settle to the bottom of the tube. Another test is as follows: Put a small amount of urine into a saucer, add a little calomel, and stir. If the urine contains iodoform a brown color will be noted (R. T. Morris). The finding of iodin in the urine, however, is not proof that the patient is poisoned. We may find it when no sign of poisoning exists. But it calls for the removal of all iodoform gauze, as otherwise symptoms of poisoning will probably arise. In chronic cases of iodoform-poisoning the first symptoms usually observed are moroseness, bewilder-

ment, and irritability, followed by depression, with unsystematized persecutory delusions, delirium, coma, and even death.

In systemic poisoning by iodoform, discontinue the use of the drug, sustain the strength of the patient, and favor the elimination of the poison.

Iodoform sometimes produces great local irritation of the cutaneous surface, the dermatitis being eczematous or else being manifested by crops of vesicles filled with turbid yellow serum or even bloody serum. These vesicles rupture and expose a raw, oozing surface, looking not unlike a burn. The dermatitis usually exists only in the region with which iodoform was in contact, but in some cases it spreads widely. The use of the drug should be abandoned at once. To continue its employment would not only increase the dermatitis, but might produce constitutional symptoms. The vesiculated area should be washed with a stream of normal salt solution to remove iodoform, each vesicle should be opened, and the part should be dressed for several days with gauze wet with normal salt solution. After acute inflammation has ceased zinc ointment or cosmolin should be applied.

Fever of Ptyalism or Mercurial Fever.—Corrosive sublimate may be absorbed from a wound, a serous surface, or a mucous membrane, fever, ptyalism, and diarrhea resulting. The absorption of bichlorid of mercury may be followed by cramp in the limbs and belly, feeble pulse, cold skin, extreme restlessness, and even collapse and death. At the first sign of trouble withdraw the drug and treat the ptyalism (see page 283).

Fever Due to Awakening of an Area of Pulmonary Tuberculosis.—A quiet, nonprogressive area of pulmonary tuberculosis may burst into activity after an operation, and is particularly apt to if ether has been administered. The surgeon must be watchful of this condition. Several times I have seen a person with signs suggesting bronchitis at the base of one lung develop a moderate and prolonged fever. Such a condition is not bronchitis because it is unilateral. The sputum shows pus cocci, but no tubercle bacilli. I formerly regarded it as tuberculosis, but it is always recovered from and is probably bronchopneumonia of one lobe of one lung.

Fever of Morphinism.—Sometimes a morphin habitué suffers from severe chills and intermittent fever of the quotidian or tertian type. The condition is usually thought to be malarial, a view which is strengthened by the common association with neuralgia; but quinin proves futile as a remedy and blood examination gives a negative result. If we have reason to suspect that the patient is using morphin, examine the urine for the drug and wash out the stomach and examine the washing. The latter test is of value even when morphin is used hypodermatically, because some of the drug is excreted into the stomach.

Fever of Cocain-poisoning.—(See Local Anesthesia.)

Hepatic Fever.—(See section on Liver and Gall-bladder.)

Neurotic or Hysterical Fever.—This remarkable condition is occasionally, though seldom, encountered. It is unusual for the temperature to rise above 101° F. Most of the reported cases of great hyperpyrexia are instances of simulation and fraud. That very great elevation can occur is shown by the case seen by Mr. J. W. Teale, which case was also observed by Sir Clifford Allbutt. The temperature rose again and again to 118° F. In such cases the temperature rises very rapidly, remains at its height but a short time, and then falls as rapidly as it arose. It may happen that elevated temperature is the sole evidence of illness, there being no wasting, thirst, or other febrile symptoms. Cold sponging rapidly lowers the temperature. Such elevated temperature may occur irregularly or be attained daily for months. As a rule, hysterical stigmata can be detected. Osler points out that cases of hysterical fever "with spurious local manifestations" are very deceptive. The case may resemble meningitis, peritonitis, or some other acute inflammatory condition; but the course of the supposed malady is found to be atypical and the symptoms are observed to be variable and often anomalous. There is no leukocytosis; frequently there is an apparent increase in red cells, because of vasomotor disturbance, a fall in hemoglobin, and an increased proportion of lymphocytes and eosinophils ("Clinical Hematology," by J. C. DaCosta, Jr.). It is dangerous to make a diagnosis of neurotic fever; it must not be done unless all other possible causes have been excluded. Some supposed cases depend upon unrecognized tuberculosis, some on visceral syphilis, some on undiscovered malignant disease, some on toxin absorption from the alimentary canal.

An **emotional fever** sometimes occurs after accidents or operations. The patient may have a chill, and then develop violent headache, photophobia, and hysterical ex-

citement, with elevated temperature. Inexplicable elevations of temperature may occur in neurasthenia.

Malaria.—It is wise to examine the blood in supposed septic fevers, for only by this means can malaria be excluded. It is more common to mistake sepsis for malaria than malaria for sepsis. In malaria the spleen is enlarged, the febrile attacks exhibit periodicity, neuralgias are common associates, and quinin cures the condition.

Surgical Scarlet Fever.—It is maintained by some writers (notably Sir Victor Horsley and Sir James Paget) that a child is rendered especially susceptible to scarlet fever by the shock of a surgical operation. Scarlet fever which develops after a wound, a burn, or an operation is spoken of as surgical scarlet fever. Warren quotes Thomas Smith as having had 10 cases of scarlet fever in 43 operations of lithotomy in children. The puerperal state is supposed also to predispose to scarlet fever. It is not certain whether the poison enters by the wound, or whether shock and exhaustion predispose to ordinary scarlatina, or whether ordinary scarlatina was incubating before the accident or operation. Some surgeons hold that an attack of scarlet fever after an operation is a mere coincidence. Others maintain, and with great show of reason, that a red scarlatiniform eruption appearing after an operation rarely indicates genuine scarlet fever, but usually points to infection, as such eruptions are known occasionally to arise in septicemia. It *rarely* indicates scarlet fever, and yet it sometimes does. There is such a condition as surgical scarlet fever, as is proved by the facts that victims of the disease have been known to communicate it, and that it is often followed by "nephritis and usually by desquamation" (Holt's "Diseases of Infancy and Childhood").

Hoffa has discussed this subject elaborately. He concludes that four types of eruption can follow operation: (1) a vasomotor disturbance due to irritation of sensory nerves, and manifested by a transient urticaria or erythema; (2) a toxic erythema due to absorption of aseptic pyrogenous material from the injured area—the absorption of carbolic acid, iodoform, of corrosive sublimate, or the effect of ether; (3) an infectious rash, which is sometimes found in septicemia or pyemia, and is due to minute emboli composed of bacteria, which emboli lodge in the capillaries; (4) true scarlet fever, with the usual symptoms and complications, the micro-organisms having entered by way of the wound and the eruption often beginning at the wound edges (quoted in Warren's "Surgical Pathology"). Surgical scarlatina is aberrant. It develops rapidly, the period of incubation is extremely brief, and the throat may or may not be involved. Holt tells us that the rash is usually atypical and that "the general symptoms, particularly those relating to the nervous system," are "especially severe" ("Diseases of Infancy and Childhood"). The infection is believed to be due to a specific germ, but it has not been certainly identified. Streptococci have been found in the throat, skin, and the pus from secondary otitis media.

If surgical scarlet fever develops the wound should be drained and asepticized, and, if the situation admits of it, dressed with hot antiseptic fomentations. The general treatment is the same as for ordinary scarlatina.

Fever of Malignant Disease.—Elevation of temperature may occur during the course of sarcoma or carcinoma. It is particularly apt to if the neoplasm is visceral, if growth is very rapid, or if ulceration exists. Malignant growths of the liver are especially apt to cause elevation of temperature and leukocytosis.

Fever of malignant disease usually appears as irregular elevations of temperature of short duration. In some cases there is a continuous or remittent fever; in some an intermittent fever. Even the hectic type is met with.

Urinary Fever and Urethral Fever.—(See section on Disease of Genito-urinary Organs.)

Syphilitic Fever.—(See page 269.)

Thyroid Fever.—(See section on Thyroid Gland.)

Postoperative Thermic Fever (Insolation Sunstroke).—In the heat of summer I have seen several patients after operation present rises of temperature apparently due to heat stroke. In one case of appendicitis the temperature rose to 107° F. and the other symptoms of thermic fever developed during an operation for appendicitis. One case of appendicitis died after operation from what was believed to be heat stroke. There are 12 cases reported (Alexis V. Moschcowitz in "Surgery, Gynecology, and Obstetrics," Oct., 1916).

I do not believe that heat stroke can rise only in one who has been exposed to the direct rays of the sun. If we believe direct exposure the requisite, we must disbelieve in postoperative insolation. Brouardel says—"it is not the solar radiation which kills.

People are found dead in the shade of a wood or under a tent, while the thermometer registers 97° F. in the shade" ("Death and Sudden Death").

The ice-bag to the head, cold sponging and proctoclysis with iced water constitute the best treatment.

IV. SUPPURATION AND ABSCESS

Suppuration is a process in which damaged living tissues and inflammatory exudates are liquefied by the action of pyogenic organisms, and it is a common result of microbic inflammation. The chief pus cocci are the various staphylococci and streptococci. Colon bacilli, typhoid bacilli, and pneumococci are at times pyogenic. Staphylococci tend to produce local suppuration; streptococci tend to cause spreading suppuration. It is generally taught that pyogenic bacteria liquefy damaged tissues and exudates by peptonizing them, the active agent in effecting the chemical change being poison furnished by the bacteria. There is some evidence that white corpuscles by disintegration set free enzymes, which dissolve or aid in dissolving albumin. Streptococci and staphylococci vary greatly in virulence, and the intensity and diffusion of a pyogenic infection depends upon the virulence and number of the bacteria and the level of vital resistance. Streptococci and staphylococci may both be present in one focus, and there may be secondary infection with bacteria of putrefaction or other bacteria. The pyogenic infection may be primary or it may be secondarily implanted in a disease area containing other micro-organisms. The pyogenic organisms are very irritant, and when deposited cause inflammation; inflammation leads to exudation, but the exudate cannot coagulate or coagulates but imperfectly, because it is peptonized by the ferment of the micro-organisms and also perhaps because albumin is dissolved by leukolysin from the white corpuscles. If an area of embryonic tissue is invaded by many pyogenic micro-organisms, it is promptly peptonized. The peptonizing action is upon the fibrinous elements of an exudate and upon the intercellular substance of embryonic or granulation tissue. Cells are separated from intercellular substance, and in consequence degenerate and die. Peptonized exudate or peptonized embryonic tissue is called pus. In suppurations induced by staphylococci a barrier of leukocytes is first formed around the region of irritation; this barrier is reinforced by fibroblasts, the pus is imprisoned, and rapid spreading and wide diffusion are prevented. In inflammations induced by streptococci the peptonizing action of the organisms is so great that no barrier of white blood-cells or of proliferating connective-tissue cells forms in time to imprison the micro-organisms, hence the suppuration spreads rapidly and widely. During the existence of a streptococcic infection some bacteria always enter the blood. Suppuration can be induced by the injection of pyogenic bacteria, by their entry through a wound, and by rubbing them into the skin. In some rare instances, especially when the diet has been putrid, they may enter through the blood and lodge at a point of least resistance. When a medullary canal suppurates after a chill to the surface or after a blow that does not cause a wound, we know that the bacteria must have arrived by means of the blood. Bacteria which reach a point of least resistance through the blood come from some atrium of infection which may be discoverable or which may not be found. The entry of pyogenic bacteria does not necessarily cause suppuration, as the healthy human body can destroy a considerable number, even if given in one "dose"; but a large number of virulent types even in a healthy, and even a small number in an unhealthy body almost certainly leads to pus formation. The pus of all acute abscesses contains bacteria of suppuration, but the pus of tuberculous abscesses does not, unless there be a mixed infection; in other words, pure tuberculous pus is not pus at all.

Can suppuration be induced without the actual presence of bacteria? It is true that the injection of irritants can cause the formation of a thin fluid which contains no bacteria, but this non-bacterial fluid is not pus. A purulent fluid may be formed by injecting cultures of pus cocci which have been rendered sterile by heat, the bacteria having been killed, a ferment contained in the bacterial cells being the active agent. Purulent material also results from the injection simply of the sterile products of the growth of pyogenic cocci. This purulent or sterile fluid is known as *spurious* or *aseptic pus*. An area of such aseptic suppuration does not tend to spread and the process concerns us but little as surgeons, except in cases of pyemia, in which thrombi containing toxins alone may occasionally induce limited secondary abscesses.

Impaired health or an area of lowered vitality predisposes to suppuration. Diabetes and albuminuria are common and influential predisposing causes, because in these

diseases tissue resistance is always at a low ebb. In amyloid disease resistance to pus cocci is greatly impaired. It is lessened in lithemia and in any condition of ill health. The lymphatic glands, medulla of bones, serous membranes, and connective tissue are especially prone to suppurate.

Pus may form within a few hours after bacteria have been deposited, or it may not form for days. The older surgeons claimed that pus could do good by protecting granulations and separating disorganized tissue. It is now known that it is absolutely harmful by melting down sound tissue and poisoning the entire organism. Modern surgery has to a great degree abolished pus.

If pus stands for a time, it separates into two portions—(1) a watery portion, the liquor puris or pus-serum, containing peptone, fat, microbic products, osmazone, and salts, and not tending to coagulate; (2) a solid portion, or sediment composed of dead and living micro-organisms of suppuration, connective-tissue cells, often epithelial cells, perhaps red blood-cells, lymphocytes, pus-corpuscles, débris of tissue, and shreds of dead tissue. The pus-corpuscles are either polynuclear white blood-cells or altered connective-tissue cells containing many nuclei. Most of them are dead, some have ameboid movements and are still capable of limited phagocytosis under favorable circumstances (C. J. Bond, "Brit. Med. Jour.," June 3, 1916). Some of the pus-cells are fatty, others are granular and contain more than one nucleus, and all are degenerating. A pus-cell is waste matter, and it cannot aid in repair. Very exceptionally pus disappears by absorption, by caseation, or by calcification.

Pus in General.—The color of pus is variable and depends upon the nature of the bacteria; the presence or absence of blood, fibrin, body secretions or body excretions (bile, urine, mucus, feces, etc.); and the existence or non-existence of putrefaction.

Its consistence varies. In some cases it is scarcely thicker than water, in others it is like cream, and in still others it is cheesy. Thick pus is opaque and of a greenish-yellow color, and thin pus has a distinct reddish or yellowish tinge. When freshly evacuated many varieties are almost or quite odorless, and are alkaline or slightly acid in reaction.

Some varieties possess a very offensive odor. Pus contaminated by the bacteria of putrefaction is certain to have a foul odor. Pus which forms in the tonsil, in the brain, about the vermiform appendix, or around the rectum usually possesses an offensive odor.

Forms of Pus.—*Laudable*, or *healthy pus*, a name long in vogue, is a contradiction, no pus being healthy. In former days free suppuration after an operation was regarded as a favorable indication, and when it occurred the surgeon congratulated himself that surgical fever was at an end. At the present day suppuration after an operation is an evidence of previous infection, of lack of care, failure in our precautions, or of infection by the blood. The so-called *laudable pus* is seen coming from a healing ulcer, and is an opaque, yellowish-white, or a greenish fluid of the consistence of cream, without odor or with a very slight odor if it is not putrid, and having a specific gravity of about 1030.

Malignant, *watery*, or *ichorous pus* is a thin, watery, putrid fluid. It is pus filled with the organisms of putrefaction.

Stinking pus may be ichorous. Its odor may be due to the Bacterium coli commune. If this bacterium is the cause the pus is very foul, but not thin. Pus of this nature is met with in ischiorectal abscess and appendiceal abscess. The odor of stinking pus may be due to ordinary bacteria of putrefaction, in which case the pus is usually thin.

Sanious pus is a form of ichorous pus containing blood coloring-matter or blood. It is thin, of a reddish color, and very acrid, corroding the parts with which it comes in contact. It is found notably in caries and carcinoma.

Concrete or *fibrinous pus*, which contains flakes of fibrin or coagulated fibro-purulent masses, is met with in serous cavities (joints, pleura, etc.). These masses also form in infective endocarditis.

Red pus signifies the presence of the Bacillus prodigiosus.

Blue Pus.—The color of blue pus is due to the Bacillus pyocyaneus. The Bacillus pyocyaneus may be the sole cause of a suppuration, but usually when it appears it constitutes a secondary infection in a suppurating area. It causes a blue or bluish-green hue in pus and wound discharges. Blue pus appears suddenly and disappears with equal suddenness. It quickly disappears if antiseptics are used in the wound. Its presence is not an evil augury; in fact, wounds infected by it seem to heal sooner than would be the case in plain pyogenic infection.

Orange Pus.—The color of orange pus is due either to the action of Sarcina auran-

tiaca, or to the formation of crystals of hematoidin from the coloring-matter of red blood-cells which have been mingled with the pus. Pus of this color appears only in violent inflammations.

Serous pus is a thin, serous fluid, containing few flakes.

So-called *tuberculous*, *scrofulous*, or *curdy pus* is not pus at all, unless the tuberculous area has undergone pyogenic infection.

So-called *gummy pus* arises from the breaking down of a gumma which has outgrown its own blood-supply. It is not pus.

Mucopus is found in purulent catarrh—that is, in suppurative inflammation of an epithelial structure. It contains pus elements and epithelial cells.

Caseous pus comes from the fatty degeneration of pus-corpuscles or inflammatory exudations. It occurs especially in tuberculous processes. A caseous mass may calcify.

Signs and Symptoms of Suppuration.—Suppuration is announced by the intensification of all local inflammatory signs. The heat becomes more marked, the discoloration dusky, the swelling augments, the pain becomes throbbing or pulsatile, and the sense of tension is greatly increased. The skin at the focus of the inflammation after a time becomes adherent to the parts beneath, and fluctuation soon appears. This adhesion of the skin is a preparation for a natural opening, and is known as *pointing*. An important sign of pus beneath is edema of the skin. This is always observed in a superficial abscess, and is sometimes noticeable in empyema or pyothorax, in appendiceal abscess, and in perirenal suppuration. The above symptoms can be reinforced and their significance proved by the introduction of an aseptic tubular exploring needle and the discovery of pus. Irregular chills, high fever, drenching sweats, weakness, and a feeling of serious sickness are very significant of suppuration in an important structure or a large area. It must always be remembered that in some virulent pyogenic infections the human organism is so overwhelmed with toxins that, though the patient is desperately ill, the temperature is normal or even subnormal. This means that body resistance has abandoned the conflict. In abscess of the brain the temperature, after an initial rise, often becomes normal or subnormal because of stimulation of the heat inhibitory center by toxins or by irritation.

Diffuse Cellulitis or Phlegmonous Suppuration (Purulent Infiltration).—This process may involve a small area or an entire limb, and is due to infection by the Streptococcus pyogenes (streptococcus of erysipelas), usually associated with mixed infection with other bacteria, particularly the bacteria of putrefaction. The streptococci are intensely virulent. Barriers of white corpuscles do not form early enough to restrain them, and tissues break down before cellular multiplication is able to encompass the bacteria. The bacteria disseminate through the lymph-spaces and lymph-vessels, and some enter the blood. The disease in severe cases produces enormous swelling, areas which feel boggy, a dusky red discoloration, and great burning pain. Gangrene of superficial areas is not unusual, due to thrombosis of vessels or coagulation necrosis from toxins. The discharges of the wound, if a wound exists, are apt to dry up, and the wound becomes foul, dry, and brown. The adjacent lymphatic glands are much enlarged. The disease is ushered in by a chill, which is followed by high oscillating temperature, due to suppurative fever, sapremia, or even septic infection or pyemia. Sweats are noted during periods of falling temperature. Diffuse suppuration tends to arise in an infected compound fracture, after extravasation of urine and after the infliction of a wound upon a person broken down in health. It is not unusual after typhoid or scarlet fever, and is typical of phlegmonous erysipelas. The pus is sanious and offensive, and burrows widely in the subcutaneous tissue and intermuscular planes. Diffuse suppuration may widely separate muscles and even lay bare the bones. It is a very grave condition, and may cause death by exhaustion, septic intoxication, septic infection, pyemia, or hemorrhage from a large vessel which has been corroded. *Cellulitis* of a mild degree is due to attentuated streptococci or to staphylococci. An area of cellulitis may surround an infected wound or a stitch-abscess. Its spread is manifested by red lines of lymphangitis running up to the adjacent lymphatic glands. Light cases may not suppurate, the lymphatics carrying off the poison. Any case of cellulitis is, however, a menace, and any severe case is highly dangerous. (See Erysipelas.)

Wooden, Woody, or Ligneous Phlegmon.—This condition was fully described by Réclus in 1893. It is chronic inflammation of the cellular tissue and fascia, and is characterized by the production of quantities of fibrous tissue. It occurs in those over fifty years of age. The neck is the region usually involved. It begins with hard swelling of one side of or of the front of the neck and for weeks is unaccompanied by any other sign. The swelling may be at first localized, but it spreads slowly and widely and

finally comes to involve an extensive area, even perhaps the front of the neck and both sides from the jaw to the collar-bone. It may involve the cervical muscles and thus create rigidity, and it may compress the larynx and trachea and thus interfere with breathing. In most cases there is difficulty in swallowing. After weeks, or perhaps a month or two, the skin becomes edematous and red or rather of a violet hue. There is no fever and rarely pain. The significant facts are the gradually advancing hard swelling long unaccompanied by fever, the pain, discoloration, or cutaneous edema. The condition is said to be due to the deposition and multiplication of bacteria, which reach the tissues from the lymph-glands and reach the glands from an area of infection in the pharynx, a salivary gland, or the mouth. Pus does not form at all or only minute encapsulated foci form, probably because the bacteria are of greatly attenuated virulence or because the local vital resistance to these bacteria is at a high level. Inflammation occurs, there is copious exudation, and enormous amounts of fibrous tissue form. If pus forms, it may discharge spontaneously in six or seven weeks. The causative bacteria are often attenuated pyogenic microbes. In one of Réclus's cases diphtheria bacilli were found, and this case got better after having been given antitoxin. Cases have been reported which were caused by pneumococci.



Fig. 28.—Wooden phlegmon.

Wooden phlegmon is occasionally found in syphilitics, but it is not a syphilitic condition. Neither Bright's disease nor diabetes has anything to do with its origin. It may be mistaken for actinomycosis or tuberculosis. It is frequently mistaken for sarcoma or carcinoma, in fact, Lange believes it to be cancer. I know that it may be sarcomatous. In two of my cases excision of a portion of tissue furnished the proof. There are two forms of the condition, a pyogenic and a malignant and the microscope alone can prove which exists. Clinically, my cases of sarcoma were identical with ordinary wooden phlegmon. Of course, phlegmon is not the proper term for a ligneous cancer or sarcoma. Wooden phlegmon arises in those who are in ill health rather than in the vigorous or robust. It is always dangerous and is frequently fatal. One of Réclus's cases died of edema of the glottis. We have spoken of woody phlegmon as though it could involve the neck only; as a matter of fact it can involve other parts. Réclus maintains that it can occur in the right iliac fossa, and that perinephric sclerosis is in reality due to it (Powers in "Jour. Amer. Med. Assoc.," July 20, 1911). A case has been reported by Todd in which the abdominal wall was involved ("Jour. Missouri State Med. Assoc.," February 8, 1912). Duse also reported such a case ("Gazz. d. Osped.," xxxi, 1910). W. W. Grant, of Denver, has reported ligneous phlegmon of the abdominal wall ("Jour. Amer. Med. Assoc.," April 5, 1913). A similar condition may arise in the perineum, after urinary extravasation or fistula formation. Charles A. Powers, of Denver, has reviewed this subject and presented the report of an admirably studied case (Ibid., July 20, 1911).

Treatment.—Extirpation, if feasible, is the best plan. It is seldom feasible, and the surgeon instead makes numerous incisions and usually dresses with antiseptic poultices. In these cases free suppuration occasionally occurs after a long delay, and when it does occur a cure may promptly follow evacuation. An autogenous vaccine should be made and injected into the indurated area. The surgeon must be prepared to do tracheotomy should an emergency arise. For a malignant case use *x*-ray or radium.

Furuncle, or **boil,** is an acute and circumscribed inflammation of the deep layer of the true skin and the subcutaneous cellular tissue following bacterial infection of a hair-follicle or a sebaceous gland and resulting in local necrosis of the dermis. The infecting organism is the Staphylococcus pyogenes aureus which gains entrance through a slight wound or a trivial abrasion. Shaving or scratching may be causal. If hair is cut very short it may grow beneath the skin solely, and such an ingrowing hair is a

common cause of furuncle. Boils are very common in individuals with Bright's disease, diabetes, gout, lithemia, tuberculosis, and disorders of menstruation and digestion; and crops of boils are apt to appear during convalescence from typhoid fever. Cheselden's Anatomy (1713) speaks of boils and carbuncles occurring in diabetics ("New York Med. Jour.," Jan. 10, 1920). Some persons develop boils after eating sweets, others after eating eggs (Francis, "Brit. Med. Jour.," Aug. 17, 1912). A rough collar may be responsible for a boil on the neck. Rowing men are liable to boils on the buttocks. Boils are commonest in the spring, and sometimes an epidemic of furunculosis appears in a hospital, a jail, or an asylum.

The **symptoms** of a boil are as follows: a red elevation appears, which stings and itches; this elevation enlarges and becomes dusky in color; a pustule forms that ruptures and gives exit to a very little discharge which forms a crust. Inflammatory infiltration of adjacent connective tissue advances rapidly, and the boil in about three days consists of a large, red, tender, and painful base capped by a pustule and a little crusted discharge. In rare instances, at this stage, absorption occurs, but in most cases the swelling increases, the discoloration becomes darker, the skin becomes edematous, the pain becomes severe and pulsatile, and the center of the boil becomes raised. About the seventh day rupture occurs, pus flows out, and a "*core*" of necrosed tissue is found in the center of a ragged opening. This core consists of the sebaceous gland and hair-follicle, which have undergone coagulation necrosis (Warren). In a day or two more the core will be discharged, and healing by granulation will begin. A *blind boil* lasts only three or four days and has no core. The constitution often shows reaction during the progress of a boil. Boils may be either single or multiple. The development of one boil after another, or the formation of several boils at once, is known as "*furunculosis*." Boils are commonest upon the neck and the back.

Lymphangitis is very rare. In unusual cases a boil leads to abscess formation. Distant abscess may arise long after a boil has healed and metastasis may be fatal. Bone, kidney, perirenal tissue, brain, or other parts may be involved in secondary abscess. A boil endangers life if it involves a vein, hence furuncles of the face and of the neck are dangerous. The lesion which may arise is suppurative thrombophlebitis, a clot propagating perhaps to an intracranial sinus. Thrombophlebitis of the facial vein is usually rapidly fatal, causing sinus-thrombosis of the cavernous sinus (see Reidel in "Deutsche med. Woch.," 1915, Nos. 4 and 5).

Treatment.—In a superficial boil early in the case when the area is hard do not incise. Paint the boil and the region about it with iodin, freeze the parts with ethyl chlorid, and, with a very sharp knife, remove a small circular piece of skin from the top of the boil. This permits fluid to escape and favors the subsequent evacuation of the core. Do not squeeze the inflamed area. The parts about the boil are to be dressed daily with Credé's silver ointment (to prevent infection of other hair follicles). Dress the boil with hot antiseptic fomentations. Every day try the core with forceps to aid its removal. In later cases when fluctuation exists the treatment consists in excision or in crucial incision, removal of necrotic tissue, irrigation with peroxid of hydrogen, touching with pure carbolic acid, the site of the boil being dressed with hot antiseptic fomentations and the adjacent skin with Credé's silver ointment. When the sore becomes a granulating surface employ dry dressings. A boil which involves or threatens to involve a vein should be excised at once. The vein should be divided if possible above any clot which it may contain and the ends of the cut vein should be ligated. If there are many boils or crops of boils (furunculosis) seek for the provocative disease and treat it. The commonest causes are diabetes and Bright's disease. Brewer's yeast is given by some. Others give nuclein itself. Sulphurous acid has been advised. Always give an autogenous vaccine.

Oriental Sore, or Endemic Boil of the Tropics.— The exact significance of this term has been clouded by authors. Some consider tropical ulcer as synonymous, while others regard it as sloughing phagedena. Some regard tropical ulcer as an infection due to spirochetes. Here oriental sore is regarded as identical with the tropical ulcer, but not with any tropical ulcer. It is a condition of cutaneous leishmaniosis due to infection with those protozoa which constitute the genus *Leishmania*. Other names for the condition are Aleppo boil, Delhi boil, endemic boil of the tropics, bouton de Baghdad, etc. The Aleppo boil was once apparently confined to India, Arabia, Syria, Cyprus, Sicily, Persia, Egypt, Algeria, etc. Of late it has appeared in Mexico, the West Indies, Brazil, Panama, the Philippine Islands, and Hawaii. It is not a pyogenic process, but an infectious ulceration. Papules, which are granulomata, appear upon the exposed parts of the body. These papules usually ulcerate, the ulcers

crust, are superficial, do not furnish purulent discharge, have raised edges, sharp margins which are not undermined, irregular outlines, seldom cicatrize for at least a year, and leave ineradicable sunken scars. Exposed parts of the body, except the palms, soles, and scalp, are infected. Infection is supposed to arise by direct transference of the discharge to a wound or abrasion, or to be brought by flies, lice, bed-bugs, fleas, or other insects. It is endemic in certain regions, but some seasons it may be almost absent and other seasons it is wide-spread. It is most common at the beginning of the cooler season. It can occur in either sex at any age, and in those of any calling. The period of incubation may be measured by days, weeks, or months. Probably there are febrile seizures during the onset or later in the case. The blood may show mononuclear leukocytosis. The disease may be responsible for anemia, but seldom causes death.

Treatment.—Intravenous injections of tartar emetic every third day until healing begins. Start at a dose of ½ gr. and gradually increase to 1½ gr. Locally use antiseptics, the *x*-rays, and expose the part daily to direct sunlight. The disease is occasionally seen among sailors in our seaport towns. I have seen it in the Naval Hospital in Philadelphia, under charge of Captain Raymond Spear.

Carbuncle (*benign anthrax*) is a circumscribed infectious inflammation of the deeper layer of the true skin and of the subcutaneous tissue, with fibrinous exudation,



FIG. 29.—Diabetic carbuncle with extensive gangrene (Dr. Righter's case).



FIG. 30.—Columna adiposa (Warren).

multiple foci of necrosis arising, and the tissue adjacent to each necrotic plug becoming gangrenous. The infection takes place through a hair-follicle. It is really a multiple boil with extensive infiltration of adjacent tissues. A boil may become a carbuncle, and pus from a carbuncle inoculated into a healthy person may cause either a boil or a carbuncle. The causative organism seems to be the Staphylococcus pyogenes aureus. Carbuncle is most common in the upper part of the back and of the neck (Fig. 29). In this region the skin is very thick; each hair-follicle holds only a downy hair, is shallow, and projects but a short distance into the cutis vera. Columns of fatty tissue run from the subcutaneous tissue in an oblique direction to join the point and sides of the hair-follicle. These columns are known as *columnæ adiposæ*, and each one contains a sweat-gland (Fig. 30). When pus enters one of these columns, it seeks an outlet; it cannot spread easily to the sides, so it slowly works its way to deeper tissue and from one to another interspace and finds its way to the surface through other fatty columns (Warren's "Surgical Pathology") (Fig. 31). When pus finds its way to the surface, an opening forms, hence the numerous foci of pointing; finally a large opening forms (Fig. 32). Carbuncles are most common in the spring of the year. In persons with diabetes and Bright's disease carbuncles not unusually occur.

The local **symptoms** in the beginning resemble those of a boil, but the constitution sympathizes from the very start (perhaps a chill and always a septic fever) and the pain is usually severe. The inflammatory area begins as a papule with an indurated base, it enlarges enormously, is boggy to the touch, is dusky in color, is edematous, and the skin is not freely movable over the deeper parts. In a few days many pustules appear, each pustule marking the site of a focus of necrosis. Large vesicles filled with bloody serum very frequently form. In some cases about the tenth day the pustules rupture, the necrotic plugs are discharged, and the case slowly progresses toward cure; but in many cases the carbuncle spreads at the periphery while pustules are rupturing near the center of inflammation, and pus forms in the deeper tissues, reaching the surface through many small openings, each of which is partly blocked by a plug of dead tissue. A carbuncle in this stage resembles a honey-comb (Fig. 32), discharges bloody pus, and large masses of skin and subcutaneous tissue are destroyed. The entire carbuncular mass may become gangrenous, and a sudden and almost complete cessation of pain points to this complication. An ordinary carbuncle remains acute for about three weeks, but healing requires a month or more. The most dangerous situations in which to have a carbuncle are the face and neck (tends to produce septic phlebitis, septic clots in the facial, jugular, or ophthalmic veins, or in the cerebral sinuses, or infective emboli). The mortality of facial carbuncle is at least 50 per cent. The most usual positions for carbuncle are the neck, the back, and the buttocks. The diagnosis of carbuncle is made by noting the multiple foci of necrosis and the profound constitutional involvement. A carbuncle may produce death by causing septicemia, pyemia, septic thrombosis of a cerebral sinus, or profuse hemorrhage.

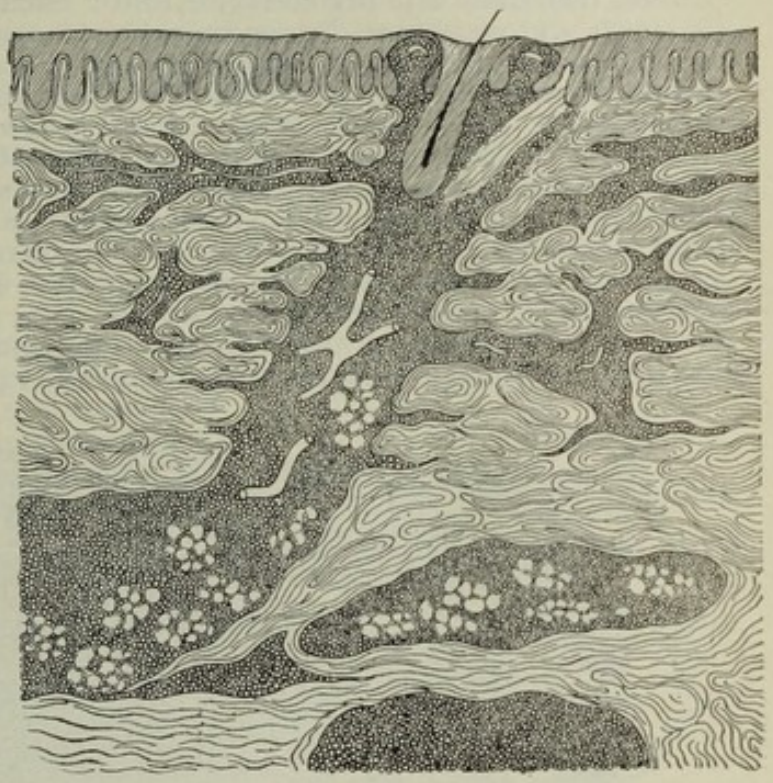


FIG. 31.—Infiltration of columna adiposa and subcutaneous tissue with pus in carbuncle (Warren).

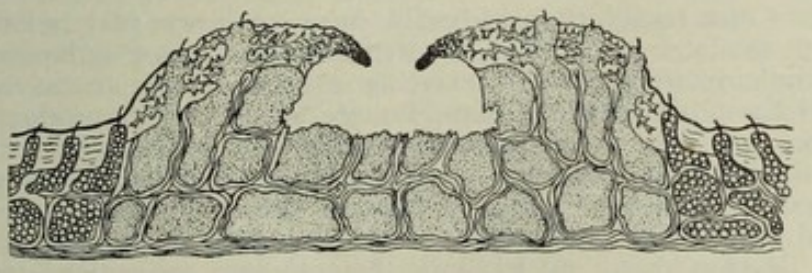


FIG. 32.—Diagram of a carbuncle (Warren).

Treatment.—Some have suggested the treatment of a carbuncle in an early stage by injecting 5 to 30 drops of carbolic acid (80 per cent.) into and around the inflammatory mass. Such a method does not promise success and necessitates dangerous delay. The best treatment if the case is seen sufficiently early is thorough extirpation while the patient is anesthetized. The entire area of the infection is thus removed, and the large wound heals by granulation and is to be subsequently skin-grafted. When the condition is too far advanced to admit of complete extirpation, the following useful plan should be employed:

Give ether, make free crucial incisions, remove dead and necrosing tissue and also

the points of the skin-flaps with the scissors and forceps, curet pockets, arrest hemorrhage by pressure and hot water, cauterize with *pure* carbolic acid, dust with iodoform, pack with iodoform gauze, and dress with hot antiseptic fomentations. Cover the gauze with a piece of some impermeable material and lay a hot-water bag upon the dressing. Every day, or several times a day, remove the dressings, wash with peroxid of hydrogen, irrigate with hot salt solution, dust with iodoform, and reapply the iodoform gauze and antiseptic fomentation. Keep up this treatment until sloughs are separated, then dress with dry antiseptic gauze. Secure sleep by morphin, give quinin, milk-punch, and nourishing diet, and maintain the action of the bowels and kidneys. An autogenous vaccine may be of service.

Acute Abscesses.—An acute abscess is a circumscribed cavity of new formation containing pus. We emphasize the fact that it is a *circumscribed cavity*—circumscribed by a mass of leukocytes and proliferating fibroblasts. A *purulent infiltration* is not circumscribed, hence it does not constitute an abscess. An essential part of the definition is the assertion that the pus is in a cavity of *new* formation, in an abnormal cavity; hence pus in a natural cavity (pleural, pericardial, synovial, or peritoneal) constitutes a *purulent effusion*, and not an abscess, unless it is encysted in these localities by walls formed of inflammatory tissue.

An acute abscess is due to the deposition and multiplication of pyogenic bacteria in the tissues or in inflammatory exudates. Eighty per cent. of abscesses are due to

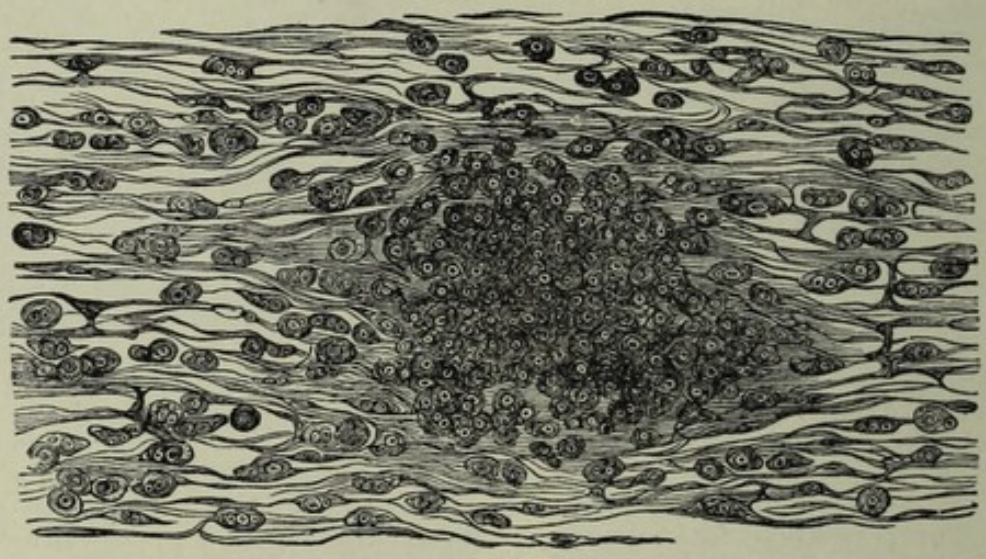


FIG. 33.—Infiltration of connective tissue of cutis (× 500) with beginning suppuration in the center (Senn).

staphylococci. Colon bacilli, typhoid bacilli, or pneumococci may be causal. Pyogenic bacteria attack exudates or tissues, form irritants which cause inflammation or intensify existing inflammation, and by exerting a peptonizing action on intercellular substance and the fibrin of the exudate, liquefy tissue and the products of inflammation, and form pus. As a rule, within twenty-four hours after lodgment of the bacteria the exudation increases in amount, the migrated leukocytes gather in enormous numbers, the fibers of tissues swell, and the connective-tissue spaces distend with cells and fluid. The connective-tissue cells, acted on by pus cocci, multiply by karyokinesis, develop many nuclei, lose their stellate projections, degenerate, and constitute one form of pus-corpuscle, leukocytes forming the other. All the small vessels are choked with leukocytes, this blocking serving to cut off nourishment and tending to produce anemic necrosis. Liquefaction occurs at many foci of the inflamed area, drops of pus being formed, the amount of each being progressively added to and many foci coalescing (Fig. 33). The pus-cavity is circumscribed, not by a secreting pyogenic membrane, but by a mass of fibroblasts whose cells and intercellular material have not as yet broken down; such a mass of fibroblasts is often called embryonic tissue, and it is circumscribed by a zone of inflammation in which there are hordes of migrated leukocytes (Fig. 34). As an abscess increases in size, the embryonic tissue from within outward liquefies into pus, and the zone of inflammation beyond continually enlarges and forms more embryonic tissue.

After a time the inflammation reaches the surface, the embryonic tissue glues the superficial to the deeper parts, the superficial parts inflame and become embryonic tissue, and the intercellular substance is liquefied. When pus has all but reached the surface, a thin layer of tissue only being undestroyed, an elevation or tit of thin tissue is formed, due to the fluid pressure. This process is known as *pointing*. The elevation or point thins from tension and liquefaction, and finally gives way and *spontaneous evacuation* occurs. When an abscess forms in an internal organ or in some structure which is not loose, like connective tissue—for instance, in a lymphatic gland—a mass of pyogenic bacteria, floating in the blood or lymph, lodges, and these bacteria by means of irritant products cause coagulation necrosis of the adjacent tissue and inflammatory exudation around it. The area of coagulation necrosis becomes filled with white blood-cells, and the dry necrosed part is liquefied by the cocci. Suppuration in dense structures causes considerable masses of tissue to die and to be cast off, and these masses float in the pus. Death of a mass with dissolution of its elements is necrosis, or inflammatory gangrene. Pus travels in the line of least resistance. It may reach a free surface, or may break into a cavity or joint, may invade bone or destroy a vessel. When an abscess ceases to spread or is evacuated, the fibroblastic layer forming the walls becomes vascularized and is converted into *granulation tissue*. An abscess heals by the collapse of its walls and fusion of the granulations (union by third intention), or by granulation (union by second intention). In either case granulation tissue is ultimately converted into fibrous or scar tissue.

Forms of Abscesses.—The following are the various forms of abscesses: *Acute*, which follows an acute inflammation. *Strumous*, *cold*, *lymphatic*, *tuberculous*, or *chronic* abscess is due to the bacilli of tuberculosis, and does not contain true pus unless there is secondary infection. It presents no signs of inflammation. Such an abscess occasionally forms in a week or two, and hence is not necessarily chronic. *Caseous* or *cheesy* abscess, a cavity containing thick cheesy masses, is due perhaps to the fatty degeneration of inflammatory exudate and pus-corpuscles, but most commonly results from the caseation of a tuberculous focus. *Circumscribed* abscess is one limited by a layer of fibroblasts. *Diffused* abscess is an unlimited collection of pus, in reality not an abscess, but either a purulent effusion or a purulent infiltration. *Congestive*, *gravitative*, *wandering*, or *hypostatic* abscess is a collection of pus or tuberculous matter which travels from its formation point and appears at some distant spot (as a psoas abscess). *Critical* or *consecutive* abscess is one which arises during an acute disease. *Diathetic* abscess finds its predisposing cause in a diathesis. *Embolic* abscess is due to an infected embolus. *Tympanitic* or *emphysematous* abscess is one which contains air or the gases of putrefaction. *Encysted* abscess, in which pus is circumscribed in a serous cavity. *Fecal* or *stercoraceous* abscess is one containing feces in consequence of a communication with the bowel. *Follicular* abscess is one arising in a follicle; *hematic* abscess, one arising around a blood-clot, as a suppurating hematoma; *marginal* abscess, which appears upon the margin of the anus. *Pyemic* or *metastatic* abscess is the embolic abscess of pyemia. *Milk* abscess is an abscess in the breast of a nursing woman. *Ossifluent* abscess arises from diseased bone. *Psoas* abscess is a tuberculous abscess arising from vertebral caries, the matter following the psoas muscle, and usually pointing in the groin (see page 173). A *sympathetic* abscess, arising some distance from the exciting cause, such as a suppurating bubo from chancroid, is not in reality sympathetic, because infective material has been carried from the primary focus. *Thecal* abscess is a purulent effusion in a tendon-sheath. *Tropical* abscess is an abscess of the liver, so named because it occurs chiefly in those dwelling in tropical countries: it usually follows dysentery. *Urinary* abscess, caused by extravasated urine. A *verminous* abscess is one which contains intestinal worms and communicates with the bowel. A *syphilitic* abscess occurs in the bones during tertiary syphilis, and is gummatous and not primarily pyogenic. *Brodie's* abscess is a chronic abscess of the head of a long bone, most common in the head of the tibia (see page 455). A *superficial* abscess occurs above the deep fascia; a *deep* abscess occurs below the deep fascia. A

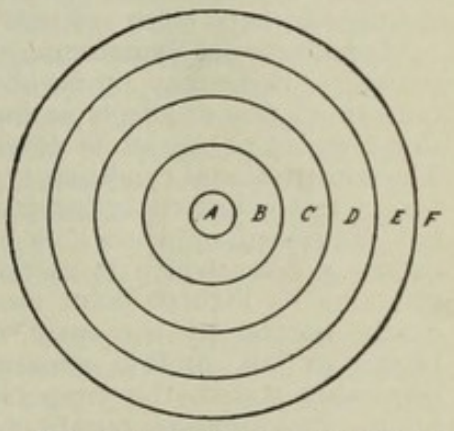


FIG. 34.—Diagram of an abscess: *A*, Pus; *B*, layer of fibroblasts; *C*, tissue infiltrated with leukocytes; *D*, zone of stasis; *E*, zone of active hyperemia; *F*, healthy tissue.

residual or *Paget's* abscess is a recurrence of active changes around the residue of a former tuberculous abscess (see page 169).

Symptoms of Acute Abscesses.—In an acute abscess, as before stated, a part becomes inflamed and a quantity of fibroblasts are formed; fibroblastic tissue is liquefied (as above noted) and pus is produced. An acute abscess can occur in a person of any constitution.

Local Symptoms.—Locally, there is intensification of inflammatory signs and enormous increase of the swelling. At first the area is hard, but afterward becomes soft, and it finally fluctuates. The discoloration becomes dusky. The pain becomes throbbing and the sense of tension increases. The pain is greater the denser the implicated tissue and the greater the number of nerves it contains. At every pulse-beat the tension in the abscess increases temporarily, and hence the pain momentarily increases. Pain is increased by a dependent position of the part. There is great tenderness. The pain may be felt at the seat of suppuration or may be referred to some distant point. Tenderness is located at the focus of disease. The cutaneous surface, if the abscess is adjacent, appears polished and is edematous, after a time fluctuation can be detected, and eventually pointing is observed. If pus is deeply situated the skin may not be reddened, and perhaps the area of induration cannot be palpated. In such a case there is often rigidity of the muscles overlying the abscess (as in abdominal suppurations), the skin may be edematous (as in deep abscess of the neck), and besides local pain there may be pain due to pressure upon a nerve-trunk, the pain perhaps being referred to a distant point.

Constitutional Symptoms.—If there is a small collection of pus in an unimportant structure, there may be no obvious constitutional disturbance. If the abscess contains much pus or affects an important part, disturbances are certain to appear, from slight rigors or moderate fever to chills, high temperature, and drenching sweats. The constitutional condition typical of an abscess is due to the absorption of retained toxins, and is known as "suppurative fever" (see page 60). When an abscess is open but ill-drained, or when it is unopened and deep seated, long-continued suppuration causes a fever which is markedly periodic: the temperature rises in the evening, attaining its highest point usually between 4 and 8 P. M., and sinks to normal or nearly normal in the early morning (from 4 to 8 A. M.). When the temperature begins to fall, profuse sweating takes place. This fever is known as *hectic*. As previously stated, the temperature may be normal or subnormal in abscess of the brain. Prolonged suppuration causes albuminoid changes in various organs, notably in the liver, spleen, and kidneys. Albuminoid changes are especially common when there has been mixed infection of a tuberculous area and long-continued suppuration. It also occurs as a result of protracted suppuration of old syphilitic lesions.

J. C. DaCosta, Jr. ("Clinical Hematology"), tells us that "in both trivial and extensive pus foci the number of leukocytes may be normal or even subnormal; in the former instance because systemic reaction is not provoked, and in the latter because it is overpowered. Leukocytosis may also be absent in case toxic absorption is impossible, owing to the complete walling off of the abscess. In all other instances save these a definite and usually well-marked leukocytosis occurs, amounting on the average to a count of about twice the mean normal standard, but frequently greatly exceeding this figure in the individual case."

The signs and symptoms of an abscess are somewhat modified by location, and it would seem wise to discuss acute abscesses in different situations.

Acute Abscesses in Various Regions.—*Abscess of the brain* may follow cerebral concussion or fracture of the skull, may result from a wound, may arise during a general infection, but in about 50 per cent. of cases results from chronic suppurative disease of the middle ear. In *abscess* of a silent region of the *brain* symptoms may long be entirely absent. The usual symptoms are a temporary initial rise of temperature, which soon gives place to a normal and in one-half of the cases of a subnormal temperature, headache, vomiting, delirium, drowsiness, and choked disk. Localizing symptoms, spasmodic or paralytic, may be present. There is usually but not always leukocytosis. In but few uncomplicated cases are there elevated temperature and sweats at the height of the process. Toward the end of the case there may be elevated temperature and delirium. In extradural abscess there is fever from beginning to end (see page 764).

Appendiceal or *appendicular abscess* results from inflammation, usually but not always with perforation of the vermiform appendix, plastic peritonitis leading to agglutination of the mesentery and omentum, adhesion of the bowels and mesentery, and the formation of a barrier of leukocytes and a mass of fibroblasts. This process

circumscribes the pus. If the pus in suppurative appendicitis has been formed by colon bacilli or staphylococci, it will probably be circumscribed and limited. If the pus has been formed by streptococci, it will probably not be limited, and the peritoneum will be attacked by diffuse septic peritonitis. The signs of appendicular abscess are pain, tenderness, muscular rigidity, and the existence of a mass in the right iliac fossa. The mass may be palpated through the abdominal wall or perhaps the rectum and is dull on percussion. There may be vomiting, and sometimes constipation and sometimes diarrhea. Very seldom is there skin edema and fluctuation. The patient lies upon his back, usually with one or both thighs flexed. In appendicular abscess there is fever, usually higher at night than in the morning and profuse sweating occurring during the fall. In some cases the temperature is persistently high; in some the elevation is trivial; in some chills occur. A sudden fall of temperature with shock is produced by rupture of the abscess wall. If this accident happens, general peritonitis quickly arises. In appendicular abscess there is marked leukocytosis, unless the walls are very thick or unless the process has diffused and general peritonitis has taken place, in which conditions it may be absent. Appendiceal abscess may be assumed to exist when the symptoms of appendicitis persist after the fifth or sixth day, or when, after the symptoms have subsided, they reappear a day or two later (see page 991).

Abscess of the liver may not be announced by symptoms until rupture. It may follow dysentery, may be a result of the lodgment of infected clots from the hemorrhoid veins, may follow upon the infective phlebitis of appendicitis, may result from septic cholangitis or suppuration of a hydatid cyst. Abscess from dysentery is apt to be solitary. Portal infection induces multiple abscesses. We speak now of solitary abscess. The bacterial origin of this is improbable. Amebæ are usually present. We usually find fever of an intermittent type, profuse sweats, pain in the back, the right shoulder, or the right hypochondriac region, enlargement of the area of liver dulness, and hepatic tenderness. Sometimes there are fluctuation and skin edema over the liver, and the general cutaneous surface may be a little jaundiced. The symptoms vary as the pus invades adjacent organs. When there are pain on respiration and evidences of diaphragmatic pleuritis, the pus is probably breaking into the pleural sac. There may or may not be leukocytosis (see page 1019).

Deep Abscess of the Neck.—The majority of these abscesses are due to suppuration of lymph-glands, bacteria having reached the glands from an adjacent area of infection, cutaneous, mucous, or osseous. Suppuration beneath the deep fascia induces dusky discoloration of the surface, great pain, extensive edematous swelling, and often interference with respiration. The constitutional evidences of suppuration are noted. Acute suppuration under the deep fascia of the submaxillary region causes extensive inflammatory edema, interference with respiration and deglutition, violent constitutional symptoms, and often sloughing of tissues (see Ludwig's Angina). A deep abscess over the carotid artery is lifted by each arterial beat and may be mistaken for aneurysm, but the pulsation is not expansile. The pus of a deep abscess may track its way into the mediastinum or axilla, or the abscess may break into a large blood-vessel, the pharynx, the wind-pipe, or the gullet.

Axillary Abscess.—Superficial abscesses are usually multiple, are in reality furuncles, and result from infection of the sweat-glands and hair-follicles.

Deep abscesses are in most instances due to suppuration of the axillary lymph-glands. The most common cause is an infected wound or a focus of suppuration about the hand, forearm, arm, or chest, but they may result from caries of a rib, or may follow a deep cervical abscess. An axillary abscess may be lifted at each beat of the artery and to this extent it resembles an aneurysm, but the pulsation is not expansile.

Acute retropharyngeal abscess is usually due to suppurative lymphadenitis. It is a rare disease, except in infants. The abscess usually forms upon one of the lateral halves of the pharynx. The retropharyngeal lymph-glands are on each side, between the wall of the pharynx and the rectus capitis anticus major muscle in front of the first and second cervical vertebræ (Cunningham's "Anatomy"). An abscess may be due to traumatism, to acute infectious diseases, to infective processes of the mucous membrane of the mouth, ear, and nasopharynx, to pyogenic infection of a tuberculous abscess, to vertebral or occipital osteomyelitis. In 40 per cent. of cases infection of the nose or ears is the assigned cause (Wishart in "Canadian Med. Assoc. Jour.," Sept., 1923). In the great majority of cases the disease is due to suppuration of the deep cervical glands. Lymphadenitis need not of necessity eventuate in abscess. Pus may find its way into the mediastinum and may break into a bronchus, the esophagus, or a great vessel. If an abscess breaks into the wind-pipe or a bronchus it will

cause, probably, death by asphyxia. Edema of the glottis is to be apprehended in all cases. There is pain, difficulty in swallowing, dyspnea, nasal voice, bulging into the pharynx, which is detected by inspection and palpation, enlargement of the deep cervical glands, fever, sweats, and great weakness. An infant is observed to breathe and swallow with difficulty, and the neck is swollen. Tuberculous Retropharyngeal Abscess is considered on page 172.

Subphrenic or *subdiaphragmatic abscess* is apt to begin beneath the diaphragm, though in some few instances the pus forms above this muscle, and subsequently gains access to the region beneath. Such an abscess may contain not only pus, but gas, and in some cases also fluid from the stomach or intestine. The gas of a subphrenic abscess may have entered from a perforation of a hollow viscus or may have been made by gas-forming bacteria. Subphrenic abscess may arise after perforation of the bowel or stomach, or it may result from infected spinal abscess, perinephric abscess, traumatism, abscess of liver, kidney, spleen or pancreas, empyema, or pneumonia (Greig Smith's "Abdominal Surgery"). Inflammation of the gall-bladder or appendicitis may cause it. The symptoms are pain, fever, sweats, dyspnea, cough, and the physical signs of a collection of fluid beneath the diaphragm and often of gas in the cavity of the abscess. There is usually leukocytosis (see page 72).

Abscess of the lung gives the physical signs of a cavity; the expectoration is offensive and contains fragments of lung tissue. An abscess may usually be located by the use of the *x*-rays. Pyemic abscesses may exist and yet escape discovery. (See Surgery of Respiratory Organs.)

Abscess of the mediastinum may arise secondarily to deep abscess of the neck or vertebral suppuration; suppuration of the mediastinal glands, lung, or pleura, caries of a rib or of the sternum, ulceration of the esophagus or pericarditis. It causes throbbing retrosternal pain, pain in the back, chills, fever, sweats, irregular pulse, and often dyspnea. A lump may appear which pulsates and fluctuates, but the pulsation is not expansile.

Perinephric abscess usually causes tenderness and pain in the lumbar region or about the hip-joint, this pain perhaps running down the thigh and being accompanied by pain in and retraction of the testicle. Induration or edema of the skin may be observed in the lumbar region. If fluctuation occurs at all it is a very late sign. The constitutional symptoms of suppuration usually exist (see page 72). There is usually a high leukocytosis.

Abscess or *empyema of the antrum of Highmore* is a collection of pus within the maxillary antrum. It results from inflammation of the jaw, the teeth, or the mucous membrane of the nose. It causes pain, edematous swelling of the overlying soft parts, and crepitation on pressure upon the superior maxillary bone. Pus may escape from the nostril of the diseased side when the head is bent in the direction of the healthy side. A rhinoscopic examination discloses the fluid passing into the nares. The antrum on the side of the abscess cannot be transilluminated by an electric light in the mouth (*Garel's sign*). The constitutional symptoms of suppuration usually arise.

Alveolar abscess is suppurative dental periostitis due to diseased teeth. The simplest form is a *gum-boil*, a collection of pus between the gum and the bone external to the inflamed root of a tooth. In more severe cases the suppuration begins within the tooth socket and the pus escapes around the neck of the tooth; a distinct and local abscess may be situated at the end of the root, absorption of bone having occurred, or a considerable cavity may form in the bone, the external maxillary plate being perforated. In the very severe cases the cheek is involved. An alveolar abscess may break through the gum into the mouth or it may break externally through the cheek. Acute alveolar abscess causes intense pulsatile pain, marked swelling of the gum and cheek, and sometimes very great edematous and dusky swelling of the face. A sinus may follow its evacuation. Dead bone may form. A chronic apical abscess may give rise to no definite symptoms and yet be a focus of infection leading to distant infection of bone, gland, joint, pleura, etc.

Abscess of the larynx invariably causes laryngeal edema, which obstructs respiration and puts life in jeopardy. Such an abscess is most apt to appear upon the oral surface of the epiglottis, but may arise within the larynx. It induces violent cough, pain, interference with the voice, swallowing, and breathing, and the swelling can often be felt with a finger and can always be seen by the aid of a laryngoscope.

An *ischiorectal abscess* is situated in the areolar tissue of the ischiorectal fossa. The pyogenic organisms usually gain entrance to the lymphatics by way of an abrasion, fissure, or ulceration of the rectum or anus. A perforation made by a foreign body

may inaugurate the condition. In rare cases bacteria reach the fossa in the blood-stream. The condition may be due to pyogenic infection of a tuberculous focus. The pain is severe and throbbing; there are great tenderness, redness and edema of skin, induration, and usually the constitutional symptoms of pus formation. Fluctuation is a very late sign because of the density of the fascia.

Prostatic abscess may result from catheter infection, from infection of the bladder or urethra, or from traumatism, but the commonest cause is gonorrhea. There may be one abscess, several abscesses, or many abscesses. Pus may break into the rectum, the bladder, or the urethra, or may break externally. A prostatic abscess is manifested by chills, fever, sweats, frequent and painful micturition, tenderness of the perineum and rectum, and agonizing pain, developing during an attack of acute prostitis. A finger in the rectum can palpate the swollen gland.

Abscess of the breast follows absorption of pyogenic bacteria from a fissure or abrasion of the nipple. Some surgeons maintain that the bacteria enter along the milk-ducts, while others assert that they gain entrance by the lymphatics. It is most common in nursing women. Its symptoms are swelling, tenderness, pulsatile pain, dusky discoloration, skin edema, fluctuation, and usually constitutional disorder. (See Mastitis.)

Orbital abscess is a diffuse suppuration due to cellulitis or a collection of pus due to caries or necrosis of the orbital wall, suppuration of the accessory nasal sinus, facial erysipelas, or dental caries. A wound may cause it. In severe orbital cellulitis the movements of the eye are limited, the lids are very red and edematous, the conjunctiva is red and swollen (chemosis), and, if the case is not promptly relieved, optic neuritis may arise and sloughing of the cornea occur.

Von Bezold's Abscess.—In this condition the pus of a suppurating mastoid process breaks through the mastoid near the tip and enters into the sheath of the digastric muscle or the sheath of the sternocleidomastoid. There exist extensive inflammatory swelling of the neck, a history of mastoid trouble, usually a lessened amount of pus flows from the ear, pain in the neck, and constitutional symptoms. The condition suggests thrombosis of the lateral sinus, but the symptoms are not so violent and are not pyemic as they are in that disease.

Abscess of the Groin or Pyogenic Bubo.—Such an abscess may have mounted up from the pelvis, tracked forward from the sacro-iliac joint, or descended in the psoas sheath from the vertebræ, but in a very great majority of cases it is due to suppuration of the lymphatic glands. A bubo may be tuberculous, venereal, or pyogenic. A pyogenic bubo results from an area of infection in the trajectory drained by the lymph-vessels of the inguinal or femoral glands. The glands involved may be superficial or deep. The symptoms are those ordinarliy linked with suppuration. Occasionally the pulsations of the great vessels may lift the mass.

Abscess of the Popliteal Space.—This results from traumatism, mixed infection of a tuberculous or syphilitic area, suppuration of the contained lymph-glands, of one of the adjacent bursæ, or of the neighboring bone. In rare cases it arises as a result of suppuration of the sac of an aneurysm. The symptoms are severe pain, swelling, flexion of the knee, and edema of the leg. The pulsations of the popliteal artery may be transmitted to the abscess. These pulsations are not expansile, as in aneurysm. Pus may pass under the deep fascia, up or down the extremity, or may break into the knee-joint.

Suppurative thecitis or *felon* is a form of diffuse suppuration. (See Felon.)

Palmar abscess is a purulent effusion (see page 677).

Furuncle and *carbuncle* are discussed on pages 66 and 68.

Empyema is a purulent effusion into the pleural sac (see page 877). It is technically an abscess if it becomes encapsuled.

Diagnosis.—The diagnosis of an abscess rests upon: (1) its history; (2) fluctuation; (3) pointing; (4) surface edema; (5) the use of the tubular exploring needle; (6) fever and leukocytosis.

Fluctuation is the sensation imparted to a finger held against a cavity containing fluid when a wave is started in the fluid by striking the mass with a finger of the other hand. Fluctuation cannot be obtained if the amount of fluid is small. It should never be sought for across a limb, but rather along it, because a false sense of fluctuation can always be obtained across the muscles of the limb. *Pointing* and *surface edema* have been discussed.

A suspected abscess in a part containing large blood-vessels under no circumstance should be opened by a bistoury without knowing that the diagnosis is certainly correct. This knowledge is obtained in some cases by inserting a small aspirating needle and

observing the nature of the fluid which exudes. This operation must be performed with aseptic care; otherwise, if there is no abscess, infection may be inaugurated; if there is an abscess, mixed infection may occur. The older operators used a grooved exploring needle, but many able surgeons object to its use on the ground that when plunged into an infected area pus bathes the track of puncture and may cause infection of other tissues and diffusion of the pyogenic process. The tubular exploring needle is the proper instrument.

An abscess which moves with the pulse because it rests upon an artery may be confounded with an aneurysm. The pulse movements of such an abscess are in one direction only; the abscess is lifted with each pulse-beat, but does not enlarge, and if a finger is laid upon either side of it the fingers will be lifted, but not separated. The pulse movements of an aneurysm are in all directions; they are expansile, the sac grows larger, and the fingers will not only be lifted, but will also be separated. The small tubular exploring needle may be used in doubtful cases; if aseptic, it will do no harm even to an aneurysm. A rapidly growing, small-cell sarcoma feels not unlike an abscess, but the exploring needle discovers blood and not pus. A cystic tumor is separated from an abscess by the absence of inflammation, or, if it inflames, by the nature of the contained fluid. Ordinary caution will prevent one confounding an abscess with strangulated hernia. A tuberculous abscess is separated from an acute abscess by the absence of inflammatory signs in the former. The contents of the acute abscess differ from those of the tuberculous abscess. When an abscess exists in an important region (brain, appendix, liver, etc.) cultures of the pus should be taken after incision. Such studies often give valuable information as to the probable course of the condition, and an accumulation of many accurate observations will add greatly to scientific information. Figure 35 shows a convenient case for carrying culture-tubes.

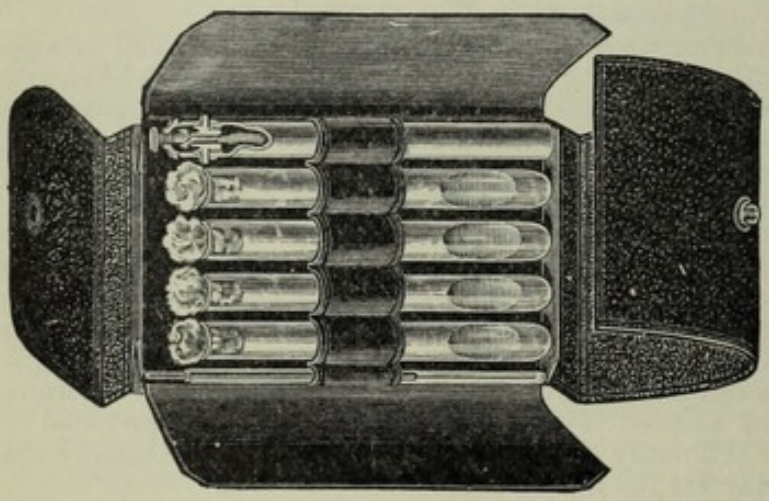


FIG. 35.—Vischer's case for carrying culture-tubes for inoculation.

Prognosis.—The prognosis varies according to the number of abscesses, their location and size, the vital resistance of the patient, and the virulence of the causative bacteria.

Treatment.—In the treatment of an abscess there is one absolute rule which knows no exception, namely, that whenever and wherever pus is found the abscess should be evacuated at once, and, after evacuation, thorough drainage must be provided for. It should be opened up early, if possible, even before fluctuation and positively before pointing, to prevent tissue destruction, subfascial burrowing, and general contamination. Drainage is continued until the discharge becomes scanty, thin, and seropurulent.

Alveolar abscess requires prompt incision through the gum, extraction of the diseased tooth in most cases, and the rinsing of the mouth at frequent intervals with hot fluid. Heat should not be applied to the cheek or jaw externally, as it would favor external rupture. If spontaneous rupture externally is inevitable, then an incision must be made at the point where the abscess is nearest the surface. The cut will leave less scar than will spontaneous evacuation. It is necessary to gouge through the external table of the bone if pus is lodged between the two osseous plates.

Abscess of the liver, if pointing forward or downward, and if the liver is adherent to the parietal peritoneum, is opened at one operation; if the liver is not adherent, some surgeons operate in two stages. In the two-stage operation an incision is made along the edge of the ribs down to the liver, which organ is then stitched to the edges of the wound. In a day or two after the first operation the two layers of peritoneum are firmly adherent, and the abscess can be opened without danger of the passage of pus into the peritoneal cavity. The abscess, located by an aspirating needle, is opened by the Paquelin cautery, is washed out with salt solution, and a tube is inserted. If care is taken the operation can be safely completed in one

séance even if the liver is not adherent to the parietal peritoneum. If this course is determined on, after the liver is exposed by incision, the exposed surface of the organ is surrounded with iodoform gauze, the abscess is located by an aspirating needle, is opened by the cautery, is irrigated and drained as directed above. Some physicians try to locate an abscess by plunging an aspirating needle into the liver before making an abdominal incision. This procedure seems to me uncertain and dangerous. An abscess of the dome of the right lobe of the liver (the commonest seat) should be reached by resecting a rib, incising the pleura, and opening through the diaphragm (transthoracic hepatotomy).

Abscess of the mediastinum, like all other abscesses, requires incision and drainage. This is effected, if the abscess can be reached in front, by cutting between the rib cartilages or by trephining the sternum. Abscess of the posterior mediastinum can be reached only by resecting portions of several ribs near their vertebral ends.

In *abscess of the lung* an incision is made and the pleura is exposed. The incision is usually through an intercostal space; but if the spaces are narrow it will be necessary to resect a rib. If the two layers of pleura are found adherent the operation is proceeded with. If they are not adherent they are stitched to each other and to the lung with catgut sutures, and the surgeon waits forty-eight hours before continuing. This precaution is taken in order to prevent collapse of the lung from acute traumatic pneumothorax, and to save the pleura from receiving pus during operation. The operation is completed by locating the pus by means of an aspirating needle, evacuating it by the cautery at a dull-red heat, and inserting a drainage-tube into the abscess cavity (see page 889).

A *subphrenic abscess* requires operation at once. Immediately before operating, if in doubt, it may be justifiable to endeavor to locate pus with an aspirating needle. Incise the abscess and open any secondary abscesses. Many abscesses point below the diaphragm, and are easily reached by an incision in the loin or in the epigastric region. Lannelonge resects the eleventh and twelfth ribs and raises the pleura out of the way. Some surgeons prefer to practise rib resection and incise the adherent pleural layer of the diaphragm. After drainage has been continued for a time it may be necessary to do a secondary operation in order to cure the lesion causative of the abscess, for instance, it may be necessary to close a chronic gastric perforation (see page 1015).

In *abscess of the antrum of Highmore* bore a gimlet-hole through the superior maxillary bone, above the canine tooth, or perforate the bone by means of a trocar. Irrigate daily with boiled water or normal salt solution. Prevent contraction of the opening by inserting a small piece of rubber tissue fastened externally to keep it from slipping in. In persistent cases it may be necessary to draw a tooth, break through the socket of the first or second bicuspid into the antrum, and insert a silver or hard-rubber tube, and also to perforate the antrum from the inferior meatus and keep the opening patent. In very persistent cases osteoplastic resection of a portion of the upper jaw will be demanded.

In *appendicular abscess* incise, support the abscess walls with gauze, remove the appendix in most cases, but not in all, and insert a drainage-tube and strands of gauze (see page 1055).

An *ischiorectal abscess* must be opened early. The surgeon never waits for fluctuation. Fluctuation is a very late symptom. To wait for it entails great destruction of tissue and serves no useful purpose. Place the patient on his side, with the legs drawn up. Insert a finger in the rectum, lift the abscess toward the surface and incise it from the surface. The incision runs from the anal margin like a spoke from the hub of a wheel. Cut away the roof of skin. Irrigate with salt solution, inject iodoform emulsion, pack with iodoform gauze, dress, and later let the patient know he is in danger of developing a fistula.

A *retropharyngeal abscess* must be opened early, because delay may lead to fatal obstruction and because if spontaneous evacuation occurs the patient may be suffocated. The condition is a grave surgical emergency. Many surgeons open it from within the mouth. This plan, it has been said, exposes the patient to the danger of septic bronchopneumonia from inhalation of purulent elements and to serious gastrointestinal disorder from swallowing quantities of pus. Again, if opened through the mouth, the abscess is liable to become putrid. Forty-one cases in the Toronto Hospital for Sick Children were opened from within the mouth and not one died (Wishart in "Canadian Med. Assoc. Jour.," Sept., 1923). Wishart's technic is as follows: Do not give an anesthetic. Swathe the child, insert a mouth-gag. Depress the tongue, using an electric light for inspection. Plunge closed scissors into the swelling, open the in-

strument, withdraw it, have the child at once thrown on the side with the tongue depressor held in place. The pus will not then flow into the larynx and trachea. Some surgeons prefer to open it from the neck by Hilton's method, the incision being carried through the sternocleidomastoid muscle or posterior to it. Drainage is inserted and the abscess is treated in the usual way. The operation is performed with the aid of infiltration anesthesia.

In *abscess of the breast* make an incision radiating from the nipple, or, what is better, incise under the breast by means of a cut at the inferior thoracic mammary junction and enter the abscess from beneath.

In *abscess of the brain* the skull should be trephined, the membranes incised, and the abscess sought for, opened, and drained (see page 763).

In suppuration within the *orbit* due to cellulitis, incise the conjunctiva and drain. In suppuration due to caries or necrosis of the upper orbital wall make a transverse incision through the upper lid, reach the pus by Hilton's method (see page 79), remove carious or loose necrotic bone, and drain.

A *perinephric abscess* requires an incision in the lumbar region and free drainage.

An *abscess of the larynx* requires immediate incision, scarification, and inhalation of steam to abate swelling. In a severe case the surgeon should at once perform tracheotomy.

Bezold's abscess requires one or more incisons in the neck for drainage. Then the mastoid is exposed, its tip, including the osseous fistula, is removed, and its interior is cleared out by a complete operation.

A *prostatic abscess* should be opened promptly by a perineal incision.

In an ordinary *superficial abscess*, after cleansing the parts, make the skin tense, locate the superficial vessels and nerves, and plan the incision to avoid them. Incise with a sharp-pointed curved bistoury at the most dependent part of the abscess or through the region of pointing. If the abscess is upon the face or neck, make the incision in the line of the skin creases so as to limit the scar. The incision must not be made suddenly and fiercely, neither should it be made with hesitation and uncertainty. Thomas Bryant says: "It should be done, as ought every other act of surgery, with confidence and decision, boldness and rapidity of action being governed by caution and made subservient to safety" ("Practice of Surgery"). Permit the pus to run out spontaneously; pressure, as a rule, is undesirable because it may damage the abscess wall and cause diffusion of the infection. If tissue shreds block the opening, they must be picked out with forceps. If the atmospheric pressure will not cause the pus to flow out, make light pressure with warm, moist, aseptic gauze pads. After the pus has come away, gently wash the cavity with normal salt solution or boiled water, and drain with a tube for two or three days when the discharge will become serous. It is not desirable to overdistend the abscess cavity with fluid, because the hydrostatic pressure may break down the wall of young cells and infection be diffused. Do not irrigate with powerful disinfectants. They cannot be used strong enough to really disinfect, but may easily be used strong enough to cause necrosis of an abscess wall. Peroxid of hydrogen is not to be used unless the incision is large, because the gas it generates may tear the abscess wall and diffuse the infection. Peroxid of hydrogen is a dangerous agent to inject into the cavity of a deep abscess of the neck, as the liberated gas may not escape from the opening, but may pass widely into the tissues and cause great distention. The author saw a child who narrowly escaped death after such an injection. In this patient the gas passed beneath the pharyngeal mucous membrane and the swelling almost occluded the air passages. If an abscess contains putrid pus the incision should be free, and after evacuation the cavity should be irrigated with hot salt solution or peroxid of hydrogen and injected with iodoform emulsion. Pursue rigid antisepsis in dealing with purulent areas. It is true we already have infection with pyogenic bacteria, but infection can also take place with organisms of putrefaction, causing pus to become putrid, or with other bacteria, for instance, those of tetanus. If a tube is not used and the cavity is filled with iodoform gauze, remember that gauze will not drain pus and requires to be changed once a day or oftener. An abscess should be dressed with hot, moist, antiseptic dressings (antiseptic fomentation) and the part must be put at rest. When the discharge becomes thin and scanty, dry aseptic or antiseptic dressings are used.

In a *deep abscess* or an abscess situated near important vessels do not boldly plunge in a knife. Hilton says to "plunge in a knife is not courageous, as it is without danger to the surgeon, but may be fatal to the patient." A brilliant surgeon, Mr. Dease, of Dublin, plunged a knife into a femoral aneurysm, mistaking it for an abscess. The

artery was tied at once, but the patient quickly died. Mr. Dease saw his other patients, went to his home, cut his own femoral artery, and bled to death. Remember also that a large amount of pus displaces normal anatomic relations. *Hilton's method* of opening a deep abscess (as in the axilla or neck) is to cut to the deep fascia, nick the fascia with a knife, and then push into the abscess a grooved director until pus shows in the groove; along the groove push a pair of closed dressing forceps; after they reach the depths take out the director, open the forceps, and withdraw them while open, and so dilate the opening, then insert a tube and gently irrigate the cavity with warm salt solution.

Always endeavor to open an abscess at its most dependent part, remembering that the situation of this part may depend upon whether the patient is to be erect or recumbent. If we do not make the opening at the lowest point, all the pus will not run out and the walls will not completely collapse. If the opening is not at the most dependent point the projecting end of the tube should be long enough to reach below the level of the bottom of the pus cavity, and the interior of the tube should be moistened from time to time with salt solution to keep the discharge from drying and caking. A deep abscess must be drained thoroughly until the discharge becomes seropurulent. When the tube is removed it is wise to insert a piece of rubber tissue just through the outlet of the abscess. This tent prevents the skin from closing over the channel. It is removed and a new one inserted every day until it is clear that there is no longer danger of fluid becoming blocked and retained. When an abscess contains diverticula or pouches they should be slit up or a counteropening ought to be made. A counteropening is made by entering the dressing forceps at the first incision, pushing them through the abscess to the point where we wish to make our counteropening, opening the blades, and cutting between them from without inward. The blades are then closed and projected through the incision; they are opened in order to dilate the new door, and are closed again upon a drainage-tube, which is pulled through from opening to opening as the instrument is withdrawn. When pus burrows, insert a grooved director in each channel and slit the sinus with a knife. An abscess may make an opening through dense fascia, the opening being small like the neck of an hour-glass (*shirt-stud abscess*). Always examine to see if such a condition exists, and if it is found, incise the fascia.

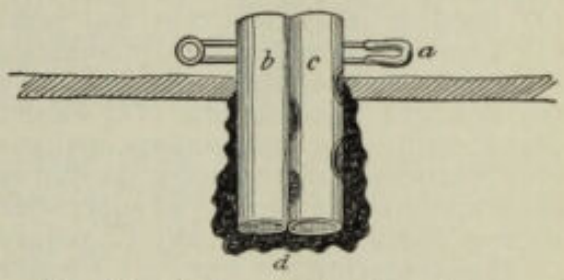


FIG. 36.—Drainage-tubes for abscess requiring irrigation. The abscess has been opened at its most dependent point.

In a deep abscess containing putrid pus frequent irrigation is desirable. In such a case two tubes may be employed (Fig. 36). The tubes are prevented from slipping in by the use of a safety-pin (*a*). The irrigating fluid is passed into the cavity (*d*) through the tube *b*, which is without fenestra, and most of it runs out through the tube *c*, which possesses fenestra.

Rest is of the first importance in the healing of an abscess, and we try to obtain it by bandages, splints, and pressure, which will immobilize adjacent muscles and approximate the abscess walls. If an abscess is slow to heal, use as a daily injection a solution of corrosive sublimate of the strength of 1 : 1000, or 3 drops of nitric acid to 1 oz. of water, or 3 gr. of zinc sulphate to 1 oz. of water, or a 5 per cent. solution of carbolic acid, or a 2 per cent. aqueous solution of pyoktanin, or 20 drops of tincture of iodin to 1 oz. of water, or a 2 per cent. solution of acetate of aluminum. The constitutional treatment of an abscess depends upon the severity of the morbid process and the importance of the structures involved. In a serious case the patient should be put to bed, opiates should be given with a free hand, the bowels be kept active by calomel and salines, skin activity be maintained, the taking of nutritious food insisted on, and stimulants liberally employed.

Purulent Effusions.—(See Suppurative Thecitis, Palmar Abscess, Suppurative Synovitis, Purulent Peritonitis, Empyema, etc.)

V. ULCERATION AND FISTULA

An **ulcer** is a loss of substance due to molecular death of a superficial structure. The molecular death is brought about by bacteria. Ordinary ulcers are caused by pus organisms. The action of the pus organisms is the same as in an abscess. A broken abscess becomes an ulcer, and an ulcer is in structure a half-section of an abscess. The floor of an ulcer consists of granulation tissue and corresponds to the abscess wall. An abscess arises from molecular death within the tissues; an ulcer, from molecular death of a free surface. An ulcer may increase in size by molecular death of adjacent structures or by sloughing, that is to say, by death of visible masses of tissue. A wound healing by granulation is often wrongly called an ulcer. An ulcer must not be confounded with an excoriation. In an ulcer the corium is always, and the subcutaneous tissue is generally, destroyed, and a scar is left after healing. In an excoriation the mucous layer of epithelium is exposed, or this is destroyed and the corium is exposed. In an excoriation the corium is never destroyed, and no scar remains after healing. An ulcer heals by granulation (see page 50). Embryonic tissue by vascularization becomes granulation tissue, granulation tissue is converted into fibrous tissue, the fibrous tissue contracts, and, by pulling strongly the edges of the ulcer together, lessens the size of the cavity. When the granulations reach the level of the skin the epithelium at the edges of the ulcer proliferates and the sore is soon covered over with new epithelium.

Necrosis of a superficial part may arise from: (1) Inflammation. The pressure of the exudate can cut off the circulation, or bacteria may directly destroy tissue. Suppuration occurs. (2) The action of pus bacteria, causing primary cell necrosis. (3) Bacteria of putrefaction and organisms of suppuration acting upon a wound. (4) Traumatism or irritants, producing at once stasis, which is added to by secondary inflammation, the exudate undergoing purulent liquefaction. (5) Prolonged pressure. (6) Deficient blood-supply. (7) Faulty venous return. (8) Degeneration of a neoplastic infiltration (gummatous, malignant, or tuberculous). (9) Trophic disturbance. (10) Nutritional disturbances (as scurvy). Most ulcers are due directly to pus organisms, and areas of necrosis of superficial parts that arise from something else (as gummatous degeneration) usually suppurate.

Classification.—Ulcers are classified into groups according to the condition of the ulcer and the associated constitutional state. In the first group we find the varicose, hemorrhagic, acute, chronic, irritable, neuralgic, etc. In the second group are placed the tuberculous, syphilitic, senile, scorbutic, etc. All ulcers, whatever their origin, are either *acute* or *chronic*, and such conditions as great pain, hemorrhage, edema, exuberant granulations, phagedena, sloughing, eczema, gout, syphilis, scurvy, etc., are to be looked upon as complications. The leg is so common a site for ulcers as to warrant a special description of ulcers of this part. In describing an ulcer state the patient's previous history and his occupation; the supposed cause; the situation; the outline; the duration, and the mode of onset of the ulcer. A knowledge of the victim's occupation may furnish the key to the cause (for instance, the ulcers of tanners which are due to chrome salts. See the author and Dr. John F. X. Jones in "Annals of Surgery," Feb., 1916). State if the ulcer is single or if multiple sores exist, and if there is or is not pain; whether or not any healing has ever occurred, and the patient's constitutional condition. Set forth the complications; the state of anatomically related glands; the condition of the edge, the floor, and the parts about the ulcer, and the nature and quantity of the discharge.

Acute or **inflamed ulcer of the leg** may follow an acute inflammation and may be acute from the start, or may be first chronic and then become acute. It is especially common in drunkards, and among those of dilapidated constitutions. It is characterized by rapid progress and intense inflammation. There is rarely more than one ulcer. In outline these ulcers are usually oval, but may be irregular. The floor of an acute ulcer contains no granulations, but is composed of raw and inflamed tissues, or is covered by a mass of gray aplastic lymph, or it may have upon it large greenish sloughs. The edges are thin and undermined. The discharge is very profuse and ichorous, excoriating the surrounding parts. The adjacent cutaneous surface is inflamed and edematous, and there is much burning pain. In some cases the glands in the groin enlarge. Constitutionally, there is gastro-intestinal derangement, but rarely fever. When the ulcer spreads with great rapidity and becomes deeper as well as larger in surface area, it is called "phagedenic." The formation of sloughs indicates that tissue death is going on so rapidly that the dead portions have not time to break

down and be cast off. Limited stasis produces molecular death; more extensive stasis, a slough. If a chronic ulcer becomes acute, existing granulations are destroyed.

Treatment.—In treating an acute ulcer of the leg, give a dose of blue mass or calomel, followed in eight or ten hours by a saline (2 dr. each of Rochelle and Epsom salts), and order light diet. Deny stimulants except in a case of diphtheritic ulcer or if the patient is a hard or a regular drinker. Administer opium if pain is severe. Spray the ulcer with hydrogen peroxid, use the scissors and forceps to get rid of sloughs, and after sloughs are removed wash the ulcer with corrosive sublimate solution (1 : 1000) or paint it with pure carbolic acid. Paint the skin adjacent to the ulcer with equal parts of tincture of iodin and alcohol. Dress with hot antiseptic fomentations. Apply a bandage from the toes to well above the ulcer. Insist on the patient remaining in bed with the leg slightly elevated. Change the dressings before they become cool and always as soon as they are saturated with discharge. Every day or two paint the skin about the ulcer with equal parts of iodin and alcohol.

Many cases do very well after antiseptization and dusting the ulcer with iodoform, warm lead-water and laudanum being applied to the inflamed parts around the ulcer; but in a bad case hot antiseptic fomentations, compression, and elevation are more useful until sloughs separate. Dichloramin-T is a valuable drug in the treatment of acute ulcer. If the discharge is offensive, apply acetanilid, aristol, or iodoform, or use 3 gr. of chloral to 1 oz. of water before applying hot fomentations or ordinary antiseptic dressings. A 25 per cent. ointment of ichthyol is very useful when applied to parts around the ulcer. If sloughs continue to form, touch the sloughing area with a 1 : 8 solution of acid nitrate of mercury or with a solution of pure carbolic acid, and reapply antiseptic fomentations. If an ulcer continues to spread, cleanse with peroxid of hydrogen, dry with absorbent cotton, touch with nitrate of mercury solution (1 : 8), and apply antiseptic fomentations. Repeat the application of nitrate of mercury every day until the ulcer ceases to extend and granulations begin to form. When granulations begin to form freely moist hot dressings are no longer desirable, and dry aseptic or antiseptic dressings can be used.

If an ulcer is covered with a great mass of aplastic lymph, touch daily with a solution of silver nitrate (40 gr. to 1 oz.) or with acid nitrate of mercury (1 : 15), and dress with iodoform and antiseptic fomentations. Give internally tonics, stimulants, and nutritious liquid food. In any case, when granulations form, dress antiseptically with dry dressings, moisten daily with dichloramin-T, or employ a non-irritant ointment, such as cosmolin. If granulations form slowly touch them every day with a solution of silver nitrate (10 gr. to the oz.) and dress antiseptically, or apply a stimulating ointment (resin cerate or 1 dr. of ung. hydrarg. nitratis to 7 dr. of ung. petrolii, or an ointment of copper sulphate (3 gr. to the oz.), or dress with gauze soaked in a solution of 3 drops of nitric acid to 1 oz. of gum arabic. When the granulations are healthy cicatrization can be greatly hastened by an application of scarlet red ointment (8 per cent.). This is kept in place for twenty-four hours at a time. It is used intermittently.

Chronic ulcer of the leg is characterized by low action and slow progress. It may be chronic from the start, or it may result from acute ulcer. Usually it is found as a solitary ulcer 2 inches above the internal malleolus. *Syphilitic ulcers* often occur in a group, are usually crescentic, and are frequent upon the front of knee. A *tuberculous ulcer* may have no granulations, but is usually covered with pale edematous granulations, which signify the existence of a tendency to venous stasis. The edges of a tuberculous ulcer are undermined and irregular, the parts about it are livid and tender, and the discharge is thin and scanty (see page 177). An *ordinary chronic ulcer* is circular or oval, and is surrounded by congested, discolored, and indurated skin, this induration being due to fibrous tissue, and there is often eczema or a brown pigmentation of the neighboring skin. The floor of the ulcer is uneven, and usually is covered with granulations, each of which is red and the size of a pin-point, but which may be exuberant or edematous. If granulations are absent, the ulcer has the appearance of a piece of liver, or is smooth and glazed. The edges are thick, turned out, and not sensitive to the touch. Occasionally, but rarely, they are thin and undermined. Some ulcers are indurated and adherent; this adhesion to the deeper structures prevents healing by antagonizing contraction. An ulcer may fail to heal because of severe infection; because of want of rest; because of absence of granulations resulting from deficient blood-supply; because of edematous granulations; because of exuberant granulations; because of adhesion to deep structures, or because of some constitutional disease.

Treatment.—In treating a chronic ulcer give a saline cathartic every day or so. Treat any existing diathesis. Insist on rest and, if possible, elevation. Asepticize

the ulcer. Draw blood by shallow scarifications of the bottom and edges of the ulcer and the skin about it. If the ulcer is adherent to deeper structures, make incisions like those shown in Figs. 37 and 38, each cut going through the deep fascia. These incisions, besides permitting contraction, allow granulations to sprout in the cuts and absorb exudate. Nussbaum advocated encircling the ulcer with an incision about ½ or ⅔ inch away from the edge of the ulcer, the incision passing through the skin. After incision keep the part elevated and dressed antiseptically for two days. In two days after scarification or incision scrape the ulcer with a curet until sound tissue is reached. Use hot antiseptic fomentations for two days more, then paint the parts adjacent to the ulcer with tincture of iodin and alcohol (1 : 3), dress the parts about the ulcer with ichthyol ointment, and dress the ulcer antiseptically or with sterile gauze. In a day or so the use of ichthyol should be discontinued and the ulcer be dressed with sterile gauze, normal salt solution, boric acid, solution of acetate of aluminum, chlorin-water, a solution of permanganate of potassium, sulphur, glutol, or protonuclein. Glutol (formalin-gelatin) is very useful in some cases and so is protonuclein. When healing begins, treat as outlined for healing acute ulcer (see page 81). Baking two or three times a week allays pain and stirs an indolent ulcer to reparative efforts. The temperature employed should be 250°–300° F. A baking should last from half an hour to an hour. During the intervals between the bakings the ulcer should be dressed with scarlet red (Sonnenschein in "N. Y. Med. Jour.," Dec. 19, 1914).

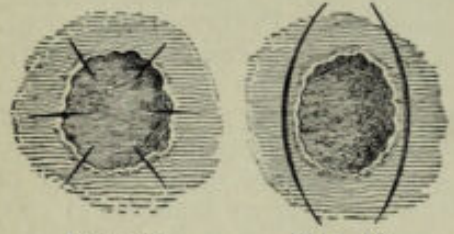


FIG. 37. FIG. 38.

FIGS. 37 and 38.—Incisions for adherent ulcer.

Unna's dressing is satisfactory in many cases. It is applied as a fluid, painted on when hot. It solidifies on cooling and resembles rubber. The paint is made as follows: Dissolve 4 parts of the best gelatin in 10 parts of water by means of a hot-water bath. While the fluid is hot add 10 parts of glycerin, and then 4 parts of powdered white oxid of zinc and stir energetically until the mixture is cold. Melt the paint before using by placing the receptacle in a hot-water bath. The extremity must be clean and thoroughly dry. Apply the paint from just above the roots of the toes to just below the knee. Cover the layer of paint with a gauze bandage; put over this another layer of paint, then another bandage, and so on until three, four, or five bandages have been applied. To prevent wrinkling apply the gauze in short pieces. The outer layer of the dressing is a coat of the paint. This dressing is worn from four to eight weeks unless it loosens sooner. When it loosens, it is changed. If the ulcer discharges freely and stains the dressing, cut a trap-door in the dressing and through this cleanse the ulcer and apply dressings and a bandage as often as necessary (Michael in "Chicago Clinic," No. 8, 1900).

An excellent treatment if the patient must walk about is *camphor*, first recommended by Schulze ("Münchener medicinische Wochenschrift," March 19, 1901). It is most conveniently used, as Walbaum shows, in the form of spirits of camphor (Ibid., June 25, 1901). He applies the dressing in the following manner: Clean the ulcer with green soap and every day apply gauze wet with a 2 per cent. solution of the acetate of aluminum. In about three days the discharge will become scanty and free from odor. It is at this period that camphor should be used. A small piece of gauze wet with spirits of camphor is applied directly upon and only to the ulcer. Over this is applied a large piece of dry sterile gauze, a rubber-dam, a large piece of absorbent cotton, and a bandage from the toes up. Every other day the dressings are removed, the ulcer is washed with a 2 per cent. solution of carbolic acid, and the dressings are reapplied. Usually the ulcer is healed in three weeks.

Complications.—Remove by scissors and forceps any badly damaged tissue. Take out dead bone; slit sinuses; trim overhanging edges. **Eczema** is treated locally by washings with ethereal soap, applying powdered oxid of zinc or borated talcum, and wrapping the leg in cotton. Unna's paint is very useful in chronic eczema. If the part is crusted, the crusts should be removed by applying some oily materials and washing with ethereal soap and water. Ordinary soap should not be used. In an acute case soap and water always do harm and the part is to be cleaned by "gently wiping with cold cream or petrolatum" (Stelwagon on "Diseases of the Skin"). If crusting is very marked it may be necessary to remove it by means of an ordinary poultice or, better, a starch poultice made with a 2 per cent. solution of boric acid. When scales or crusts are slight or absent or when they have been removed, the remedial agent should

be applied. The remedies for eczema are legion. Among them are a solution of lead acetate; lead-water and laudanum; a powder composed of 30 gr. of powdered boric acid and ½ oz. each of talc and zinc oxid; ung. picis liquidæ, 1 dr. with sufficient ung. zinci oxidi to make 1 oz.; ½ oz. of liquor carbonis detergens to 1 pint of water. In every case of eczema place the patient upon a plain and nutritious diet; order him to avoid wines and liquors; give an occasional saline laxative; keep the skin and kidneys active, and if the patient is gouty or rheumatic, give appropriate remedies. The value of arsenic in eczema has been much overrated.

Varicose veins may demand either ligation at several points, excision, Trendelenburg's operation (see page 409), or the continued use of a flannel roller or a Martin rubber bandage. Never operate on varicose veins if phlebitis exists unless a clot has formed, in which case it may be proper to apply a ligature above the clot. Never operate for varicose ulcer if there is no venous clot, unless the ulcer is in an aseptic state. *Inflammation* of the ulcer is met by rest, elevation, painting the neighboring parts with dilute tincture of iodin, and applying about the ulcer ichthyol ointment. For *calloused edges*, blister the edges, employ radiating incisions, or cut the edges away. Ordinary *thick edges* should be strapped. In strapping use zinc oxid adhesive plaster and do not completely encircle the limb (Fig. 39). When the parts are *adherent* the ulcer is immovable, being firmly anchored to structures beneath it. In such a condition completely or partly surround the sore with a cut through the deep fascia (see Figs. 37, 38). This cut sets the ulcer free from its anchorage and permits it to contract. *Edematous granulations* require dry dressings and pressure by a flannel bandage, a rubber bandage, or adhesive plaster. If the bottom of the ulcer is *foul*, dry it and touch with a solution of acid nitrate of mercury (1 : 8) or with crystals of pure carbolic acid. Repeat this every third day and dress with hot antiseptic fomentations until granulations appear. *Superfluous granulations* (proud flesh) should be cut away with scissors, scraped away, or burned down with a strong solution of silver nitrate, with the solid stick of lunar caustic or, better, with pure carbolic acid, which causes much less pain than does silver. *Absence of granulations* or scantiness of granulations means deficiency of blood-supply. The surgeon endeavors to bring more blood to the part, and to do this induces inflammation. The usual method of procedure is to apply daily to the sore a solution of nitrate of silver (10 or 15 gr. to the ounce). Argyrol of a strength of 25 per cent. is not painful and is as efficient. In obstinate cases blister the ulcer or scrape it, or paint it, with tincture of iodin, or apply pure carbolic acid, or touch it with the actual cautery. In many cases granulation is greatly stimulated by a twenty-four-hour application of an 8 per cent. ointment of scarlet red. If it causes irritation its use is suspended for a day or two, and then the ointment is reapplied. If an ulcer of the leg becomes painful at one point (see page 85), touch with pure carbolic acid after curetting, or find the painful spot with a probe and divide the exposed nerve filament with a tenotome.

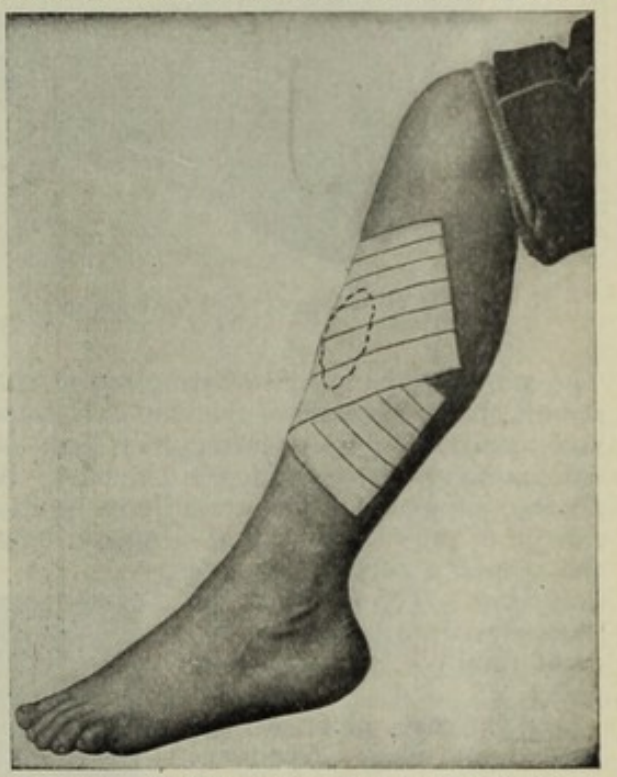


FIG. 39.—Strapping an ulcer of leg ("Keen's Surgery").

If healing entirely fails, *skin-graft*. Among the methods of skin-grafting are: (1) Reverdin's, (2) Thiersch's, and (3) Wolfe's. (See Plastic Surgery.)

When a man having an ulcer must go out and about, the camphor ointment can be employed (see page 82), Unna's dressing may be applied (see page 82), the patient can use a firmly applied roller or, better still, a Martin bandage. Martin's bandage, which is made of red rubber, limits the amount of arterial blood going to the ulcer and favors venous flow from the sore and its neighborhood. The bandage should be used as follows: Before getting out of bed spray the sore with hydrogen peroxid by means of an atomizer, remove the froth with absorbent cotton, wash the leg with alcohol, dry

it with a towel, dust the skin with borated talcum powder, and apply the bandage from the toes up. All of these things should be done before putting the foot to the floor. At night, after getting on the bed, remove the bandage, wash it with soap and water, dry it with a towel, hang it unrolled over the back of a chair to air, and again cleanse the leg and ulcer. If these rules are not strictly observed, the Martin bandage will produce pain, increase suppuration of the ulcer, and intensify eczema of the leg.

Tuberculous Ulcers. — (See page 177.)

Syphilitic Ulcers.—(See page 273.)



FIG. 40.—One type of varicose ulcer.

A **healthy ulcer** is covered with small, bright red granulations which do not bleed on touching, are painless, and grow rapidly. The edges of the sore are soft and show the opalescent blue line of proliferating epithelium. The sore is movable, the discharge is purulent and yellow, and the parts about are not inflamed.

Various Ulcers.—The **fungous** or **exuberant ulcer of the leg** is produced by interference with the return of venous blood from the part, and it is specially common after burns and other injuries when cicatricial contraction causes venous obstruction. The granulations are large, deep red in color, bleed when touched, form rapidly, and mount above the level of the skin. The discharge from a fungus ulcer is profuse, thin, and bloody. In the treatment of such an ulcer venous return must be favored by bandaging and by elevation of the part. If the edges are very thick, divide them in a number of places. The superfluous granulations should be burnt down with lunar caustic or pure carbolic acid or should be cut off. Strapping with adhesive plaster or the use of a rubber bandage does good. The sore can be dressed with europhen, aristol, dichloramin-T, or dry aseptic gauze.

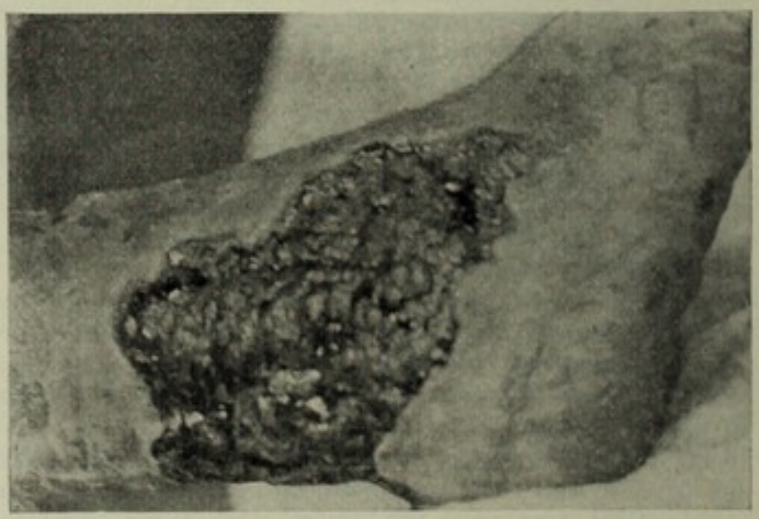


FIG. 41.—One type of varicose ulcer. Woman about sixty (Dr. W. L. Clark).

A **varicose ulcer of the leg** is an ulcer dependent upon varicose veins. Varicosity of veins of the leg causes stasis of blood, stasis impairs nutrition, a slight traumatism in an area of impaired nutrition becomes infected, and the area of chronic infection is an ulcer. Varicose ulcers are found particularly in those victims of venous varicosity who lead laborious lives, who lift and strain, who stand long in one position, who are subjected to slight and frequent traumatisms of the legs, and who are careless as to cleanliness and the care of sores. There are two distinct types.

1. The ulcer of superficial varix is the common form. It may follow repeated brief ulcerations, it is above visible varicose veins and is said to "ride" the vein (J. Homans in "Surg., Gynec., and Obst.," March, 1917), in old cases there is much pigment about the veins and pigmentation may have existed before ulceration. Ulceration of this type is usually single, but may be multiple. The usual situation is above the inner

malleolus, but may be anywhere in the lower half of the leg. The sore is oval, round, or irregular in outline. Its edges are thick, everted, and swollen. The swelling is largely due to edema, and is found to pit on pressure. The edges are not undermined, but slope gently to the floor of the ulcer. The floor is usually covered with rather large granulations which bleed freely on touching. In a varicose ulcer the destruction of tissue often begins at the margin of a congested area and advances toward the center. Such an ulcer is usually surrounded by eczema and an area of pigmentation. To aid the healing of a varicose ulcer it is first of all necessary to favor the return of venous blood from the part by position and bandaging. Martin's bandage is very useful and the daily use of the hot-air apparatus is of value. It may be necessary to operate on the veins and perhaps to excise the ulcer. Excision of a large ulcer should be followed by skin-grafting.

2. The other type of varicose ulcer follows in from six months to two years blocking of the iliacs (milk-leg). This blocking may have occurred during pregnancy or a fever or after an abdominal operation. The lumen of the veins becomes restored, but the internal saphenous remains rigid and its valves are incompetent, the perforating veins are dilated, blood flows from the deep veins to the superficial veins, the lymph current is interfered with, the deep fascia is thickened and fibrous, areas of edema and scar-like formation are common (Homans, Ibid.).

In tissue of such impaired vitality ulcers are prone to form. There may be one, several, or a number of ulcers. There is great induration around and beneath the ulcer, the skin about it is red and irritable, and no varicosities are visible, but the surgeon can feel small, hard veins in the calf and thigh. The ulcer will not heal from rest in bed or medical treatment. Excision is necessary. On excision a very much enlarged perforating vein will be seen just beneath the base of the ulcer and it must be ligated. The wound should be skin-grafted.

Erethistic, irritable, or **painful ulcer** is a very sensitive ulcer, a condition due to the exposure of nerve-filaments and destruction of nerve-sheaths. Irritable ulcers are especially found near the ankle, over the tibia, in the anus (fissure), or in the matrix of the nail (ingrowing nail). Fissure of the anus is considered on page 1177. An *ingrowing nail* is sometimes encountered on the finger, but far more commonly affects the toe. The great toe is especially apt to suffer. We call it ingrowing nail, but the condition is really overgrowing skin. As a result of wearing ill-fitting boots or stockings, especially shoes which are too short or are pointed, the toes are forced together and the skin at the edge of the nail is squeezed. After a time an ulcer forms.

When a nail begins to ingrow the condition can usually be arrested by wearing well-fitting shoes and stockings, allowing the nail to grow somewhat long and cutting it square across instead of cutting away the troublesome corner. Daily a little absorbent cotton should be packed under the embedded corner. In more severe cases, under local anesthesia, cut away the overlapping skin and a portion of the flesh on the side of the toe, split the nail longitudinally, and remove the ingrown portion of nail and a corresponding part of the matrix.

An erethistic ulcer of the cutaneous surface is treated as follows: Curet and touch with pure carbolic acid or with the solid stick of silver nitrate. Chloral, 20 gr. to the ounce, allays the pain; so do cocain and eucain for a time. In some cases the painful spot can be located definitely by a probe and the nerve-filament divided by a tenotome.

The **indolent ulcer of the leg** shows no tendency to heal. In such an ulcer there is usually venous congestion from varicose veins or from cardiac weakness. A great mass of scar tissue forms at the base and edges, which fastens the ulcer to bone or fascia, so that the edges cannot contract. Healthy granulations cease to form. The edges of such an ulcer are thick, smooth, immovable, and free from tenderness. Granulations are entirely absent or there are seen here and there a few unhealthy granulations. The discharge is thin, seropurulent, and offensive. The parts about the ulcer are congested and pigmented. The pigmentation is due to the fact that in the area of chronic congestion numbers of red blood-cells have been disintegrated. Such an ulcer is treated by making incisions to loosen the base and edges, so that contraction can take place. Venous congestion is corrected by means of position, the use of compression, and in some cases the administration of cardiac stimulants. In all cases the surgeon employs stimulating applications to the ulcer in order to increase the supply of arterial blood. Scarlet red ointment (8 per cent.) strongly stimulates granulation.

The **callous ulcer of the leg** is the most chronic form of indolent ulcer and is sunken deeply below the level of the skin. Its border is hard and knobby. Its floor shows no granulations, and is either smooth and glistening or foul and liver colored. The dis-

charge is thin and scanty, and the ulcer varies little in appearance from week to week or even from month to month. The treatment consists in scraping and cauterizing



FIG. 42.—Marjolin's ulcer (epithelioma) in a man twenty years of age, arising in the cicatrix of a burn.



FIG. 43.—Same case as Fig. 42, after excision and skin-grafting by the Thiersch method.

the ulcer; making radiating incisions through the margins and floor or elliptic incisions about the ulcer; applying antiseptic dressings and firm bandages. In some cases the ulcer should be strapped. A daily baking in the hot-air oven is often of great benefit. In severe cases it is necessary to extirpate the ulcer and apply skin-grafts.

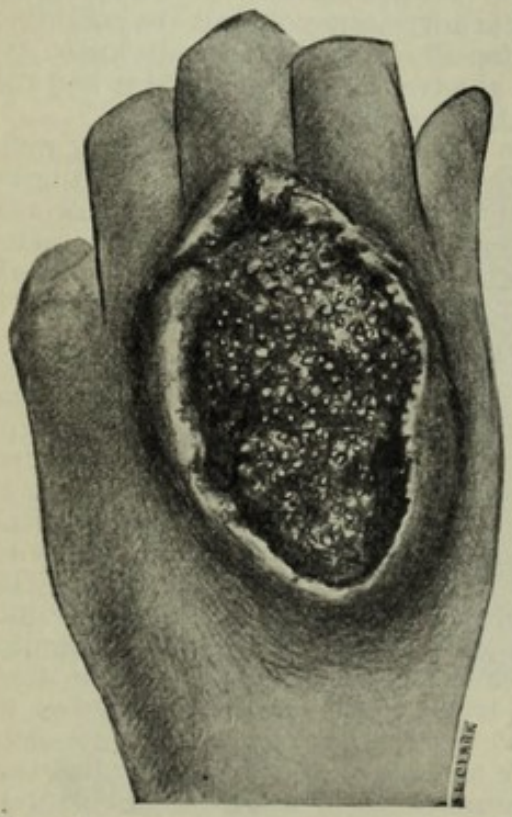


FIG. 44.—Marjolin's ulcer (epithelioma) from the scar of a burn.

Hemorrhagic ulcers bleed easily and profusely. Pressure must be applied; it is sometimes necessary to cut or burn away the granulations.

Phagedenic Ulcers.—The phagedenic ulcer results from the profound microbic infection of tissues debilitated by local or constitutional disease, and is commonly venereal. This ulcer has no granulations and is covered with sloughs; its edges are thin and undermined, and it spreads rapidly in all directions. Such an ulcer should be touched with strong caustics or the actual cautery, and dressed with iodoform gauze and antiseptic fomentations. Tonics and stimulants should always be administered.

The **edematous ulcer** may result from impediment to the venous return or, as De Nancrede points out, may be produced by the persistent use of poultices or wet dressings upon any ulcer.[1] It is most often met with in tuberculous processes and is occasionally seen in the leg when varicose veins exist. The granulations are large and pale, and are apt to bend over like unsupported vines. The discharge is profuse and seropurulent. The edges are softened and desquamating. An edematous ulcer requires dry dressings, stimulation, and compression.

A **rodent** or **Jacob's ulcer, noli me tangere,** or **cancroid ulcer,** is a superficial epithelioma developing usually from sebaceous glands, sweat-glands, or hair-follicles.

[1] "Principles of Surgery."

It requires scraping and cauterization, the application of the *x*-rays or radium, or, what is better, excision (see page 339).

Marjolin's ulcer (Figs. 42-46) is an epithelium arising from a chronic ulcer or an old cicatrix. The malignant change begins at some point of the edge of the ulcer, and its first evidence is induration. The induration spreads slowly and may eventually involve a considerable part of or even the entire ulcer. Marjolin's ulcer is the seat of scalding, darting pain; the discharge is profuse, ichorous, and foul, and the floor of the



FIG. 45.—Epithelioma arising in the scar of a burn (Marjolin's ulcer).

ulcer is uneven, warty, or cauliflower-like. The anatomically related lymph-glands eventually become involved. This involvement is seldom early because induration has blocked lymph-channels. In order to confirm the diagnosis a bit of tissue should be removed, and the removed piece must include a portion of the edge of the ulcer and of some apparently sound tissue beyond it. If a microscopic examination shows epithelial infiltration of the apparently sound tissue, a diagnosis of malignant disease must be made. In an early stage of such an ulcer the *x*-rays or electric desiccation may be successful. If these fail, free extirpation and removal of the anatomically related glands may cure the patient. In a more advanced case, even if an extremity is involved, try the *x*-ray or electric desiccation. If this treatment does not cause rapid and decided improvement, amputate and clear out the related lymphatic area. In a very advanced case use the *x*-rays or radium. Figure 42 shows a Marjolin ulcer in a man twenty years of age. It arose in the cicatrix of a burn. I removed it and applied Thiersch grafts to the raw surface. Figures 44–46 show Marjolin's ulcers.



FIG. 46.—Marjolin's ulcer arising from a chronic ulcer of the leg.

Decubitus, or **bed-sore,** is due to pressure upon an area of feeble circulation (see page 112). It is in most instances a condition of gangrene.

Neuroparalytic or **trophic ulcer** is due to impairment of the trophic nerve-fibers or of the trophic centers in the cord.

The **perforating ulcer,** as it was named by Vesigne, is believed to result from peripheral neuritis. It is certain, however, that in some of these cases there is arteriosclerosis, and it has been held that the vascular sclerosis is the real cause and that the nerve changes are secondary to the vascular changes. My own belief is that perforating ulcer is a condition dependent upon both arteriosclerosis and peripheral neuritis,

traumatism usually being the exciting cause of the ulcer. It is met with most frequently in diabetics, but may be encountered in the victims of chronic alcoholism, injuries and diseases of the spinal cord, injuries and diseases of nerves, Bright's disease, and syphilis. I have seen this ulcer in an individual with a fractured spine, in several tabetics, and in not a few diabetics. The perforating ulcer commonly affects the plantar surface of the metatarsophalangeal joint or the pulp of the great toe or little toe about a callosity or corn. It may arise on the heel or the sole or the side of the foot. It is usually unilateral, but sometimes both feet are affected. In very rare cases more than one ulcer is present on the foot. Very rarely it affects the palm of the hand. The parts about the corn inflame, and pus forms and reaches into the bone. A sinus evacuates the pus by the side of the corn or callosity or the center of the callosity exhibits a blister containing seropus. A portion of the callous mass is cast off and a shallow ulcer is often exposed. This ulcer is small, has a punched-out appearance, and is surrounded by calloused margins. The ulcer penetrates deeply and after a time the bone is laid bare or the joint opened. The margins of the ulcer or sinus exhibit sprouting granulations and these are encircled by an area of markedly thickened epidermis. The discharge from a perforating ulcer is thin and scanty, and the ulcer, which slowly advances, is very chronic. It is not painful and is slightly, if at all, tender. The foot is cold and often edematous and the parts about the ulcer may be anesthetic. The ulcer may heal when the patient is kept in bed and open again when he gets out. The disease is far more common among males than among females and is most often met with in the fifth or sixth decades of life. As this ulcer may be present in anesthetic leprosy, in diabetes, peripheral neuritis, syphilis, in a paralyzed limb, and tabes dorsalis, and as the part on which it occurs is apt to be sweaty, cold, and more or less anesthetic, and as the sore may be hereditary, it is usually set down as trophic in origin. In the treatment of a perforating ulcer I follow the plan suggested by Treves. This consists in putting the patient to bed and applying fomentations to the sore. Every time a fomentation is removed the raised epithelium around the ulcer is cut away and then the fomentation is reapplied. In about two weeks an ulcer remains surrounded by healthy tissue. Treves treats this sore with glycerin made to a creamy consistency with salicylic acid, to each ounce of which mixture 10 min. of carbolic acid have been added. He directs the patient to wear during the rest of his life some form of bunion-plaster to keep off pressure. If in a perforating ulcer the bone is diseased, it must be removed. If the patient is diabetic he must be placed on antidiabetic diet and drugs. Nerve-stretching has been recommended as the proper treatment for perforating ulcer, but I have never tried it. Favorable reports as to the value of periarterial sympathectomy have been published, but I have never tried it (page 423). No matter what treatment is employed, the sore is apt to reappear in the old situation or an adjacent region when the part is subjected to pressure. In order to prevent pressure upon the region of ulceration some advise the use of an artificial leg, the knee being kept bent. It may be necessary to amputate the toe or the foot. Hesitate at amputation if there is diabetes or arteriosclerosis.

The **scorbutic ulcer** is covered with a dark brown crust, beneath which are pale and bleeding granulations. The parts adjacent are of a violet color.

Epitheliomatous, sarcomatous, tuberculous, and syphilitic ulcers and ulcers of the stomach and duodenum are considered under these respective diseases.

Curling's Ulcer.—This is an ulcer of the first portion of the duodenum which in very rare cases follows an extensive burn or scald of the cutaneous surface. Curling described this condition in 1841, but Sir Berkeley Moynihan points out in his book upon "Duodenal Ulcer" that Long, of Liverpool, described it in 1840. It is small, clean cut, and deep. It may be due to toxic material in the bile, the toxic material being due to the burn, but against this is the occurrence of the ulcer well above the opening of the bile-duct. Sir Berkeley Moynihan regards it as a toxic ulcer and points out that the ulcer practically never occurs unless there have been septic changes in the burnt area. Septic emboli may be the cause. So far no case of Curling's ulcer seems to have been treated surgically. As Sir Berkeley Moynihan says, "there is no reason why it should not prove successful if the condition of the patient were not too exhausted by the extent or severity of the original injury." If perforation occurs, the treatment is as for any other perforating duodenal ulcer.

A **fistula** is an abnormal communication between the surface and an internal part of the body, or between two natural cavities or canals. The first form is seen in a rectal fistula, a urethral fistula, or a biliary fistula; and the second form is seen in a vesicovaginal fistula. Fistulæ may result from congenital defects, as when there is

failure in the closure of the branchial clefts, and can arise from sloughing, traumatism, and suppuration. Fistulæ are named from their situation and communications. For instance, a pleural fistula, an intestinal or fecal fistula, a rectal fistula, an anal fistula, a gastric fistula, a bronchial fistula, a vesical fistula, a biliary fistula, etc. Many fistulæ are tuberculous and lead to some deeply placed tuberculous focus. A fistula in communication with a viscus (for instance, the gall-bladder) may be maintained by an obstruction of the duct of that viscus; the removal of such an obstruction cures the fistula.

A **sinus** is a tortuous track opening usually upon a free surface and leading down into the cavity of an imperfectly healed abscess. A sinus may be an unhealed portion of a wound. Many sinuses are due to pus burrowing subcutaneously. A sinus fails to heal because of the presence of some irritant fluid, as saliva, urine, or bile; because of the existence of a foreign body, as dead bone, a bit of wood, a bullet, a septic ligature, etc.; or because of rigidity of the sinus walls, which rigidity will not permit collapse. Sinuses may be maintained by want of rest (muscular movements) and general ill health. The walls of a tuberculous sinus are lined with a material identical with the Volkmann's membrane of a cold abscess.

Treatment.—In treating a fistula or a sinus, remove any causative obstruction and any foreign body, lay the channel open, curet, brush with pure carbolic acid, and pack with iodoform gauze. To stimulate a sinus to granulation it is sometimes necessary to touch it throughout with the actual cautery, nitric acid, pure carbolic acid, nitrate of silver fused on a metallic probe, or in a solution of a strength of 40 gr. to the ounce, or argyrol of a strength of 50 per cent. Fresh air is a necessity to the patient, and nutritious food and tonics must be ordered. There is some testimony, although scarcely as yet evidence, that the use of bacterial vaccines may at times be of value in the treatment of certain sinuses. Sometimes cure of a tuberculous sinus may be secured by repeated injections of iodoform emulsion or by injecting a paste of subnitrate of bismuth and vaselin (see page 584). The mixture remains in the sinus and serves as a framework for granulations. When a sinus closes after injections of bismuth paste bismuth concretions sometimes form and lead to reopening after weeks or months. Direct sunlight benefits tuberculous sinuses. In obstinate cases of fistula or sinus entirely extirpate the fibrous walls, sew the deeper parts of the wound with buried catgut sutures, and approximate the skin surfaces with interrupted sutures of silkworm-gut.

VI. MORTIFICATION, GANGRENE, OR SPHACELUS

Mortification, or gangrene, is death in mass of a portion of the living body—the dead portions being large enough to be visible—in contrast to ulceration, or molecular death, in which the dead particles have been liquefied, cannot be seen, and are cast away. When all the tissues of a part are dead, the process is spoken of as *sphacelus*. Gangrene is, in reality, a form of necrosis, but clinically the term "necrosis" is restricted to molar death of bone or to death of parts below the surface *en masse*. In gangrene, a portion of tissue dies because of anemia, and the dead portions may either desiccate or putrefy. Gangrene may be due to tissue injury, either chemical or mechanical, to heat or cold, to failure of the general health, to circulatory obstruction, to nerve disorder, the nerves involved being the vasomotor or possibly the trophic, or to microbic infection. A microbic poison can directly destroy tissues. It can indirectly destroy them by causing such inflammation that the products obstruct the circulation, but gangrene can occur when no bacteria are present. The essential cause of gangrene is that the tissues are cut off from a due supply of nourishment and cell nutrition is no longer possible. In other words, the essential cause of gangrene is the cutting off of arterial blood. De Nancrede says: "Indeed, except when the traumatism physically disintegrates tissues, as a stone is reduced to powder, heat or strong acids physically destroy structure, or cold suspends cellular nutrition so long that when this nutrition becomes a physical possibility vital metabolism cannot be resumed, gangrene always results from total deprivation of pabulum" ("Principles of Surgery").

Classification.—Gangrene is divided into the following three great groups:

(1) **Dry gangrene,** which is due to circulatory interference, the arterial supply being decreased or cut off. The tissues dry and mummify.

(2) **Moist gangrene,** which is due to interference not only with arterial ingress, but also with venous return or capillary circulation, the dead parts remaining moist.

(3) **Microbic gangrene,** arising from virulent bacteria. In this form the bacterial process *causes* the gangrene, and is not merely associated with it.

The above classification, if unqualified, suggests erroneous ideas. It indicates that there is an essential difference between dry gangrene and moist gangrene, which is not the case. If, when gangrene begins, the tissues are free from fluid, the patient develops dry gangrene; if they are full of fluid, he develops moist gangrene. If the arterial supply is gradually cut off, the tissues are sure to be free from fluid, and the gangrene will certainly be of the dry form. If arterial blood is suddenly cut off, the gangrene may be dry or moist, according as to whether the tissues are or are not drained of fluid. When gangrene results from inflammation, strangulation, and infection it is certain to be the moist variety because the tissues are sure to be filled with fluid.

De Nancrede says, in his very valuable work on the "Principles of Surgery": "Yet, let accidental inflammation have preceded the final blocking of an artery, or let ligation of the main artery cause gangrene because the collateral circulation cannot become developed, and if an aneurysmal sac is so situated as to interfere with a free return of venous blood and lymph, this anemic gangrene will in both instances prove moist and not dry."

There are many gangrenous processes which belong under one or other of the above heads, namely: *congenital* gangrene, a rare form existing at birth; *constitutional* gangrene, arising from a constitutional cause, as diabetes; *cutaneous* gangrene, which is limited to skin and subcutaneous tissue, as in phlegmonous erysipelas; *gaseous* or *emphysematous* gangrene, in which the tissues become distended with putrefactive gases and crackle on pressure; *hospital* gangrene, which is defined by Foster as specific serpiginous necrosis, the tissues being pulpefied: some consider it a traumatic diphtheria; *cold* gangrene, a form in which the parts are entirely dead (sphacelus); *hot* gangrene, which is associated with inflammation, as shown by heat; *dermatitis gangrænosa infantum*, or the multiple cachectic gangrene of Simon; *idiopathic* gangrene, which has no ascertainable cause; *mixed*, which is partly dry and partly moist; *primary*, in which the death of the part is direct, as from a burn; *secondary*, which follows an acute inflammation; *multiple*, as gangrenous herpes zoster; *diabetic* or *glycemic gangrene*, which arises during the existence of diabetes; *gangrenous ecthyma*, a gangrenous condition of ecthyma ulcers; *pressure*, which is due to long compression; *purpuric* or *scorbutic*, which is due to scurvy; *Raynaud's* or *idiopathic symmetrical*, which is due to vascular blocking, perhaps from nerve disorder; *senile*, the dry gangrene of the aged; *venous* or *static*, which is due to obstruction of circulation as in a strangulated hernia; *trophic*, which is due to nutritive failure by reason of disorder of the trophic nerves or centers; *thrombotic*, which is due to thrombus; *embolic*, which is due to embolus; and *decubitus*, *decubital* gangrene, or bed-sores due to pressure.

Dry gangrene arises from deficiency of arterial blood. For this reason De Nancrede calls it anemic gangrene.

This form of gangrene is far more apt to result from the gradual than from the sudden cutting off of the supply of arterial blood, and is more common if the blood-vessels are diseased than if they are healthy; but even in a person with healthy arteries gangrene will ensue upon blocking of the main artery, if the collaterals fail to supply the part with blood. This form of gangrene can occur after laceration, ligation, or the lodgment of an embolus in the main artery of a limb; but in such accidents considerable fluid usually remains in the tissues and the gangrene is apt to be moist rather than dry.

Gangrene Due to Embolism or Thrombosis.—An embolus may cause gangrene, hence the cause of embolism is responsible for the gangrene. There may be vascular disease. There may be or there may have been an infectious process (typhoid fever, pneumonia, influenza, diphtheria, etc.). If an embolus causes gangrene, it is probable that the blocking is complete. Why an embolus in a young person causes gangrene is perplexing, because in such a person we can tie a large artery with comparatively little fear of gangrene. It must be that a clot forms proximally to the embolus, fills a considerable extent of the vessel, and cuts off the collaterals. When an embolus lodges in an artery and causes dry gangrene, the case runs the following course: sudden severe pain at the seat of impaction, and also tenderness; pulsation above, but not below, this point, after obstruction has become complete; the limb below the obstruction is blanched, cold, and anesthetic; within forty-eight hours, as a rule, the area of gangrene is wide-spread and clearly evident; the limb becomes reddish, greenish, blue, and then black, the skin becomes shriveled and its outer layer stony or like horn because of evaporation. The entire part may become dry; but usually there are spots where some fluid remains, and these spots are soft and moist, and the dead

tissue, where it joins the living, is sure to be moist. The moist areas become foul and putrid, but the dry spots do not. In dry gangrene, at the point of contact of the dead and living tissues, inflammation arises in the latter structures, a bright red line forms, exudation occurs, and ulceration takes place. This line of ulceration in the sound tissues is called the *line of demarcation*. It is Nature's effort at amputation, and in time may get rid of a large portion of a limb, and then heal as any other ulcer. A line of demarcation rarely causes hemorrhage because it enters a vessel only after inflammation has caused occlusion by thrombosis. In dry gangrene from arterial obstruction there is gastro-intestinal derangement and also some fever. The gangrene does not extend up to the point of obstruction, but only to a region in which the anastomotic circulation is sufficiently active to permit of the formation of a line of demarcation. Below this point inflammatory stasis arises, but before this can go on to ulceration the parts die. In cases in which the arterial obstruction is sudden and complete, the limb swells decidedly. This is due to the sudden loss of *vis a tergo* in the arterial system, venous reflux occurring and fluids transuding. In such a case the tissues contain fluid and putrefy and the process, though due to the cutting off of the arterial circulation, is moist gangrene. Embolic gangrene attacks the leg more often than the arm. A thrombus in



FIG. 47.—Dr. Nassau's case of double gangrene from popliteal thrombosis in a man with arteriosclerosis.

an artery rarely causes gangrene except in the aged or when it forms upon an embolus. In a pure thrombus the collateral circulation has time to adjust itself; but gangrene may follow thrombus formation, and when it does it comes on more slowly than does gangrene from embolus. Gangrene from thrombosis is dry except in certain cases of gangrene arising during an infection, for instance, pneumonia, in which case veins may be thrombosed as well as arteries, and the gangrene may be moist.

Treatment of Thrombotic and Embolic Gangrene.—When injury or blocking of a large artery causes us to fear the onset of gangrene, the patient should be placed in bed, the extremity should be elevated a little, kept wrapped in cotton-wool, and surrounded with bottles filled with warm water. Baking in the hot-air oven is very useful (Willy Meyer, De Witt Stetten). It is useless when an artery is extensively diseased to incise it and remove a clot, because another clot will form at once. If a clot forms in a limited area of disease, it may be possible to excise the diseased section of the artery and do end-to-end anastomosis, or insert by implantation a section taken from a distant vein. In cases of thrombosis, however, some surgeons prefer arteriovenous anastomosis which does not seem to be a logical procedure (see page 94). In embolism it is a logical procedure to make a longitudinal incision in the artery, re-

move the embolus, and suture the wound in the vessel. So far arteriotomy for embolism has not been as successful as Carrel's experiments lead us to infer it should be; the probable reason is that most reported operations were upon elderly people in whom, because of diseased arteries, extensive clots existed. The operation is to be employed very early after blocking, before extensive thrombosis and before gangrene. Lejars believes that in the young results are sure to be better. Mosny and Dumont report a successful arteriotomy for embolism of the femoral artery in a case of mitral stenosis (quoted in "Lancet," March 9, 1912). Other successful operations are on record. If in spite of our efforts gangrene begins and progresses, wait for a line of demarcation, and while waiting dress the dying and dead parts antiseptically, wrap the extremity in cotton and keep it warm, and see to it that the patient gets plenty of sleep and nourishment. It is also advisable to give tonics and stimulants. When a line of demarcation forms, amputate well above it.

Gangrene from Thrombo-angiitis Obliterans, Juvenile Gangrene, Buerger's Gangrene, or Presenile Gangrene.—It is not due to endarteritis obliterans. Buerger regards the condition as thrombo-angiitis obliterans, appearing in the larger arteries and also in the deep veins of the leg ("Amer. Jour. Med. Sciences," Oct., 1908). The vessels become obliterated. In some cases migrating phlebitis develops in the superficial veins and it may even long precede involvement of the deeper vessels. The clots in the deeper vessels become canalized, vascularized connective tissue. In this condition there is always an absence of elastic fibers save a few around the large canalizing vessels. Here we have a definite and positive organization of a thrombus with little participation of the elastica (J. Parsons Schaeffer, in "The Anatomical Record," Jan., 1917). L. Buerger has seen many hundred cases. He believes that the start of the condition is an acute inflammation with occluding thrombosis and the formation of areas of giant-cells. As healing advances giant-cells and inflammatory material disappear and the clot becomes organized and canalized. Finally fibrous tissue forms in the adventitia, causing artery, vein, and nerves to adhere, hence the pain ("Amer. Jour. Med. Sciences," Sept., 1917).

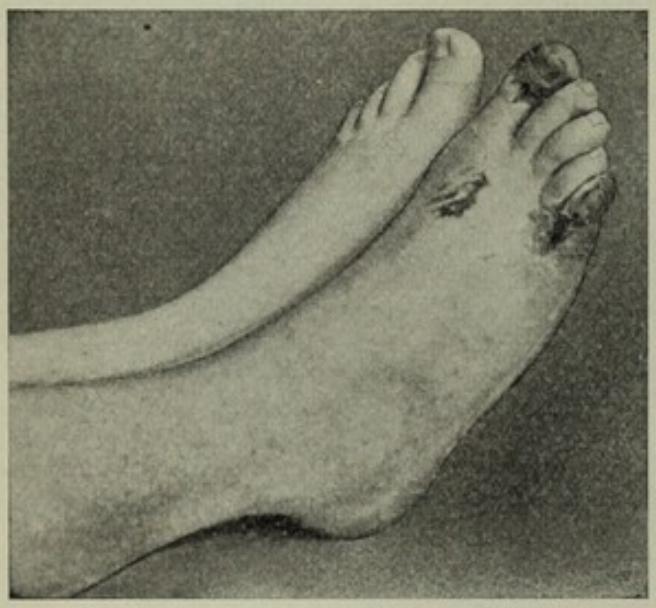


FIG. 48.—Gangrene from thrombo-angiitis obliterans.

In this condition perivascular inflammation comes to exist. In cases which have lasted for years there may be arteriosclerosis. Some hold that this form of gangrene is most apt to occur in sclerotic vessels. Buerger regards infection as the cause. Some think ovarian secretion protects females. The points at which an occluding clot is most apt to form are the tibials and the bifurcation of the popliteal. If this clot forms slowly and the collaterals are in good condition gangrene will not occur, if the clot forms rapidly and the collaterals are not in good condition gangrene will occur.

Mayesima, of Japan, claims that in presenile gangrene there is an increase in the viscosity of the blood (quoted by Willy Meyer in "Annals of Surgery," March, 1916).

It occurs among young adults (from twenty to forty, I have never seen a case in a man over fifty) and is especially noticed among the Russian, Gallican, and Polish Jews in our large cities. It is not limited to Hebrews, but there is a very strong racial predisposition. Cases have been reported among Chinamen, Japanese, Swedes, and other nationalities. It is said not to occur at all in women. I have seen one Jewish woman with what I believed to be thrombo-angiitis obliterans. This form of gangrene is said to be apt to arise after typhus fever (Goodman in "Med. Record," Aug. 18, 1917). Bacteremia may result in thrombo-angiitis. Oversecretion of the adrenals has been suggested as the cause of the disease (Oppel). Occupation does not seem to have a causal influence. Many but not all of the victims smoke quantities of cigarettes. A diet containing too much salt meat has been blamed, but the disease can arise in those on ample diet. Occupations requiring prolonged standing have been thought to predispose. It usu-

ally, but not always, begins in the left leg. It may start almost simultaneously in both legs. If it begins in one leg, the other tends to become affected sooner or later. *Intermittent claudication* is the first sign and may precede other signs by months or even years. When the patient walks he has attacks of severe pain in the toes, foot, or leg, the extremity feels cold and looks bloodless, and no pulse can be detected in the dorsalis pedis and posterior tibial arteries. Such attacks are at first brought on by exercise and cold, later they appear to arise spontaneously.

When the foot is warmed some color may return and feeble pulse may be appreciated. Sooner or later these patients get so that any attempt at walking causes violent pains in the calf muscles, pain so violent as to make the victim limp in torture or at once stop walking.

After a case has lasted a number of months *symptomatic erythromelalgia* may develop. When the foot is hung pendent the toes and dorsum become red. This is not identical with the erythromelalgia described by S. Weir Mitchell. Buerger makes the distinction clear. In thrombo-angiitis the condition is aggravated in pendency and disappears on elevation; there is no pulse in the dorsalis pedis and posterior tibial; when color has faded from pressure it returns slowly on the removal of pressure; pain is aggravated by pendency; marked swelling unusual, though foot and toes may be puffy; intermittent claudication is the rule; usually trophic disturbances (ulceration, gangrene); course slow and progressive; terminates in gangrene of one lower and then of other lower extremity, and upper extremities may become involved; strong predilection for males and Hebrews; wandering phlebitis not unusual in superficial veins. In Mitchell's erythromelalgia the pulse is never absent and during the attacks is very forcible; attacks inaugurated by pendency; redness returns at once after pressure is removed; pain violent and redness intense; swelling during attack; no intermittent claudication; seldom get trophic lesions and never until late; no migrating phlebitis; no sex or racial predisposition (see Buerger's valuable treatise, "The Circulatory Disturbances of the Extremities").

After a case has lasted for many months it will be impossible at any time to detect a pulse in the dorsalis pedis or posterior tibial, or, perhaps, in the popliteal. The patient is wearing out with violent pain and cannot walk. Whenever the foot hangs down it becomes red or cyanotic. A bleb or ulcer may form upon the foot or great toe; it is sure to be intensely painful, and finally dry gangrene occurs. Gangrene may occur in a few months after the onset of the disease, but it seldom occurs until after years.

In one case, an American male in the early forties, I amputated the leg above the knee, at a later period the other leg at a corresponding point, and later still re-amputated the extremity first operated upon, gangrene from thrombosis having arisen in the stump. A few weeks later the man died with evidences of beginning gangrene in the fingers and hands. Autopsy was refused. The examination of the vessels in all the legs I have amputated accorded with Buerger's view that the condition is one of thrombo-angiitis obliterans, the veins often suffering as well as the arteries. The clot often fills the vessels of the toes, the dorsalis pedis, the plantar, and may extend up both tibials to the popliteal. Before gangrene arises various diagnoses are apt to be made (Raynaud's disease, intermittent claudication, erythromelalgia).

The characteristic combination is violent pain, with absent pulse in the dorsalis pedis and posterior tibial arteries.

There is an acute form of the condition (*acute thrombo-angiitis obliterans*) which is due to streptococci or to rapidly formed arterial toxic thrombi (Kramer in "N. Y. Med. Jour. and Med. Record," Oct. 4, 1922). It is apt to be fatal, but recovery may follow sloughing or amputation. Usually the vessels are permanently damaged by the time the diagnosis is made.

Treatment.—All sorts of treatments have been tried, from injections of sodium citrate to hyperemia by suction; from a diet free from meat and salt to salt solution by hypodermoclysis; from reflected light upon the extremity to the *x*-rays, and all of them have failed totally or proved only palliative. As soon as the diagnosis is made forbid long walks, prolonged standing, the wearing of tight shoes or garters, and protect the patient from all possible injuries to the toes and feet. In a well-developed case put the patient to bed, forbid walking and standing, and take means to increase the circulation. The postural method of Buerger is of value (see Buerger's "Circulatory Disturbances of the Extremities"). During intervals between the postural treatments the limb is slightly elevated on a pillow and heat is applied (electric lamps under the bedclothing). Diathermy is useful. I have seen notable relief of pain and apparent checking of be-

ginning gangrene by the use of Ringer's solution given by hypodermoclysis. This plan was introduced by Ito and Koga, of Japan, and has been endorsed by Willy Meyer ("Annals of Surgery," March, 1916). It acts by reducing the viscosity of the blood. Meyer advises us to dissolve one of the tabloids used for Ringer's solution in 500 c.c. of distilled water and inject it daily or every other day. Use it 15 or 20 times. A series of injections can be repeated.

In one of my cases the pain disappeared after ten injections. Later the symptoms may return, in which case the injections should be given again. Meyer suggests a trial of intravenous injection of a 2 per cent. aqueous solution of sodium citrate. With this treatment Meyer associates baking of the limb, and advises a trial of organotherapeutic preparations ("Annals of Surgery," March, 1916).

In these cases it is not possible to remove the thrombus surgically because the vein is involved and the blocking material in the vessels is organized material attached to the walls (B. M. Bernheim, "Southern Med. Jour.," 1915, viii).

Since 1902, when Carrel made his report on vascular anastomosis, surgeons have tried to arrest this and other forms of gangrene by *reversal* of the *circulation*. The plan is to anastomose the femoral vein to the femoral artery end-to-end, as Carrel and Guthrie advise, or laterally, as Murphy, Bernheim, and Weiting advocate (J. S. Horsley and R. H. Whitehead in "Jour. Amer. Med. Assoc.," 1915, lxiv).

Buerger, Horsley, Stetten, and others strongly oppose the operation. Carrel, Bernheim, Goodman, and others advocate it. Stetten collected 136 operations for different forms of gangrene and found a direct mortality of more than 30 per cent. and complete failure of the operation in more than 72 per cent. ("Surg., Gynec., and Obst.," 1915, xx).

Early in a case when gangrene threatens or when it is recent and limited, if we can assume that the veins are free from clot and the operation might be justifiable Bloodgood has had success in a case which seems to have been of this type (Bernheim in "Amer. Jour. Med. Sciences," Feb., 1912). Meyer has reported a successful case ("Annals of Surgery," March, 1916). I do not believe that such an operation causes the blood to move toward the body in the arteries and from the body in the large veins. The valves in the veins certainly prevent such a thing happening in those vessels (Horsley and Whitehead, in "Jour. Amer. Med. Assoc.," March 13, 1915), but the valves may be gradually overcome. Willy Meyer ("Annals of Surgery," March, 1916) says that what occurs is as follows: "The arterial blood-stream deflected into the vein is obstructed by the valves and is deflected into branches of the femoral vein devoid of valves. These smaller, thin-walled veins enlarge. Some of the blood runs back through collaterals to "the proximal end of the ligated femoral vein. A good deal of the arterial blood does reach the foot and toes in a non-spurting, venously even flow" and this blood returns "through such branches of the venous system as have not been seized upon by arterial blood." If Meyer's theory is correct the term "reversal of circulation" is a misnomer. Bernheim believes reversal does occur and cites a case in which amputation of the foot was required after arteriovenous anastomosis. One vein bled bright blood in a constant stream from the proximal end. Another vein bled bright blood in spurts from the proximal end ("Interstate Med. Jour.," 1915, xxii). It is claimed that in a few cases successful reversal has been accomplished.

Another operation, suggested by von Oppel for threatened senile gangrene, is ligation of the popliteal vein. Lessening the carrying ability of the vein puts it in accord with the lessened carrying ability of the artery. Consequently the blood-pressure and the rate of the circulation in the two more nearly accord and the scanty arterial supply ceases to be removed too rapidly by the large vein. In this form of gangrene ligation of the femoral vein below the long saphenous should be preferred to ligation of the popliteal. Both operations are of very doubtful value. As Meyer says, they are as yet on trial. Another doubtful possibility is periarterial sympathectomy (page 423). If gangrene of a toe or toes becomes completely arrested it is justifiable to gradually remove the dead tissue and try to obtain healing of the raw areas.

Sooner or later these cases come to amputation. In some cases violent pain compels amputation even before gangrene begins. Gangrene, if involving more than a small area, calls for it imperatively. Not unusually, weeks or months after amputation of one leg, the other leg has to be sacrificed.

I have always amputated just above the knee in order to be well above the thrombi in the vessels and to be able to use a joint on the artificial limb. Surgeons have used Moszkowicz's test to determine where to amputate. (See Senile Gangrene, page 182.)

Senile gangrene, chronic gangrene, Pott's gangrene (Fig. 49), which was first described by Percival Pott, of London, as mortification of "the toes and feet" (Pott's works) is a form of gangrene due to feeble action of the heart plus arteriosclerosis of the vessels, there is failure of nutrition of the vessel wall, proliferation causes thickening and sclerosis of the intima and media, and finally there is degeneration and calcareous deposit. The vessels do not carry a normal amount of blood, and may at any time be occluded by thrombosis. If the process is uncomplicated by thrombosis an abundance of elastic fibers aid in the obliteration of the vessel. It is much more common in men than in women and is most common after sixty years of age. In a drunkard or in a victim of syphilis, Bright's disease, tuberculosis or lead poisoning the arteriosclerotic condition supposed to characterize old age may appear while a man is young in years. It was long ago said, with truth, "a man is as old as his arteries." Senile gangrene most often occurs in a toe, in toes, or in the foot. The proliferation of the intima may be followed by degenerative changes in the vessel with clotting. In the large arteries connective tissue forms, which tissue contains few capillaries. Some of these areas are very cellular. About the media endothelial spaces are determined. It is thought that these are mainly the forms of new blood-vessels that vascularize the tissue and are destroyed.



FIG. 49.—Senile gangrene of the feet (Gross).

Fatty degeneration and atheromatous changes occur. The gelatinous looking matter springing from the inner wall of the vessel helps to narrow the vessel, this action being added to by organization of clots. The adventitia is slightly or not at all noticeable in the process, the element of it is the great thickening of the inner coat. It will be noted that a large artery may be partly occluded or completely obliterated by contracting new tissue, by organized thrombi, or by both. An artery may be obliterated by thrombus formation. Some cases of gangrene result from extensive thrombosis of the popliteal artery, others from blocking of the smaller vessels. Arteriosclerosis, in the long run, becomes associated with calcification. The impairment of vascular elasticity makes the circulation insufficient. Narrowing of the caliber adds to the difficulty. Rapid thrombosis of the popliteal extends into the femoral and wide-spread gangrene may follow. There is usually wide-spread arterial disease. The patient is usually fifty or over; has had vague pains in one limb, supposed to be rheumatic, and intermittent claudication. One or more toes become gangrenous, perhaps the entire foot and part of the leg. Gangrene is usually dry. Sudden thrombus produces pain in the calf and foot, coldness of the extremity, parasthesia, paleness, and weakness of the limb. No pulsation is found in the arteries of the foot or leg. There is some reddening of the foot when the toes hang down. One or both saphenous veins may contain clots. There may be an attack causing cutaneous areas of bluish or purplish discoloration. This condition of affairs may be recovered from. However, other attacks may cause gangrene. Cold is not an uncommon cause. Injury to the toe may precipitate trophic lesion. The local circulation becomes impaired and a thrombus occurs in the tibial or the popliteal. When an ulcer forms it is usually on the big toe. Coldness of the extremity, cyanosis, intermittent claudication are noted. It is very hard to distinguish between embolic gangrene of the lower extremity and gangrene due to sudden popliteal thrombosis. Arteriosclerotic gangrene may occur with diabetes. Thrombus may cause atrophy rather than gangrene. Buerger says that arteriosclerosis with attacks of thrombosis may simulate thrombo-angiitis obliterans. The fact is that the two conditions can be associated. The *x*-rays show calcified arteries and bone is insidiously destroyed, but in gangrene from arteriosclerosis it is the bones of the foot that are particularly affected and not the distal phalanges, as is seen in Raynaud's disease. The bone absorption may involve a number of phalanges or even metatarsals.

In the true senile cases, with intermittent claudication, there may be trophic lesions, blanching on elevation, redness in the pendent position, and calcareous vessels. The early symptoms of Buerger's disease come on much more slowly, during weeks, months, or years. Blanching and rubor are much more common than in arteriosclerosis

and diabetes. In both cases there may be local areas of gangrene at first, but the gangrene of arteriosclerosis and diabetes is apt to be more rapid.

Dry gangrene is the rule in Buerger's disease. There is some phlebitis in senile cases. Gangrene of the upper extremities is very rare in senile cases and uncommon in Buerger's disease.

Arteriosclerosis causes, in the areas where the circulation is poor, a gathering of carbonic acid and lactic acid, and a diminution of oxygen. It has been maintained that this is responsible for the vasodilating reflex being converted into a vasoconstricting reflex, cramp-like pains being the result.

Symptoms.—A man whose vessels are in the state above indicated is generally in feeble health and has a fatty heart and an arcus senilis (a red or white line of fatty degeneration around the cornea). His toes and feet are cold and feel numb, they "go to sleep" easily, and he suffers from cramp and often pains in the legs and feet. Intermittent claudication is commonly the first symptom complained of. This condition may last for years. Trophic disturbances may develop or chronic redness may be noted. The feet and toes grow pale on elevation. Such a man is usually dyspeptic and short of breath, and his urine is frequently albuminous. The *x*-rays show calcareous vessels and atrophy and destruction of bone in the digits and metatarsals. The arteries may show feeble pulsation, may be pulseless, and perhaps are felt as rigid tubes, like pipe-stems. He is in danger of edema of the lungs and of dry gangrene of the toes. A slight injury or inflammation of a toe—for instance, a hangnail, stubbing a toe, or cutting a corn too close—will produce extensive inflammatory stasis followed by thrombosis, which completely cuts off the blood-supply and causes gangrene of the part. Gangrene is usually announced by the appearance of a purple and anesthetic spot followed by a vesicle which ruptures and liberates a small amount of bloody serum and exposes a dry floor. In the parts about the gangrenous area there is often burning pain. The circulation in the tissues immediately adjacent to the dead spot is retarded or stagnated, the parts being purple, and the color not disappearing or disappearing *slowly* under pressure. If the color fades under pressure it returns *slowly* when pressure is removed. The parts a little further removed are hyperemic, the color disappearing rapidly on pressure, and returning rapidly when pressure is removed. The dead parts do not putrefy at all or do so but slightly, hence the odor is never very offensive and is usually trivial. The dead parts are anesthetic, hard, leathery and wrinkled, and resemble a varnished anatomic specimen or the extremity of a mummy (hence the term *mummification*). Before the line of demarcation forms there is burning pain; after it forms pain is rarely present. If a thrombus blocks the popliteal it causes sudden and severe pain in the calf and walking becomes impossible. The foot is blanched and cold and there is no pulse below the block. Gangrene is probable, but not inevitable. In senile gangrene the distal portion of the dead area is always dry, the part near the body being generally somewhat moist. The process may be very limited or it may spread up along the dorsum of the foot and the leg, even to the knee. As it spreads the area of hyperemia advances at the margin, the area of stasis follows, and the zone of gangrene becomes more extensive. When tissues are reached, the blood-supply of which is sufficiently good to permit of inflammation going beyond the stage of stasis or to allow of stasis without extensive thrombosis, Nature tries to limit the gangrene by the formation of an ulceration which is called a *line of demarcation*. A line of demarcation may begin, but prove abortive, the tissue mortifying above it. This proves that tissue near the line is in a state of low vitality.



FIG. 50.—Dr. Keller's case of spontaneous amputation of a foot and part of a leg in a condition of senile gangrene.

The line of demarcation may prove durable and in some few cases spontaneous amputation takes place (Fig. 50). When a limited area is gangrenous, constitutional symptoms are trivial or absent; but when a large area is involved, the fever of septic absorption exists. Death may ensue from exhaustion caused by sleeplessness and pain, from septic absorption, from embolism of internal organs, or from some complication (renal, pulmonary, or cardiac). In many cases of senile gangrene clots are formed in the superficial femoral artery or its branches, an observation it is important to bear in mind when amputating.

Prevention of Senile Gangrene in the Predisposed.—Such a patient must avoid injuring the toes and feet. Cutting corns carelessly is highly dangerous, and any wound, however slight, requires rest and antiseptic dressing. The victim of general arteriosclerosis must wear woolen stockings, put a rubber bag containing warm water to his feet on cold nights, and attend to his general health. He must avoid overeating and is to be particularly moderate in the use of meats, should have a daily bowel movement, and should drink water in plenty between meals. He should avoid as far as may be work and worry, and enough sleep is imperative. A little whisky after each meal is indicated, and occasional courses of nitroglycerin are desirable. Courses of iodid of potassium, given in small doses, may retard the progress of the sclerosis. If gangrene is impending use superheated air and hypodermoclysis with Ringer's solution (page 94). If the subject is syphilitic also, give salvarsan and courses of mercury and the iodids.

Treatment of Senile Gangrene.—When gangrene occurs, it if is limited to one toe or a portion of several toes, if it is a first attack, if there is no fever or exhausting diarrhea, if there is no tendency to pulmonary congestion, if the appetite is fair and sleep refreshing, it is best to avoid radical interference and to await the formation of a line of demarcation. While awaiting the line of demarcation dress the part antiseptically, wrap the extremity in cotton wool, raise the foot several inches from the bed, and surround the part with bags of moderately warm water. Very warm water may do harm. Instead of the above plan we may use superheated air and inject Ringer's solution as described in the article on Buerger's gangrene. Give the patient nourishing diet, stimulants, and tonics; see to it that he sleeps, and during the spread of the gangrene watch for fever, diarrhea, pulmonary congestion, and kidney failure. Percival Pott pointed out a century and a half ago that opium in moderate doses is very useful. It should be given in the form of laudanum or the deodorized tincture. Dr. George W. Gay warmly advocates its use. He finds that it relieves pain, quiets restlessness, and is a cardiac and vascular tonic which increases the nutrition of peripheral parts ("Med. and Surg. Reports of Boston City Hospital," sixteenth series). I believe this praise of opium is well merited. When a line of demarcation forms, dress with warm antiseptic fomentations and iodoform, and every day pick away dead bits with the scissors and forceps. A tendon or ligament should be cut through and a protruding phalanx should be divided with a Gigli saw. If, after separation, an ulcer forms, skin-grafts may be applied. In many cases healing will occur; but even when the parts heal the patient will always be in deadly peril of another attack. If the gangrene shows a tendency to spread, if it involves more than a portion of several toes, if it is not a first attack, if there is sleeplessness, fever, exhausting diarrhea, anorexia, or a strong tendency to pulmonary congestion, do not delay, but at once amputate high up. If the gangrene shows no tendency to limit itself, or if the patient develops sepsis or exhaustion, at once amputate high up. The best point at which to amputate is above the knee, so that the deep femoral artery, which rarely becomes sclerosed, can nourish the flap and gangrene will not occur. It has been pointed out that the superficial femoral artery and its branches often contain a clot. Never amputate below the tubercle of the tibia. Some operators disarticulate at the knee-joint. Heidenhain affirms that so long as the gangrene is limited to one or two toes we should merely treat it antiseptically, elevate the limb, and wait for the dead part to be cast off spontaneously; if, however, it extends to the dorsum or sole of the foot, we should amputate at once above the knee. He further states that gangrene of the flaps almost always occurs in amputations below the knee, and high amputation is indicated in advancing gangrene with or without fever.[1] Personally, I still follow Heidenhain's rule. Many surgeons dissent from it and believe that in certain cases we can amputate lower down. Our right to do so depends on collateral efficiency. Many tests to determine the activity of the collaterals have been suggested. Matas considers them as preliminaries to operations for aneurysm (Matas in "Amer. Jour. Med. Sciences," 1914, lxiii). Mosz-

[1] "Deutsche medicinische Wochenschrift," 1891, p. 1087.

kowicz suggested a method of determining the viable area. (*Moszkowicz's test for collateral adequacy.*) He applies an elastic bandage from the toes to high up the thigh, puts in place the tourniquet band, and removes the bandage. In five or ten minutes he removes the band and notes the color of the limb as it is invaded by reactionary hyperemia. This wave of color travels toward the periphery. High up the extremity the reactionary blush appears quickly. The nearer the area of vascular obstruction, the slower the manifestation of color. In doubtful areas the blush comes slowly and imperfectly, and patches of white show here and there in the color. In a region of total ischemia no reactionary blush occurs.

Operation must be performed in the region where there was a complete red reaction, and never through an area where anemic patches were noted. This very ingenious test of Moszkowicz has not seemed to me conclusive, and I have fancied in cases of threatened gangrene that it helped to bring about the very condition we feared. It is only just to say that in other hands the test seems to have proved successful. Matas uses it to test the collaterals before operating for aneurysm. When amputation has been performed and the Esmarch band has been removed and no arterial bleeding takes place from the superficial femoral artery, a clot is lodged in that vessel. If such a condition exists, insert into the artery a fine rubber catheter or a filiform bougie and break up the clot. When blood flows we are sure that the clot has been washed out.[1]



FIG. 51.—Acute gangrene (Gross).

Some surgeons have practised arteriovenous anastomosis between the femoral vein and common femoral artery in hope of establishing sufficient circulation to prevent impending or to cure existing gangrene. The results are as yet inconclusive, but some apparent successes have been reported (see page 94). Oppel suggested ligation of the popliteal vein. Others would tie the femoral vein.

In **moist** or **acute gangrene** (Fig. 51) the dead part remains moist and putrefies. As De Nancrede points out, there are two forms of moist gangrene: "that limited to the areas actually killed by a traumatism, with some surrounding tissue which dies," and "that which tends to spread widely, this latter being usually caused by specific micro-organisms, an intense, wide-spread, rapid inflammation resulting, involving the subcutaneous and intermuscular cellular planes, by strangulation of the vessels by which all blood-supply to the remaining soft parts is destroyed."[2] In a case of moist gangrene the parts remain moist either because the main artery has become suddenly blocked, and the tissue fluids are not urged by sufficient *vis a tergo* to cause them to flow out of the limb, or because the main vein is blocked. It may arise in a limb after ligation, obstruction, or destruction of its main artery, main vein, or both; after long constriction, as by a tight bandage; after crushes and lacerated wounds, and after thrombosis of the vein. Moist gangrene may follow severe pyogenic infection or may be due to local constriction (strangulated hernia), crushing, chemical irritants, heat, and cold.

Moist gangrene of a limb may be seen typically in certain cases in which the main vein or artery or both vein and artery are constricted, damaged, or destroyed. The leg swells greatly and is pulseless below the obstruction; the skin, at first pale, cold, and anesthetic, becomes livid, mottled, purple, or greenish. A greenish color signifies putrefaction. Blebs are formed which contain a reddish or brown fluid. "These blebs, being caused by the accumulation of serum beneath epithelium which has lost its vital connection with the derm, can be slipped around upon the surrounding true skin, the epithelium readily separating for long distances around, as in a cadaver" (De Nancrede). The extremity swells enormously, there may be pain at the seat of obstruction, but there is no pain in the gangrenous area, and sapremic symptoms quickly develop. The bullæ break and disclose the brown derm and sometimes the deeper structures, which are swollen and edematous. The fetor is horrible. Slight or moderate fever usually exists. In mild cases a line of demarcation soon forms. In severe cases in which virulent anaërobic bacteria are present the process spreads with great rapidity, neighboring glands enlarge, the temperature is much elevated, no line of de-

[1] Severeano. See Mancozet's report before the Second Pan-American Medical Congress.

[2] De Nancrede's "Principles of Surgery."

marcation forms, there is profound exhaustion, and gases of decomposition accumulate in and distend the tissues and cause crackling when the parts are pressed upon. Such severe cases are, in reality, examples of foudroyant, emphysematous, or gas gangrene.

Moist gangrene from inflammations is due to pressure of the exudate, cutting off the blood-supply, or to loss of blood circulation because of microbic involvement of vessels and clotting of blood. It occurs typically in phlegmonous erysipelas. When an inflammation is about to terminate in gangrene all the signs of inflammation, local and constitutional, increase; swelling becomes very great and may be due partly to fluid and partly to gas. If gas is present pressure will cause crackling. The color becomes livid or purple. The anatomically related glands are enlarged and the symptoms of sapremia or suppurative fever exist. When gangrene is actually present the signs of inflammation have passed away, bullæ and emphysema are noted, with great swelling and all the other symptoms of molar death. The sudden cessation of pain is very suggestive of gangrene. The constitutional symptoms are those of suppurative fever and sapremia, or possibly of septic infection.

When a wound becomes gangrenous the surface looks like yellow or gray tow, the discharge becomes profuse and very fetid, and the parts about swell enormously and gradually become gangrenous.

Treatment of Moist Gangrene.—In extensive moist gangrene of a limb, if the condition is of the form described as mild, in which there are not severe symptoms of sepsis and in which the gangrene is not rapidly progressive, wait for a line of demarcation, and amputate clear of and above it. While waiting for the line to form, dress the dead parts antiseptically, wrap the extremity in cotton, apply warmth, and slightly elevate the limb. Give opium, tonics, nourishing food, and stimulants. In the severe form of moist gangrene (really gas gangrene) amputate at once high above the gangrenous process (page 99). In inflammatory gangrene, such as is sometimes associated with phlegmonous erysipelas, relieve tension by incisions, cut away the dead parts, brush the raw surface with pure carbolic acid, dust with iodoform, and dress with hot antiseptic fomentations. Stimulate freely, administer nourishment at frequent intervals, and treat the patient in general as we would a case of sapremia or suppurative fever. A gangrenous wound is treated as pointed out in the section on Sloughing.

Gas Infection and Gas Gangrene.—Virulent infection of a wound with certain micro-organisms may produce a violent spreading process or even gangrene. The gangrene was first described in 1853 by Maisonneuve under the name of *gangrène foudroyante*. In 1864 Pirogoff called it *acute gangrenous edema*. It has also been called *gas gangrene, acute mortification, fulminating gangrene, emphysematous gangrene, gangrènous emphysema, gaseous phlegmon*, and *traumatic spreading gangrene*. It is occasionally, though seldom, seen in civil life, particularly after crushes of the legs. I have seen it several times in run-over accidents, compound fractures having occurred and the wounds having been contaminated with street dirt. We were accustomed to call it acute mortification or traumatic spreading gangrene and knew that gas gathered in the tissues. Sir Anthony Bowlby says "it is practically unknown in Great Britain" ("The Treatment of War Wounds," by W. W. Keen). It must have been very rare in the war between the States, as my old master Prof. Keen never saw a case. It has been demonstrated in a case of gangrenous cholecystitis (G. G. Cottam, "Surgery, Gynecology, and Obstetrics," August, 1917), and has ensued upon ischiorectal abscess.

In the World War it proved a frightful scourge. Great numbers of those wounded in trench warfare developed gas infection and many of the wounded died.

The condition results from infection with various anaërobic micro-organisms, particularly bacteria which belong to the intestinal flora. The soil of Belgium has for centuries supported a teeming population and abounds with all sorts of fecal bacteria. Trench warfare means dust in dry weather and mud in wet weather. The soldier's skin is smeared with bacteria and his clothes contain multitudes of them. The organism responsible in most cases is the Bacillus aërogenes capsulatus (the bacillus of Welch). It is found in 70 per cent. of cases of gas infection, although very seldom in pure culture. Usually the infection is a mixed one. In rare cases the Welch bacillus is found alone. The streptococcus is the organism most often found with the bacillus of Welch. We may find the diplococcus, the Bacillus sporogenes, the Bacillus perfringens, the Bacillus proteus, or other micro-organisms. There are various strains of the Welch bacillus. The Bacillus aërogenes capsulatus and the Bacillus perfringens belong to different strains of the same organism. The Bacillus perfringens and the Bacillus aërogenes capsulatus proliferate much more rapidly when grown in symbiosis with

Bacillus proteus, Bacillus pyocyaneus, streptococcus, staphylococcus, and diphtheroid bacilli (Douglas, Fleming, and Colebrook in "Lancet," April 21, 1917). Legros ("Presse Méd.," Feb. 19, 1917) found the Bacillus perfringens with the Bacillus edematiens in a case of gas gangrene with edema.

In 4 per cent. of cases the bacillus of malignant edema is the cause (Weinberg in "Glasgow Med. Jour.," 1916, lxxxv). The various organisms named above may be found in certain soils, in animal and human feces, in street dirt, and in the dust of floors. Three classes of wounds are especially predisposed: crushes with breach of surface continuity, punctures with much blood extravasation, and lacerations with much hopelessly damaged tissue. The condition sometimes follows slight wounds, but the wounds are usually extensive. Lacerations of muscle are especially dangerous. Wallace ("Brit. Med. Jour.," June 2, 1917) and others assert that gas gangrene is first of all and chiefly a disease of muscle. Great numbers of the sufferers from compound fractures have fallen victims to the infection. Lodged foreign bodies are often actively causal, a rifle bullet much less powerfully so than a piece of shrapnel case. A shell fragment is most dangerous. A portion of clothing carried into the tissues is highly dangerous.

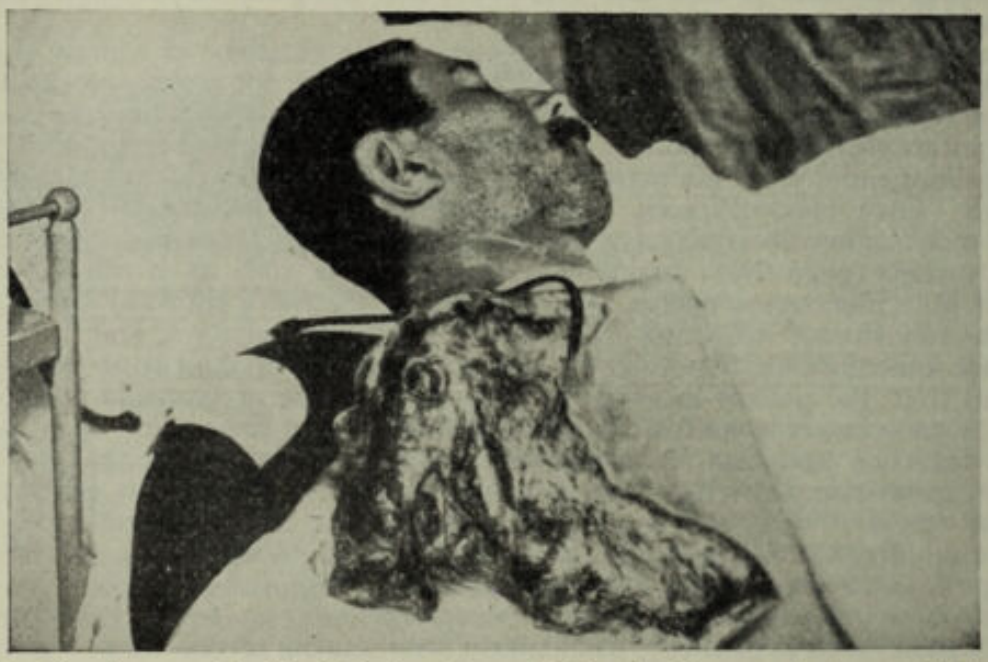


FIG. 52.—Showing a gas-bacillus infection of a mutilating shoulder wound, due to a high-explosive shell fragment and accompanied by necrotic infiltration of a large part of the chest wall, which proved fatal. The patient was received five days after injury and the necrotic material was removed, followed by a continuous irrigation. (By courtesy of the Harvard unit—Fauntleroy, "Report on the Medico-Military Aspect of the European War.")

In most of the wounded from the trenches the wound fluid contains the causal bacteria, although in many there may be no clinical evidence of the infection, and in many of these cases prompt treatment prevents disastrous consequences. Taylor says that the gas bacillus is found in 70 per cent. of the wounded ("Treatment of War Wounds," by W. W. Keen) and Fleming found it in 103 wounds out of 127 ("Lancet," Sept. 18, 1915). In trench warfare every wound is to be regarded as containing it, and the surgeon acts in accordance with this belief.

The bacteria of gas infection grow with frightful activity. Sir Anthony Bowlby saw gas five hours after the infliction of the wound and saw gangrene of an entire lower extremity and death in sixteen hours. I have seen gangrene of an entire lower extremity and death in thirty-six hours. But such great rapidity of progress is not the rule. Signs of infection are not met with in most cases until between ten and thirty hours after the wounding. The *x*-rays will show bubbles of gas in the tissues even before infection is made manifest by clinical signs. Savill maintains that the appearance of the radiograph not only indicates gas in the tissues, its situation and diffusion, but also the variety of infection, viz., pure Bacillus perfringens, or Bacillus perfringens and sporogenes, etc. (quoted in "Brit. Med. Jour.," March 3, 1917, from "Archiv. Radiol. and Elec."). Infection without gas bubbles will not show on the plate. Between thirty-

six and forty-eight hours the clinical signs become marked and positive. The infection does not seem to start in the subcutaneous tissue. It starts in the muscular tissue. If gas appears in the subcutaneous tissue it does not form there, but reaches there from the muscle (Frankan, Drummond, and Neligan in "Brit. Med. Jour.," June 2, 1917). The infection spreads within muscle sheaths and along fascial planes with very great rapidity, and muscles tend particularly to become gangrenous. The rapidity of spread is explained by the structure of the muscles. The sheaths of individual fibers are easily detached and when detached form spaces along which toxic matter passes to cause necrosis of the fibers (Wallace in "Brit. Med. Jour.," June 2, 1917). The process ascends and descends the damaged muscle. A muscle or a group of muscles becomes involved. Infection is not apt to spread to adjacent muscles. In a great majority of cases the infection is in the lower extremity. The region most liable is the buttock and then, in order, come the thigh, the leg, the arm, the forearm, and the foot. The hand is seldom, the face, neck, chest, abdomen and scalp are very seldom, attacked (see "Report of the Medico-Military Aspects of the European War," by Surgeon A. M. Fauntleroy, U. S. N.). Bowlby never saw it in the head. The apparent immunity of certain regions is thought to be due to their excellent blood-supply. The blood maintains tissue resistance and by its oxygen inhibits the growth of anaërobic microorganisms. Mixed infection by aërobes (staphylococci, streptococci, etc.) adds greatly to the danger because these bacilli appropriate oxygen and anaërobes grow without restraint. In a wound dead tissue and foreign bodies, especially bits of clothing, are great dangers (Tissier, "Ann. Inst. Pasteur," Dec., 1916). Lacerated wounds with much hopelessly damaged tissue and punctured wounds with great blood extravasation are the most usual seats of infection.

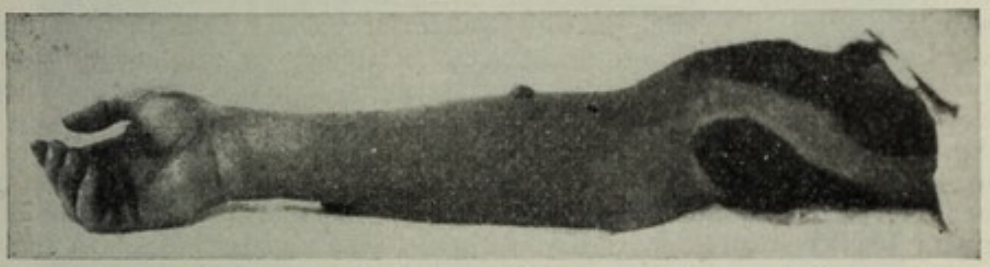


FIG. 53.—Fatal case of gas-bacillus infection of the arm and forearm, following a high-explosive shell wound of upper arm. Patient received five days after injury and an immediate amputation performed at shoulder-joint (Fauntleroy, Ibid.).

Weinberg ("Glasgow Med. Jour.," 1916, lxxxv) is so impressed with the value of good blood-supply in antagonizing the growth of anaërobes that he asserts gangrene does not occur unless the main vessel or vessels of the limb are occluded. Few agree with this contention, although all would admit that if the vessels are occluded gangrene will appear early and be most rapid in progress.

Infections were always more numerous in rainy weather because the soldiers when struck were covered with the mud of the trenches.

As the bacilli grow in the tissues they form gas and also poisons of enormous potency and these poisons with gas enter the blood. Two poisons are formed, one a hemolysin causing blood destruction, the other acting locally and causing edema and necrosis (Bull and Pritchett in "Jour. of Exper. Med.," July, 1917). Until late in the case the blood does not contain the bacteria, but in what we call the septicemic state does contain them. They are found in the wound discharge in the first few hours of the infection, can be found before there are any clinical signs of infection, and have been found in many cases which never developed clinical signs of the infection because the treatment was efficient.

Gas enters the blood and it is probable that the presence of gas in the blood explains the sudden deaths which are not uncommon in gas infections.

In from ten to thirty-six hours after the injury the pulse begins to rise, the temperature mounts a degree or two. As yet there is little swelling and practically no pain. The skin about the wound shows a light coppery hue. The wound discharge is brownish in color, contains the causal bacteria, and is somewhat foul in odor. Gas formation is already taking place, bubbles may be seen in the discharge, and will be seen certainly in the wound if free incisions are made. The *x*-rays show the bubbles of gas very early. If the infection is not arrested promptly it will develop rapidly, and all the symptoms will be intensified. By the period of forty-eight hours from the accident great changes

in the tissues have begun. The pulse becomes very rapid. The temperature rises, but not at first to a degree which would correspond to the pulse. In a day or two, however, the temperature becomes 104° to 105° F. The discharge now stinks. Great swelling occurs, partly edematous, partly gaseous. The gas causes the parts to crepitate on pressure. In some cases edema is so great as to mask crepitation.

Around the wound is an area of induration and the skin about the wound becomes coppery, brown, or purple. There is usually violent pain in the wound and backache and headache are often prominent symptoms. The expression is dull and listless and there is commonly wandering delirium. Vesicles soon crop up on the skin near the wound. The fluid of the blisters may or may not contain the bacteria.

After one, two, or three days of this state septicemia develops. The bacteria have now entered the blood and the case is hopeless. The pulse rises and the temperature falls. The pulse is rapid and weak, the respirations are shallow, stupor deepens into coma, if sudden death does not occur from gas embolism the comatose patient will pass into collapse with subnormal temperature, and thus will the tragedy terminate.

Treatment.—Early and radical treatment is imperative. If the discharge contains the bacilli, but there are no clinical symptoms, removal of foreign bodies and dead tissue, free incision, sterilization of the wound with iodin or a solution of hypochlorous acid (0.5 per cent.), drainage, or the use of Dakin's fluid will almost certainly prevent the development of the disease. During the first twenty-four hours after the injury when symptoms have just begun, free incision, extirpation of every muscle the fibers of which do not respond to external stimulus (*débridement*), opening up of every pocket, removal of foreign bodies, and the use of the Carrel-Dakin technic will save most cases. During the first forty-eight hours this plan will save many cases. The widest extirpation of infected muscle and damaged muscle is imperative.

In more advanced cases of limb involvement if free incisions, extirpations of necrotic muscles and other tissues, the Carrel-Dakin treatment fail, amputation will be necessary. In rapidly advancing cases amputation is the only chance. When amputation has been performed, if not a guillotine amputation, suture the flaps back to sound skin so as to keep them wide open and leave the wound exposed to the air. Injecting peroxid of hydrogen into the tissue about an area of gas infection has been tried, but is not to be commended. Inhalations of oxygen are thought to be of service.

Weinberg (Ibid.) believes that the polyvalent serum of Leclorinche-Vallée is valuable in treatment, especially if streptococci are present, and that an autovaccine should be made of all the organisms found in the wound. An antitoxic serum to prevent and treat gas gangrene is prepared by Bull and Pritchett ("Jour. Exper. Med.," July, 1917). They suggest that a preventive dose be given to all wounded men at the first dressing station. In the early days of the war the mortality from gas gangrene was frightful. The importance of early treatment and the necessity for radical action were not fully appreciated. Many cases were not radically treated until they reached base hospitals, which often meant a delay of five or six days. The improvement in transport now gets them to a base much sooner. The earlier and the more radical the treatment, the better the prognosis. The mortality in cases in which gangrene appeared within the first twenty-four hours after injury has been at least 50 per cent., in those in which it appeared in from twenty-four to seventy-two hours, 33 per cent. (Chalier in "Presse Méd.," March 22, 1917).

Hospital gangrene or **sloughing phagedena** is a disease that has practically disappeared from civilized communities. The last case seen in Guy's Hospital was in 1849 (Bryant's "Practice of Surgery"). It formerly occurred with dreadful frequency among the wounded in crowded, ill-ventilated hospitals, in camps, and on war vessels. There were many cases during the American Civil War. At times it would sweep through a hospital with a frightful toll of deaths. Such outbreaks led Ponteau to wonder if hospitals were not a curse. The first distinct description of it will be found in the posthumous works of Ponteau, of Lyons, published in 1783. He christened the condition "hospital gangrene." Some consider it traumatic diphtheric. Koch thinks it is due to streptococci. Jonathan Hutchinson says: "Hospital gangrene is set up by admitting to the wards a case of syphilitic phagedena." It may show itself as a diphtheritic condition of a wound, as a process in which sloughs which look like masses of tow form, or as a phagedenic ulceration. The surrounding parts are inflamed and painful, and buboes form in adjacent lymphatic glands. The system passes into a low septic state. Unlike gas gangrene, the muscles resist infection. Delirium is common. There is no formation of gas. The prognosis is most grave. Surgeon-General Sir G. H. Makins says that in the World War "hospital gangrene of the classical types has been con-

spicuous only by its absence; during a period of two and a half years I have only seen one or two cases which seemed to resemble the spongy form, although the membranous type has been occasionally seen" ("Lancet," Feb. 17, 1917).

Treatment.—In treating hospital gangrene ether should be given, the large sloughs removed with scissors and forceps, the parts dried with gauze, and cauterized with fuming nitric acid or bromin. The wound should be plentifully sprinkled with iodoform and dressed with hot antiseptic fomentations. When the sloughs separate the sore can be treated as an ordinary ulcer. The constitutional treatment is that employed for sepsis. In many cases amputation is indicated.

Special Forms of Gangrene.—Raynaud's disease may be responsible for **symmetric gangrene** of the fingers or toes. Raynaud's disease (Fig. 54) was first described as a distinct malady by Maurice Raynaud in 1862 ("L'Asphyxie locale," Paris, 1862). It is usually regarded as a vasomotor neurosis, is seen particularly in children and young female adults, but is sometimes met with in men. Chlorotic and hysteric women seem more apt than others to suffer from it. The condition is much commoner in winter than in summer, and cold seems to be an exciting cause. The well-known chilblain is an area of local asphyxia. The essential cause of Raynaud's disease is uncertain. In some acute cases associated with fever, albuminuria, and splenic enlargement it seems to be a part of an acute infectious disease. It can occur in a variety of toxic conditions and in a number of infectious diseases (typhoid fever, for instance). It



FIG. 54.—Raynaud's disease (Horwitz).

may develop in the course of gout and also of diabetes. In many cases neuritis exists; in some there is either obliterative endarteritis or angiothrombosis of the larger peripheral vessels. Some cases seem to be purely hysteric. The fact that attacks of Raynaud's disease are sometimes accompanied by hemoglobinuria has suggested malaria as a possible cause. In light of recent investigations there is a possibility that the condition is due to an infection, toxemia attacking the periarterial sympathetic. Raynaud's disease is characterized by attacks of cold, dead bloodlessness in the fingers or toes as a result of exposure to cold or of emotional excitement (*local syncope*). In the more severe cases there are capillary congestion and mottled, livid swelling (*local asphyxia*). A case may begin with attacks of local syncope, and after a longer or shorter time develop instead attacks of local asphyxia. Attacks may be occasional and far apart, may be frequent, or the condition of "dead" bloodlessness or asphyxia may be almost continuous. In some cases they only occur in winter; in others the slightest chill develops them. The patient complains of pain, tingling, numbness, coldness, and stiffness in the affected parts. In some few cases the skin of the face or trunk is attacked. Local syncope is thought to be due to vascular spasm, and local asphyxia to some contraction of the arterioles, with dilatation of the capillaries and venules. It is after local asphyxia that gangrene may appear. Attacks of Raynaud's disease occur again and again, and may never eventuate in gangrene. The *x*-rays may show areas of bone absorption in the distal phalanges.

Raynaud's disease is seldom fatal.

Ever since Raynaud's day it has been generally maintained that the attacks are always symmetric and that the blood-vessels are not diseased. We now know that many cases are successive, but not symmetric in the beginning, and that some never become symmetric. This is especially true in the lower extremities. It has been shown of recent years that cases of thrombotic blocking of the larger arteries of the legs exhibit symptoms of Raynaud's disease before gangrene occurs, and that cases of Raynaud's disease of the feet and of erythromelalgia are apt to suffer from vascular thrombosis and gangrene from this cause.

Raynaud's gangrene (Fig. 55) is a dry gangrene and is most commonly met with upon the ends of the fingers or the toes, but it may attack the lobes of the ears, the tip of the nose, or the skin of the arms or the legs. Sometimes the disease is seen upon the trunk. The gangrene may be symmetric from the beginning, may be successive, or may remain asymmetric. Certain it is that many cases which we formerly regarded as clear cases of Raynaud's disease of the lower extremities develop gangrene due either to obliterative endarteritis or angiothrombosis (see page 92). In such cases there is usually violent pain for weeks or months before gangrene begins, and in large arteries even well above the lesion the pulse is not detectable. When genuine Raynaud's gangrene is about to occur the local asphyxia at that point deepens, anesthesia becomes complete, and the part blackens and feels cold to the touch. The epidermis adjacent to the gangrene may be raised into blebs which rupture and expose dry surfaces. A line of demarcation forms, and the necrosed area is removed as a slough. During all of this process the pulse is still detectable above the lesion. Wide-spread gangrene from pure Raynaud's disease is rare; there is not often an extensive area involved—rather a small superficial spot.

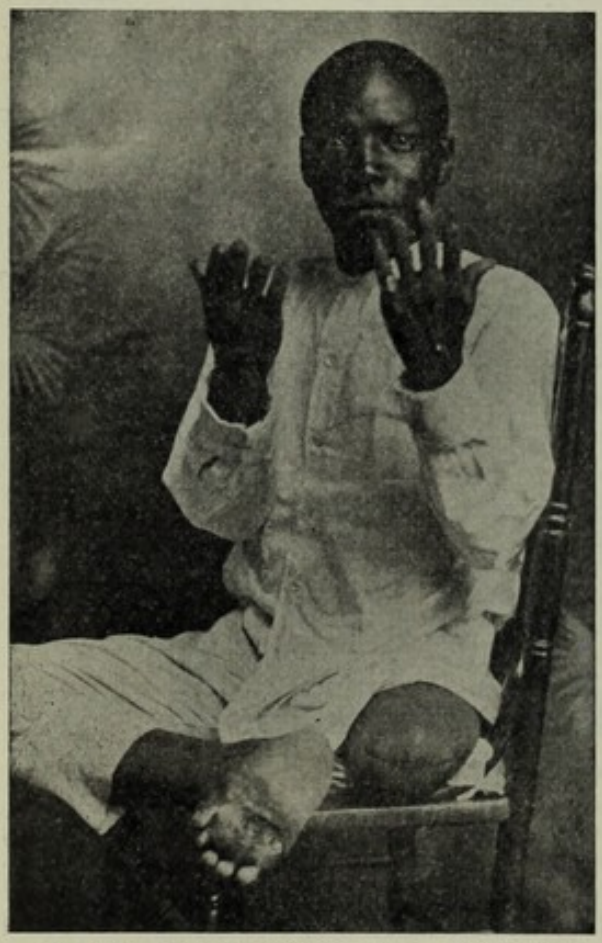


FIG. 55.—Raynaud's gangrene. Patient has lost most of the terminal phalanges of the fingers and also the left leg. Right leg was amputated soon after this picture was taken. (Patient of Dr. T. E. Wannamaker, Jr., of Cheraw, S. C.).

Treatment of Raynaud's Disease and of Raynaud's Gangrene.—If an individual suffers from attacks of Raynaud's disease, every effort should be made to improve the general health and to avoid chilling the surface of the body. During the attack employ gentle massage, place the extremity in warm water, and, if pain is severe, give morphin hypodermically. Amyl nitrite is without value in this condition. When attacks of Raynaud's disease are so severe as to threaten gangrene, put the patient to bed; if the feet are attacked, elevate the legs slightly, wrap the affected extremities in cotton-wool, and apply warmth. If the hands are affected, wrap them in cotton-wool, elevate them slightly, and apply warmth. Massage is useful. Arteriovenous anastomosis has been employed for threatened gangrene, and several apparent successes have been reported (see page 94). When gangrene occurs, dress the part antiseptically until a line of demarcation forms, and then remove the dead parts by scissors, forceps, and antiseptic fomentations. Leriche's operation should be considered (page 423). If amputation becomes necessary, wait for a line of demarcation. In gangrene of a toe, toes, or foot due to angiothrombosis or obliterative endarteritis, amputation is always necessary. The terrible pain calls for it, and even if the gangrenous area is very small it is certain to spread or new areas are sure to arise. This form of gangrene has been treated by several surgeons by anastomosing the femoral vein to the femoral artery. Several times this operation seems to have proved successful. In an advanced case with thrombosed veins it cannot succeed (see page 94).

Diabetic gangrene has been known for many years. In 1839 Monneret spoke of gangrene of the lung occurring in a diabetic ("Archives générales de Médicine," 1839). Diabetic gangrene often resembles strongly senile gangrene, but in many cases the dead portions remain somewhat moist and putrefy. Some surgeons attribute it directly to the sugar in the blood. Some think diabetes causes gangrene indirectly by rendering the tissues less resistant to infection and less capable than normally of repair. We know that sugar in blood removes fluid from the tissues and causes wound fluids to contain sugar. Hence wound fluids become excellent culture-media and body cells lose resisting power. There is a great deficiency of oxygen in the tissues, which probably predisposes to infection (Lockwood in "Lancet," Feb. 10, 1912). The frequency in diabetes of boils, carbuncles, and spreading suppuration indicates lessened resistance to infection, and any infected area may become gangrenous. If phthisis exists or arises in a diabetic it develops with fearful speed toward a fatal issue. J. C. DaCosta, Jr., and Beardsley demonstrated that diabetic blood-serum shows a lowered opsonic index for tubercle bacilli, staphylococci, and streptococci. It is an interesting fact in this connection that the blood-serum of a pancreatectomized dog has a very low bactericidal power. Some hold that diabetic gangrene is of neurotic origin, being the result of nerve degeneration. Certain it is that some few cases present symptoms resembling those of Raynaud's disease. Heidenhain believes that it is due to arterial sclerosis. That most of the victims of diabetic gangrene suffer from arteriosclerosis is certain. It seems probable that the gangrene is due to infection of tissue predisposed to infection by the presence of sugar and lessened amount of oxygen, and weakened by changes in the nerves and blood-vessels. Diabetic gangrene is most usually met with upon the feet and legs of elderly people, but it may arise at any age and may attack the genital organs, thigh, lung, buttock, eye, back, finger, or neck. It may affect only a single area, may attack several areas, or may be symmetric. It may arise in any stage of diabetes, from the earliest to the latest. It may begin as a perforating ulcer. It may attack a wound. It is much more common in men than in women. There are clearly two forms of this condition. In one there is a slowly progressive, fairly dry gangrene, probably due chiefly to arterial sclerosis. In such a case a small, dry, dead patch sometimes lasts months before spreading begins. As in senile gangrene, a trivial injury is apt to be the exciting cause. In such a case the urine contains sugar and perhaps albumin, but seldom either acetone or diacetic acid. In the other form an injury, perhaps a trivial one, is followed by a rapidly spreading cellulitis, which seldom forms pus and which eventuates in moist gangrene. In such a case the urine is apt to contain acetone and diacetic acid and there is grave danger of coma. When the gangrene follows a traumatism there are no prodromal symptoms. When it arises spontaneously in the skin, it is often preceded by pain of a neuralgic nature and attacks of "livid or violaceous discoloration of the skin, with lowered surface temperature and sometimes loss of sensation" (Elliot). In diabetic gangrene of an extremity the pain is often most violent, due probably to neuritis. In fact, neuritis may precede the gangrene. Diabetic gangrene is often superficial, but may become deep if it follows an injury or ulceration. Many of these patients are cyanosed (Lockwood in "Lancet," Feb. 10, 1912). A sufferer from diabetic gangrene is liable to cardiac failure, collapse, and coma.

Diabetic coma (*Kussmaul's coma*) is an acid intoxication due to accumulation in the blood of acids which do not belong there. It has been generally stated that the chief agent is beta-oxybutyric acid, that acid gathers in the blood because of lack of proper oxidation, that diacetic acid is formed from beta-oxybutyric acid, and that the breaking up of diacetic acid in the urine forms acetone and carbon dioxid. Hence, *acetonuria* means *acidosis*. Some blame the ketone bodies, others the acid phosphates for acidosis. Austin ("Penn. Med. Jour.," Feb., 1917) points out that the acid bodies are not the same in all cases. When a diabetic patient is starting on a protein-fat diet, and after surgical anesthesia the acid materials are largely the ketone bodies, "the same is probably true in most of the severe intoxications of childhood." In nephritis and the severe diarrheas of childhood acid phosphate is mainly responsible. Among the theories of acidosis the most striking is that of Crile ("Annals of Surgery," September, 1915). It is founded upon a series of brilliantly conceived and carefully conducted experiments. Crile points out that acidity is fatal to the life of a plant. The blood of animals is alkaline and even a trivial diminution in its alkalinity if persistent is fatal. Alkalis and bases must be broken down to furnish the energy for muscular action and heat, and when they break down acids must be set free. How are these acids eliminated? Carbon dioxid is eliminated by the lungs. An increase of carbon dioxid causes

an increased output of adrenin (which dilates the alæ nasi, bronchioles, and air vesicles), and increased activity of the respiratory center (which controls the "rate and amplitude" of respiration). An increased output of adrenin is caused by emotion, overexertion anesthesia, injury, surgical shock, auto-intoxication, Graves' disease, infection, strychnin poisoning, injections of indol, amido-acids and foreign proteins, and by certain other things (Cannon, Crile, Magnus, Elliot). These elements are called activators, and when they act they cause an increased formation of acid by-products, gaseous and in solution.

The brain controls the adrenals. If the path between the brain and adrenals is severed or if the brain function is depressed or suspended by morphin, activation of the adrenals causes no increase in the output of adrenin. The respiratory center is governed by the hydrogen-ion concentration of the blood.

Crile states that it thus becomes evident that the mechanism for the elimination of acid by-products that are gaseous consists of the brain, the adrenals, and the lungs, and the carbon dioxid is the stimulant of this mechanism. It is known that when carbon dioxid is injected into a normal man there is an increase in the output of adrenin and an increase of respiratory activity. Acid by-products which are in solution in the body fluids should be eliminated by the kidneys and the sweat-glands. Crile points out that when these by-products are first formed they are not in forms permitting elimination. They must first be transformed into salts which do not damage the kidneys (phosphates, chlorids, sulphates, urea, creatin, and creatinin); that the brain, the adrenals, and the liver are especially concerned in effecting this transformation, and the brain is the governor of the mechanism which accomplishes neutralization of acid by-products in the body fluid. When these acid by-products are not transformed, in other words, are not put in proper form for elimination, the condition of acidosis exists. Acetone is found in the urine when carbohydrates are not taken in sufficient quantity or are not assimilated by the tissues. Diabetic coma may be seen at any age, but is most often seen in young diabetics. It may arise after shock, excitement, general anesthesia by ether or chloroform (page 1212), or exhaustion. After many surgical operations some acetone can be detected in the urine (Brodner and Reimann, "Amer. Jour. Med. Sciences," 1915, cl). Coma in acid intoxication commonly comes on rapidly with vomiting, abdominal pain, weakness, restlessness, and drowsiness, which soon passes into coma. In some cases it is ushered in by collapse, in others by confusion of thought and speech, in still others by delirium or even mania. In coma the respiration is usually deep, rapid, and may be sighing. The pulse is small, of low tension, and very rapid and weak. The face is pale until the patient is near death, when it may become cyanotic. The urine is scanty and albuminous. Urinary suppression may occur. The temperature becomes subnormal, although during the onset it may be elevated and it may rise before death. The breath smells of acetone. The odor of acetone on the breath has been compared, according to the taste and fancy of the comparer, to all sorts of odors, from that of rotten apples to that of new mown hay. Some compare it to sour beer, some to chloroform, some to violets. In truth, acetone on the breath has the smell of *acetone*, a fact which we might infer. The patient lies quietly in bed and the pupils are dilated. Until recently we were sure that in from twenty-four to forty-eight hours, as a rule, the patient would die. Death may be preceded by convulsions.

Never fail to examine carefully the urine in every surgical case and especially in every case of gangrene, because diabetes or acidosis may exist when least suspected. If albumin is present in the urine of a diabetic it means increased peril; if casts are found the prognosis is still worse. In such a case uremic coma may occur and be mistaken for diabetic coma. The treatment before and after operation if acidosis exists is indicated on page 107.

The blood-sugar must always be determined when there is a suspicion of diabetes, of coma, or of threatened coma.

Treatment of Diabetic Coma.—Diabetic coma was formerly treated by purgatives (if the patient could swallow, otherwise by purgative enemas); enemas of sodium bicarbonate, the drug being also given by the mouth if the patient could swallow; sodium bicarbonate by hypodermoclysis and by intravenous injection. The solution for hypodermoclysis and for intravenous use contained 1 or 2 dr. of sodium bicarbonate to a pint of sterile water. Practically no one recovered. Now insulin is used and the success is remarkable. A medical colleague should treat the case.

Treatment of Diabetic Gangrene of Foot.—When a part is threatened with diabetic gangrene superheated air should be tried, and it may be tried even when gangrene be-

gins if the process is slow in development and occupies but a limited area. Treatment must be adopted to remove sugar from the blood. This treatment is by diet and by drugs.

For many years diabetes has been a nightmare to surgeons. In the first place, diabetes predisposes to or causes certain surgical conditions, for instance, gangrene, boils, and carbuncle. In the second place, a surgical disease like appendicitis, cholecystitis, strangulated hernia, sarcoma, or carcinoma may occur in a diabetic patient. In the third place, a diabetic may receive a fracture or an injury of any kind. Insulin is of enormous value in all of these conditions and its use has greatly lessened the danger of surgical operations upon diabetics. At the present time, if there is opportunity for preparation, we prepare a diabetic for operation by means of a rigid diet and, if necessary, by the use of insulin. Insulin in no sense relaxes dietary necessities. Diet alone may be sufficient, but if it is not, insulin is required. We no longer rely solely on urinary observations. We must know the amount of the blood-sugar, and our object is to have the urine sugar free and the blood-sugar at the normal level. The chief dangers of surgery in a diabetic are the onset of gangrene and the development of acidosis and diabetic coma. An excess of blood-sugar predisposes to gangrene. To diminish blood-sugar below normal leads to acidosis. The surgeon, between the danger of hyperglycemia and the peril of hypoglycemia, is like the ancient navigator between the cape and the whirlpool. An injury of any sort, an inflammation of any sort, and the administration of ether or chloroform predispose to acidosis. Even with all precautions taken a diabetic patient is a poor risk, but by care and attention we can greatly reduce the danger. As a rule the surgeon is not a fit person to conduct the general treatment; an internist, skilled in the knowledge of metabolic processes, should be in charge of this side of the case. The condition of the blood-vessels and the kidneys, the age of the patient, and the existence of acidosis are of the first importance in every case of diabetes. If there is infection, the tolerance to carbohydrates is notably reduced, hence the liability to acidosis is greatly increased.

If an emergency operation is required on a diabetic, detailed preparation is impossible and, anyhow, it would be a highly dangerous procedure to suddenly reduce the intake of carbohydrates. The great danger in such a case is acidosis, and we should temporarily administer carbohydrates (orange juice, orange albumen, grape-fruit, etc., etc.).

"Acidosis may be prevented in patients having glycosuria and a blood-sugar in excess of 0.25 per cent. by giving subcutaneously 5 units of insulin. This dose may be repeated in one hour and then at two-hour intervals until glycosuria is abolished and the blood-sugar is reduced to normal limits. The urine should be examined and the blood-sugar percentage ascertained at the end of one hour to determine the effect of the insulin and the necessity of repeating the injections." ("Insulin and Its Use in Surgery," by Henry K. Mohler, "Therapeutic Gazette," July 15, 1924.)

The existence of acidosis and its severity is ascertained by the percentage of CO_2 by volume found in the blood, and any figure below 30 is regarded as indicating severe acidosis. A very simple case of acidosis may be treated by diet alone, but a more severe case requires not only diet, but insulin. When there is time for preparation a diabetic can usually be brought into first class condition with a normal or nearly normal blood-sugar, with no sugar in the urine, and with no acidosis. The details of these methods belong exclusively to the specially trained internist. Certain it is that by the use of proper diet and of insulin diabetic gangrene may be restricted and a line of demarcation may form, and amputation may be performed with vastly greater safety than was possible under the older methods. Diet and insulin tend to prevent gangrene and acidosis.

When the surgeon comes to operate he should remember that the anesthetic may be a risk; that ether to some degree and chloroform to a decided degree poison the cells of the body and damage the liver particularly. This damage to body cells lessens the capacity of the body to utilize carbohydrate elements. The best anesthetic for a diabetic is gas and oxygen, and the less time the patient is under the anesthetic, the better. Local anesthesia is desirable in some cases and spinal anesthesia has been recommended. I have seen diabetic coma arise a few hours after spinal anesthesia. Shock must be carefully guarded against, as it may be an active element in inducing acidosis. I believe it is a good plan to give morphin and atropin before the operation.

Acidosis and diabetic coma are considered on pages 105, 106.

We must be careful in using insulin. It may lower blood-sugar with such rapidity and so thoroughly as to throw the patient into shock. While giving repeated doses of insulin repeated examinations of the blood must be made so as to avoid a too complete

or too rapid removal of the sugar. Dextrose is always to be kept at hand, and should shock arise, a hypodermic injection of dextrose is to be administered. The strength of the dextrose should be 10 per cent. in salt solution. Ordinary sugar must not be used. Dextrose is a monosaccharid and does not require digestive juices to disintegrate. Levulose, also a monosaccharid, may be preferred to dextrose. If dextrose or levulose is used by the rectum the proper strength is 10 per cent. in water. It is needless to say that insulin given by the mouth or rectum is inert.

For a valuable consideration as to the use of insulin see Dr. Orlando H. Petty, "International Clinics," vol. 2, series 33, and Henry K. Mohler in "Therapeutic Gazette," July 15, 1924.

Most surgeons had grown very shy of amputating for diabetic gangrene until Küster, of Berlin, warmly advocated amputating above the knee without waiting for a line of demarcation. He showed that if amputation is performed below the knee, the flaps will become gangrenous, and that after high amputation sugar may disappear from the urine. Of 11 amputations by Küster, 6 recovered and 5 died; and of these 5, 3 had albumin in the urine as well as sugar.

Heidenhain warmly advocated early high amputation, with the making of short flaps, and, in the United States, Powers, of Denver, defended the views of Küster ("Amer. Jour. of Med. Sciences," Nov. 11, 1892). Most writers came to advocate high operation without waiting for a line of demarcation if the gangrene is moist and due to bacteria attacking tissue weakened by diabetes. The same practitioners, if dry gangrene due to arterial changes exists, advocate awaiting the formation of a line of demarcation before amputating. Added knowledge of the science of diet and the undoubted value of insulin lead us to endeavor to limit all cases of gangrene. The dietary care and the administration of insulin should be given into the charge of a medical colleague, and the blood-sugar test is the only one relied on, the urine test being often fallacious. In many cases sugar rapidly disappears. In such a case during the improvement of the glycosuria and glycemia we await the formation of a line of demarcation, and while waiting the gangrenous limb is treated with superheated air and in the intervals of the baking is wrapped in cotton-wool, slightly elevated, and kept warm by superheated air. When a line of demarcation forms and only a toe or toes are involved, the dead parts are removed surgically and spontaneous healing will perhaps occur. If it does not occur, or, if the gangrene involves the dorsum or sole of the foot, amputate above the knee.

If acetone and diacetic acid persist in the urine in spite of treatment (page 107) and if that excretion contains not only sugar but also quantities of albumin, we cannot dare to wait long for a line of demarcation because of the high probability that during the wait the patient will perish of septicemia (Klemperer, "Therapie der Gegenwart," Jan., 1907). In such a case perform an immediate high amputation.

If the urine contains acetone and diacetic acid I would formerly have said that a line of demarcation could almost never form, and that high amputation must be performed at once. Under treatment of insulin and diet such a line may form. Intense pain unchecked by baking is a strong indication for operation. So is positive infection.

In operating, ether and chloroform (especially chloroform) are to be avoided because either is liable to induce acid intoxication. The operation may be performed under nitrous oxid and oxygen anesthesia. In a recent successful case I infiltrated all the nerves with novocain and amputated. There was no pain and apparently no shock.

My experience of amputation in diabetic gangrene of the leg comprises 8 cases. In 6 cases the urine contained sugar, acetone, and diacetic acid, and in 2 of these cases albumin was also present. In 2 cases sugar was in the urine, but no albumin, acetone, or diacetic acid. In each case a high amputation was performed—1 case (one of those with albumin) died of shock; 2 cases died in coma; 1 case died of sepsis; 4 cases recovered. In one case there was gangrene of a large part of the right foot. The urine showed a strong reaction for acetone and diacetic acid. The blood showed 266 mg. of sugar per 100 c.c. Patient stuporous on admission. After five days of treatment by diet and insulin the blood-sugar was 150 mg. per 100 c.c. The urine was sugar free. Stupor had disappeared. Amputation was performed above the knee. The patient recovered (Petty in "Inter. Clinics.," Vol. II, Series 33).

Treatment of Diabetic Gangrene in General.—In gangrene of some region other than an extremity, place the patient on antidiabetic treatment, treat locally with hot antiseptic fomentations, remove tissue which is completely dead with scissors and forceps, and sustain the strength.

Gangrene from Ergotism.—Ergot gangrene was first described by Dodard in the Journal des Savans for 1676 (Aitken's "Science and Practice of Medicine"). Ergotism is a diseased condition resulting from eating bread made from rye which has been attacked by a fungus (*Claviceps purpura*). It contains sphacelinic acid and sphacelotoxin. In former days it was not unusual to have epidemics of ergotism from time to time, but at present the disease is now and then found in an individual or, at most, in a few of a community. Ergotism is very rare in the United States, but is not uncommon in southern Russia. It has occurred during the administration of ergot as a drug. Billroth reported such a case. It is never seen in unweaned children. The eating of bread made of diseased rye provokes gastro-enteritis, the evidences of which are abdominal pain of a crampy character, vomiting, diarrhea, and exhaustion. The patient complains of formication and itching of the skin of the extremities; severe, cramp-like, and tingling pains in the limbs, and disorders of vision. The pulse becomes small and slow. In some cases very painful spasms attack the muscles of the extremities and, finally, tonic spasm is noted, and the patient probably perishes from exhaustion after developing general convulsions and passing into coma. In other cases certain areas exhibit "gradual blood-stasis" (Osler), anesthesia, and, finally, gangrene. The gangrene is dry and peripheral. It usually affects the fingers or toes, but may involve an entire limb and

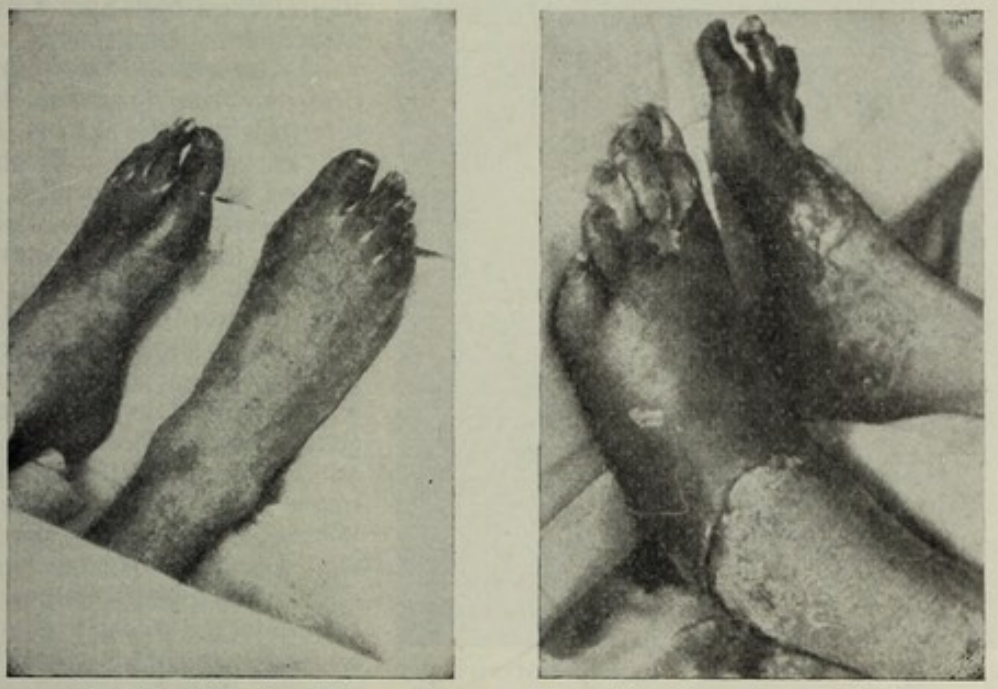


FIG. 56.—Showing different degrees of frost-bite (Fauntleroy, Ibid.).

may be symmetric. Chronic ergotism is usually recovered from, but acute cases die in from seven to ten days.[1] The ingestion of poisonous ergot in quantity sufficient to produce chronic poisoning causes tonic contraction of the peripheral arterioles, hyaline degeneration of the inner coats, and thrombosis of some vessels. It is also maintained that degeneration of the posterior columns of the spinal cord takes place.

Treatment.—Ergotism is treated by forbidding the eating of the poisonous bread, allaying gastro-enteric inflammation, favoring elimination, and administering nourishment and stimulants. If gangrene is threatened, endeavor to prevent it by gentle massage and the application of warmth. If superficial gangrene occurs, dress with warm antiseptic fomentations and elevate the part, and every day take scissors and forceps and remove the loose crusts. If deeper and more extensive gangrene arises in an extremity use heated air, wait for a line of demarcation, and amputate above it.

Gangrene from Frost-bite.—Frost-bite is most common in the fingers, toes, nose, and ears, but the genital organs, the cheeks, the chin, the feet and legs, and the hands and arms may be attacked. Cold causes a primary contraction of the vessels and pallor and numbness of the part. After reaction the vessels dilate, the part reddens and swells, and a burning sensation or actual pain is experienced. In a trivial frost-bite the swelling and redness usually disappear after a few days, but in some cases the redness is

[1] Pick in Heath's "Surgical Dictionary."

permanent, and in many cases the redness, in the form of local asphyxia, returns under the influence of slight cold. (See Chilblains.)

In a more severe frost-bite the affected part becomes purple and covered with vesicles and gangrene may or may not follow. When a part has been badly frozen it is whiter than normal, painless, anesthetic, and the peripheral portion dries. The part is deprived of all blood because of contraction of the vessels and because plasma coagulates at a few degrees above freezing. Cold disorganizes the blood, breaking up white corpuscles, with the liberation of materials active in coagulating power. Coagulation of plasma and destruction of red corpuscles with the liberation of hemoglobin subsequently take place. The thrombosis which is established prevents circulation, and the tissue cells are damaged beyond repair. The part is bloodless and anesthetic, and a line of demarcation forms; hence we note that severe frost-bite causes dry gangrene. Areas of superficial gangrene are not so uncommon. If a part which is not so badly frozen is brought suddenly into a warm atmosphere, hyperemia takes place when the blood runs into the frosted tissues, blebs form, and moist gangrene may result. Baron Larrey ("Surgical Memoirs"), in speaking of the retreat from Russia, tells a dreadful story of the suffering from cold. He says: "Persons were seen to fall dead at the fires of the bivouacs. Those who approached them sufficiently near to warm their frozen feet and hands were attacked by gangrene."



FIG. 57.—Noma. Seven days after first appearance of measles child showed gangrenous condition of mouth. Now, three days later, it involves both cheeks and under surface of upper and lower lips. Left cheek perforated. Two days before death a septic diarrhea developed which was uncontrollable (Crandon, Place, and Brown).

Treatment of Frost-bite and of Gangrene from Frost-bite.—A frost-bite in which the skin is livid and not as yet gangrenous should be treated by frictions with snow or rubbing with towels soaked in iced water. Larrey says that if frictions with snow or ice fail the part should "be plunged in cold water, in which it should be bathed until bubbles of air are seen to disengage themselves from the congealed part. This is the process adopted by the Russians for thawing a fish" ("Surgical Memoirs"). Whatever method is used, as the skin becomes warmer and congestion disappears the part should be subjected to dry friction and wrapped in cotton-wool. As previously stated, a sufferer from frost-bite should not be brought suddenly into a warm room. Some think that threatened gangrene may be averted by Leriche's operation (page 423). When gangrene follows frost-bite, if only small areas are involved, allow the dead parts to come away spontaneously, applying in the meanwhile hot antiseptic fomentations. If separation be delayed by cartilage, ligament, or bone, cut through the restraining structure. If amputation becomes necessary, await a line of demarcation, as it is not possible otherwise to be certain how high tissue damage extends, and to amputate through devitalized parts would mean renewed gangrene.

Noma is a rapidly spreading gangrenous process which is most apt to begin upon the mucous membrane of the gums or cheeks. Noma of this region is known as *cancrum oris* or *gangrenous stomatitis*. Occasionally it begins in the ears, the genitals, or the rectum. When it attacks the vulva it is called *noma pudendi* or *noma vulvæ*. It may originate in the mouth and subsequently attack other regions. Noma is a very rare disease, is chiefly met with in children between the ages of three and ten, but it may attack older persons. O. Zusch[1] reports a case in a man sixty-six years of age. King reports a case in a woman of fifty-nine.[2] It occurs in girls oftener than in boys.

[1] "Münchener medicinische Wochenschrift," May 14, 1901.

[2] "Jour. Amer. Med. Assoc.," 1911, vol. lvi.

The disease is most frequently encountered in children recovering from an acute disease. It is seen after scarlatina, typhoid, pneumonia, erysipelas, nephritis, dysentery and especially after measles; in fact, Osler says that over one-half the cases follow measles. Children of tuberculous tendencies seem more liable than others. Young children who live amidst filth and squalor, in damp and ill-lighted apartments are most prone to suffer, but that such conditions are not essential to the genesis of the disease is shown by the report of an epidemic of noma in the Albany Orphan Asylum. In this excellently situated, well-lighted, and well-ventilated building the children are carefully fed and cared for, and yet 16 cases of noma occurred after an epidemic of measles. (See "An Epidemic of Noma," by Geo. Blumer and Andrew MacFarlane, in "Amer. Jour. of Med. Sciences," Nov., 1901.) The disease is thought by many to be due to pus organisms. Lingard describes a bacillus which he considers causative. Blumer and MacFarlane conclude that the disease begins as a simple infection and a mixed infection takes place later. The mixed infection is not always due to the same organism, but is usually due to a long organism of a leptothrix type (Ibid.). Some think that cases of noma are due to a variety of spirochetes, and it is an interesting observation that in noma the Wassermann serum reaction may be obtained.

In 1908 Crandon, Place, and Brown studied an outbreak of noma. Measles had been through the ward, 46 children had had gangrenous stomatitis, and 6 of them developed gangrene of the lip and cheek. A seventh case of gangrene appeared from another source ("Boston Med. and Surg. Jour.," April 15, 1909). They decided that the lesion was necrosis due to fusiform bacilli which invade living tissue, but rapidly die in necrotic tissue. Of these 7 cases, 2 recovered. The writers state that the duration of the disease is from four to ten days. They do not regard it as proved that noma is contagious and do not advise isolation. Noma vulvæ is a very fatal lesion most common in young children. It is called also *cancer aquaticus*.

Symptoms.—The disease begins as a sloughing ulcer; thrombosis and gangrene are soon observed. The edges of the ulcer are dark red and indurated. The gangrene usually spreads with very great rapidity, but in some cases it remains apparently stationary for days at a time. There is little or no pain. The odor is horrible. The disease is frightfully destructive, and if the mouth is involved is apt to destroy the cheeks, lips, eyelids, and large portions of the jaws. There is usually fever, but the temperature may be normal or even subnormal. The pulse is rapid and exhaustion appears early and deepens rapidly. The mortality is large: Bruns says 70 per cent.; Rilliet and Barthez say 95 per cent. ("Amer. Jour. of Med. Sciences," Nov., 1901). Out of Nicoll's 11 cases, 9 died ("Progressive Med.," March, 1912). The cause of death is exhaustion, pyemia, or septic bronchopneumonia.

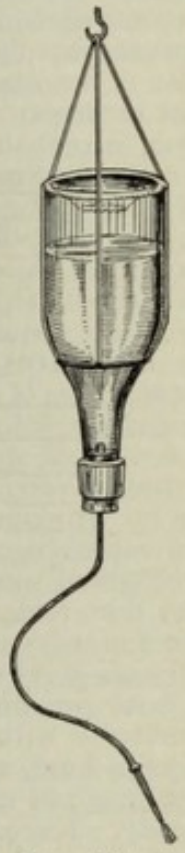


FIG. 58.—Improvised apparatus for the irrigation of a wound.

Treatment.—Administer an anesthetic and destroy the gangrenous area with the electric cautery. In noma of the mouth chloroform is used as an anesthetic instead of ether because the actual cautery is to be applied in a region surrounded with anesthetic vapor, and ether vapor is inflammable. In noma in some other regions ether can be given. After cauterization directions are given to wash the part every few hours with peroxid of hydrogen, irrigate it with hot salt solution or boric acid solution, and dress it with compresses soaked in Labarraque's solution (Blumer and MacFarlane in "Amer. Jour. of Med. Sciences," Nov., 1901). Nourishing food is given at frequent intervals, alcohol is administered, and strychnin is used to combat weakness. Rumple and Nicoll have each employed salvarsan and, they believe, with benefit. In one of Nicoll's successful cases two doses were given intravenously at an interval of three days. Each injection produced a great local reaction in the cheeks. If the surgeon succeeds in arresting the gangrene it will probably be necessary later to perform a plastic operation in order to replace loss of substance.

Sloughing is a septic process by which visible portions of dead tissue are separated. These visible portions are called "sloughs"; if they were large they would be called "gangrenous masses." A large septic slough is a gangrenous mass; a small

gangrenous mass is a slough; there is no difference in the process, which corresponds to the formation of a line of demarcation.

Treatment.—Sloughing requires thorough and frequent irrigation by an antiseptic fluid, removal of the sloughs, and antiseptic treatment. An irrigator can be improvised from an ordinary bottle (Fig. 58). Warm antiseptic fomentations are applied until granulation is well advanced. In most cases Dakin's fluid is the best remedy. Continuous irrigation with a hot antiseptic fluid is useful; in other cases continued immersion in a hot antiseptic solution is employed.

Phagedena is a process of ulceration and gangrene (most common in venereal sores) in which the surrounding tissues are rapidly eaten up, the sore becoming jagged and irregular, with a sloughy floor and thin edges. The discharge is thin and reddish, and the encircling tissues are deeply congested. This ulcer has no tendency to heal. Phagedena may attack wounds, but in this age is almost never seen except in venereal sores. When it attacks a wound the discharge is arrested, the parts about the wound become dark red and swollen, a black slough forms upon the wound, and the process spreads rapidly in all directions. The process when it attacks a wound is similar to a case of hospital gangrene, differing from the gangrene in the fact that in most cases a line of demarcation forms and the constitutional depression is not so great. Phagedena is probably due to mixed infection with pus organisms.

The **treatment of phagedena** consists in repeated touching with tincture of chlorid of iron and the local use of iodoform, the employment of continued irrigation, immersion in hot antiseptic fluids, the use of Dakin's fluid or the application of the cautery, chemical or actual. After using the cautery the part is dressed with hot antiseptic fomentations. Whatever else is done, tonics, stimulants, and nutritious diet must be given and opium is usually required.

Decubitus, Decubital Gangrene, or Bed-sore.—A bed-sore is the result of local failure of nutrition in a person whose tissues are in a state of low vitality from age, disease, or injury. The arterial condition of the aged favors the development of bed-sores. Such sores are due to pressure, aided it may be by some slight injury or by the irritation produced by urine, feces, sweat, crumbs or other foreign bodies in the bed, or by wrinkling of the sheets. The pressure destroys vascular tone, stasis results, thrombosis occurs, and gangrene follows. Sores occur over the heel, elbow, scapula, trochanter, sacrum, nucha, and upon the buttock. In some cases, even after pressure has been removed, stasis, vesication, suppuration, and ulceration will be noted. The ulcer is angry and is surrounded by a zone of swelling and hyperemia. These ordinary pressure-sores arise like a *splint-sore* due to the pressure of a splint upon the tissues over a bony prominence or the flexure of a joint. The pressure responsible for a bed-sore interferes with the blood-supply, the weakened tissues inflame, vesication occurs, sloughs form, and an ugly ulcer is exposed. When a bed-sore is about to form the skin becomes red and edematous. Pressure with the finger drives the color out rather slowly. The color becomes purple or black, a slough forms and separates, and a large, irregular, foul cavity is exposed. The discharge is profuse and offensive. The parts about are swollen and red. If the sore is not upon an anesthetic part, much suffering is produced by it. Bed-sores are most common in paralyzed parts; such parts are anesthetic, and injurious pressure is not painful and does not attract attention, and in such parts there is vasomotor paresis.

The **acute bed-sores of Charcot** are seen during certain diseases and after some injuries of the nervous system. These sores are usual over the sacrum in acute myelitis, and may appear in four or five days after the beginning of that disease or the infliction of an injury upon the spinal cord. The surgeon sees acute bed-sores upon the buttock of the paralyzed side after brain injuries, and over the sacrum and other bony points after spinal injuries. Some believe these sores are due to vasomotor disorder; but others, notably Charcot, attribute them to disturbance of the trophic nerves or centers.

Treatment of Bed-sores.—The "ounce of prevention" is here invaluable. From time to time, if possible, alter the position of the patient, keep him clean, maintain the blood distribution to the skin by frequent rubbing with alcohol and a towel, keep the sheet clean and smooth, and in some situations use a ring-shaped air-cushion to keep pressure from the part. When congestion appears (*paratrimma*, or beginning sore), at once use an air-cushion or a water-bed and redouble the care to change frequently the position of the patient. Not only protect but also harden the skin. Wash the parts twice daily and apply spirits of camphor, paregoric, or glycerol of tannin; or rub with salt and whisky (2 dr. to 1 pint); or apply a mixture of ½ oz. of pow-

dered alum, 2 fl.oz. of tincture of camphor, and the whites of four eggs; or paint with corrosive sublimate and alcohol (2 gr. to 1 oz.); or apply tannate of lead or equal parts of oil of copaiba and castor oil; or paint upon the part a protective coat of flexible collodion.

When the skin seems on the verge of breaking, paint it with a solution of nitrate of silver (20 gr. to 1 oz.). When the skin breaks, a good plan of treatment is to touch once a day with a solution of silver nitrate (10 gr. to 1 oz.) and cover with zinc-ichthyol gelatin. We can wash the sores daily with 1 : 2000 corrosive sublimate solution, dust with iodoform, and cover with soap plaster, with lint spread with zinc ointment, or with dry aseptic gauze. When sloughs form, cut them off with scissors after cleansing the parts, slit up sinuses, and use antiseptic fomentations. In sloughing Dupuytren employed pieces of lint wet with lime-juice and dusted the sore with cinchona and charcoal. In obstinate cases use the continuous hot bath. When the sloughs separate, dress antiseptically or with equal parts of resin cerate and balsam of Peru. If healing is slow, touch occasionally with a solution of silver nitrate (10 gr. to 1 oz.). Bed-sores, being expressive of lowered vitality, demand that the patient shall be stimulated, shall be well nourished, and shall obtain sound sleep.

Ludwig's Angina (*Angina Ludovici*).—This disease, which was first described by Ludwig, of Stuttgart, in 1836, is an acute septic infection about the submaxillary gland and in the cellular tissue beneath the mucous membrane of the floor of the mouth and of the upper portion of the neck. Ludwig called it "gangrenous induration of the neck" (D. Ludwig, "Med. Correspondenzblatt," p. 21, Feb., 1836, Stuttgart). The disease may arise in an apparently healthy man or during or after an infectious fever. It can arise at any age. The bacteria enter from the mouth by way of abrasions, wounds, ulcerations, or dental caries. It may be caused by delayed development of the third molar, necrosis of the tooth and alveolar process taking place and an abscess forming (G. G. Ross, "Annals of Surgery," June, 1901). In most cases the condition is a pure streptococcic infection or a streptococcic infection associated with infection by some other organism, for instance, staphylococci, pneumococci, or bacilli. In one of Davis's cases it was due to pneumococci alone; in another, to staphylococci alone (Gwillym W. Davis, "Annals of Surgery," August, 1906). In a case reported by Lockwood the bacillus of malignant edema was found. The condition is essentially an acute spreading cellulitis about the submaxillary gland. It usually begins about that gland, but in some cases seems to arise about the sublingual gland. It is usually a violent process from the start, but sometimes it is first an indolent swelling in the submaxillary region and becomes violent and begins to spread rapidly after a few days. It spreads along planes of connective tissue to the sublingual region of the mouth and to the pharynx.

The bacteria reach the submaxillary region in the lymph. A lymph-gland or perhaps several glands enlarge and are rapidly destroyed, the periglandular cellular tissue becomes involved, and, after this, spread takes place along connective-tissue planes rather than by lymph paths, and other lymph-glands seldom enlarge.

The localization in the submaxillary region, the violence of the inflammation, the rapidity of the spreading, and the subsequent involvement of the pharynx and floor of the mouth are the characteristic features of Ludwig's angina (T. Turner Thomas, "Annals of Surgery," February and March, 1908). Thomas, in the article just referred to, proves by anatomic studies that the connective tissue in the submaxillary fossa is directly continuous with that in the floor of the mouth. The disease begins as a painful indurated swelling beneath the body of the jaw, the swelling rapidly increases in the neck, and may even pass to the level of the sternum. A board-like feel of this swelling is distinctive. The skin may be pale or dusky red. There may or may not be marked tenderness.

After a few hours or a day or two the floor of the mouth becomes involved; as a result of this the tongue is raised and pushed back, the mouth is kept from closing, swallowing becomes difficult, speech is impaired, the saliva dribbles constantly, and dyspnea becomes an alarming feature of the case.

In some cases the temperature is much elevated, but in most it is moderately or only slightly elevated.

If a spontaneous opening should occur it will be within the mouth. Free suppuration may occur or only a little watery pus may form and the pus may be brown and putrid. In many cases the cellular tissue becomes gangrenous, the gangrene resembling that of noma. The mortality is high. In Thomas's collection of 106 cases it is seen that 43 died ("Annals of Surgery," March, 1908), though with the prompt inter-

vention which is now advised the mortality should be much below this figure at the present time. I have had 4 cases and 2 of them died.

Death may take place suddenly. Death is seldom due to septic intoxication or pyemia, but may be. It is usually due to edema of the glottis or to bronchopneumonia.

Treatment.—Operate promptly and incise freely. If there is an infective focus within the mouth, remove it. Make an incision through the swelling in the submaxillary region, carry the incision forward to the median line, and divide the mylohyoid muscle. "The finger should be passed upward in the wound until only mucous membrane intervenes between it and the mouth. Gangrenous tissue is cut away, the wound is painted with pure carbolic acid, and dusted with iodoform" (T. Turner Thomas, Ibid.). Drainage-tubes are inserted and the part is dressed by antiseptic fomentations. If edema of the glottis exists, tracheotomy should be performed promptly. Stimulants are given with a free hand in Ludwig's angina.

Carbolic Acid Gangrene.—Dressings moistened with a solution of carbolic acid of a strength of from 3 to 5 per cent. if wrapped for a number of hours around a finger or toe, a hand or a foot, may cause dry gangrene. There is but little danger when such dressings are applied to the tissues of the trunk, because these thicker tissues are better nourished and cannot be completely surrounded by the wet dressings. When a dressing wet with a watery solution of carbolic acid is wrapped about the part the water evaporates, and as it does so the carbolic acid becomes more and more concentrated. A well mixed solution seldom causes gangrene. A recent aqueous solution often contains free globules of acid and is particularly apt to cause gangrene (Murphy). It is claimed that a solution of carbolic acid in glycerin never causes gangrene (Pautrier in "Presse Médicale," March 2, 1907). Gangrene of a toe has occurred from the application of carbolized vaselin (Buckmaster's case, "Jour. Amer. Med. Assoc.," January 13, 1912). Two cases have been reported in which gangrene of a finger was caused by carbolized ointment (Brown, "Jour. Amer. Med. Assoc.," Nov. 11, 1911; Schussler, "Jour. Amer. Med. Assoc.," Aug. 19, 1911). In one case reported by DeWitt gangrene of the thumb resulted from injecting a ganglion of the thumb with equal parts of camphor and pure carbolic acid ("Southern Med. Jour.," June, 1909). The application of strong acid rarely causes gangrene, but Lévan found 14 reported cases in which it did (J. Lévan in "Centralbl. f. Chir.," Aug. 14, 1897), and Wallace has reported several more ("Brit. Med. Jour.," May 11, 1907). A solution as mild as 1 per cent. has caused gangrene. The continuous application of a solution of a strength of 3 per cent. or over is very dangerous and ought never to be practised. The author has seen 12 cases. Harrington saw 18 cases of gangrene in five years in the Massachusetts General Hospital, and collected 132 cases from literature ("Boston Med. and Surg. Jour.," May 2, 1901). Carbolic acid gangrene is due to great exudation into the cellular tissue, blocking the circulation (Housell), and the production of arterial thrombi, a condition to which the patient is predisposed by the injury and often by tight bandaging. The dressing is frequently applied by a druggist; it produces anesthesia of the part, and the dressing may not be removed for days, gangrene perhaps progressing beneath. In the author's 12 cases pain was absent and there was no smokiness of the urine or any other evidence of absorption of the drug. Dressing of lysol and alcohol may produce gangrene, but the necrosis is more superficial than that due to carbolic acid.

Treatment.—If the gangrene is very superficial, recovery may be obtained by using hot fomentations and picking the dead parts gradually away. In most cases the finger or toe is completely destroyed, a line of demarcation forms, and amputation is required.

Postfebrile Gangrene.—Dry or moist gangrene may follow any fever, but is most frequent after typhoid (may follow typhus, influenza, measles, diphtheria, scarlet fever, etc.). Keen tells us that the gangrene resulting from arterial obstruction is apt to be dry, and that from venous obstruction is usually moist. The same observer collected 203 cases of typhoid gangrene.[1] It is most usual in the lower extremities, but may appear in the upper extremities, cheeks, ears, nose, genitals, lungs, etc. Some writers have assigned as the cause weakness of cardiac action, but most observers believe an obstructing clot is the usual cause. This clot may come from the heart as an embolus, but in most cases it is a local thrombus secondary to endarteritis due to the action of the toxins of the bacilli of the specific fever. Keen shows that in some cases gangrene is due to obstruction of peripheral vessels and not of a main trunk. In rare cases gangrene arises after thrombophlebitis. Gangrene may begin as early as the fourteenth

[1] Keen on the "Surgical Complications and Sequels of Typhoid Fever."

day of typhoid, but usually appears late in the disease and may arise far into convalescence. In the course of a continued fever frequent examinations should be made to see that gangrene is not arising. Particular examination from time to time should be made of the lower extremities and, in young girls, of the genitals. If gangrene arises in an extremity, apply antiseptic dressings, wait for a line of demarcation, and then amputate. If gangrene occurs in other regions, remove the dead tissue and employ hot antiseptic fomentations.

Puerperal Gangrene of the Limbs.—Stein collected 74 cases and reported 2 of his own ("Surgery, Gynecology, and Obstetrics," 1916, xxiii). Most of the cases occurred after abortion. The condition may occur during pregnancy. Infection is the cause of most cases, but the condition may result from embolism, and Raynaud's gangrene may occur. Puerperal gangrene may be dry or moist according to the actual causal lesion.

Rules When to Amputate for Gangrene.—In *dry* gangrene, due to obstruction of a non-diseased artery, wait for a line of demarcation. In *senile* gangrene, if it affect only one or two toes, let the dead parts be cast off spontaneously. If a greater area is involved or the process spreads, amputate above the knee without waiting for the line. In *ordinary moist* gangrene, if there are not severe symptoms of sepsis, and if the gangrene is not rapidly progressive, wait for a line of demarcation. In the severer cases amputate at once high up. In many cases of *traumatic spreading* gangrene amputate at once high up. In cases of *diabetic* gangrene try by treatment to induce the formation of a line of demarcation, and if it forms, amputate high up. If a line does not soon form, amputate at once high up (see page 108). In *ergot* gangrene, in *carbolic acid* gangrene, in *postfebrile* gangrene, in *Raynaud's* gangrene, and in *frost* gangrene wait for a line of demarcation.

Arteriovenous Anastomosis for the Prevention or Treatment of Gangrene of an Extremity.—This operation took origin from Carrel's famous demonstration of the reversal of the circulation in a dog's leg. The axillary artery has been anastomosed to the axillary vein and the femoral artery has been anastomosed to the femoral vein. We know that by an anastomosis we can send arterial blood into a vein, but usually a clot soon forms at the junction. Those who advocate the operation assert that the force of the arterial blood-current overcomes the valves of the vein, and that arterial blood goes toward, even if it does not reach, the periphery. Further, that even if a clot does form, it forms slowly, circulation is arrested gradually, and collaterals distend during clotting.

Horsley, Stetten, and others oppose the operation. The opponents of the operation assert that the valves cannot be overcome, that the blood flows off into venous branches and returns to the heart. Though it is doubtful how far toward the periphery the blood goes, we believe that the repeated impact of the arterial blood must finally overcome the valves; and in spite of great uncertainty as to the return of blood to the heart, we know that successful reversal seems to have been accomplished in a few cases (see Meyer's explanation on page 94).

Bernheim ("Annals of Surgery," Feb., 1912) has collected 46 cases from literature and has added 6 operations, 2 of which were performed on the same individual (Halsted's case, Finney's case, Bloodgood's 4 cases). In the 52 operations gathered in Bernheim's table the ages of the subjects varied from twenty to eighty years. There were 13 deaths. He considers 15 of the cases successful, that is, "cases in which reversal, as far as one can judge, actually saved the limb from real or threatened gangrene." H. Morriston Davies recently reported a successful operation for gangrene. The artery and vein were completely divided and anastomosed in Hunter's canal ("Annals of Surgery," 1912). The mortality is large (see page 94).

The best plan is lateral anastomosis with proximal ligation of the vein to prevent the deviated blood from returning at once to the heart. Bernheim and Stone devised this method (Ibid.) and Murphy advocated it. Only one-third of the circumference of the artery is used for the anastomosis and some blood continues to flow in the artery toward the periphery. The artery carries blood to where the block is; the vein is supposed to carry blood much further. Bernheim points out that if a thrombus forms it will do so on the side of the artery and the limb will be no worse off. Carrel and others advise end-to-end anastomosis.

The operation is yet on trial. In suitable cases the operation is justifiable and age is no bar. It is useless if veins are occluded as well as arteries, hence it is useless in advanced cases of gangrene from thrombo-angiitis obliterans. If any considerable area of gangrene exists veins are involved and the operation is useless.

VII. THROMBOSIS AND EMBOLISM

Thrombosis is the antemortem coagulation of blood in the heart or in a vessel, the coagulum remaining at its point of origin and plugging up the vessel partially or completely. The process, and also the condition significant of the process, is known as thrombosis; the clot is called the *thrombus*. This process is an essential part in the arrest of hemorrhage; it occurs in phlebitis and arteritis, and affords a frequent basis for embolism. The thrombus is composed of red corpuscles, white corpuscles, fibrin, and platelets in varying proportions. Thrombi may form in the veins, in the arteries, in the capillaries, or in the heart. Clotting is due to kinase and calcium producing thrombin by acting on prothrombin, and thrombin converting fibrogen into fibrin. Fibrin is the active clot (see Howell's theory, on page 116). Thrombosis is more common in the veins than in the arteries, the slow blood-current and the existence of valves favoring the deposit, though not causing it. A thrombus forms gradually, being deposited layer by layer; hence it is stratified or laminated. Figure 59 shows a thrombus in a vein. All thrombi are either *infectious* or *simple*, the latter being also called *aseptic* or *bland*. Thrombi are also spoken of as fibrinous, red, hemostatic, leukocytic, etc.

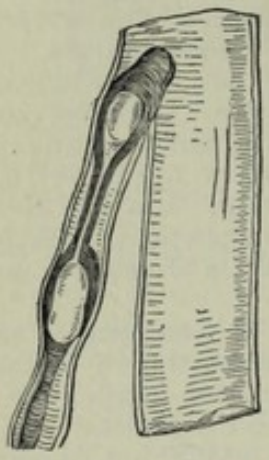


FIG. 59.—Thrombus in the saphenous vein (Green).

Causes of Thrombosis.—In the formation of a thrombus four conditions are to be considered, viz., chemical alterations in the blood, a bacterial attack on the intima, tissue changes in the inner coat of the vessel, and slowing of the circulation. One, several, or all of these conditions may exist in a case of thrombosis. In arteries the chief causes are disease of the coats and embolism. In veins the chief causes are injury and infectious phlebitis. Capillary thrombi may be due to propagation from veins or arteries or may form in the capillaries. The latter condition is seldom seen. The essential cause of all intravascular thrombi is damage to the endothelial coat and in most instances the damage is effected by bacteria, hence most cases of thrombosis seen by the surgeon are infectious. Any condition which causes the blood to contain an excess of fibrin-forming elements favors thrombosis, in the sense that a slight injury of the vascular endothelium will be followed by clot formation. Among conditions favoring thrombosis we must note particularly slowing of circulation, however caused. A special predisposing condition is the retarded circulation in tuberculosis, influenza, and fevers, the blood-clotting behind the vein valves after the endothelium has been damaged by toxins. Among other inciting states are inflammations; wounds; fractures; the pressure of a bandage or of a splint; varicose veins; ligation of a vessel; injury of a vessel; foreign bodies in a vessel; hematoma; atheroma in arteries; sutures in a vessel; pregnancy; certain diseases, such as gout, typhoid fever, and septic processes; phlebitis or arteritis arising in the vessel or from extension of surrounding inflammation, the entrance of specific organisms, arteriosclerosis, and embolism. A thrombus may form on and propagate from an embolus.

It has been asserted that so long as the endothelium of a vessel is uninjured a clot does not form. It is now taught that slowing of the blood-current in aseptic conditions, and when there has been no traumatism, will not cause thrombosis, and yet we know that in marasmus there may be clotting in an intracranial sinus. One of the functions of the endothelial coat is to keep the blood fluid by preventing corpuscular disintegration. A thrombus can form only when fibrin forms. Howell explains clotting as follows: "Kinase is found in all tissues and in blood-cells. Calcium exists in most cells. Prothrombin comes from blood-plaques and white corpuscles. Kinase and calcium act on prothrombin and form thrombin. Fibrinogen, which is derived from the liver, when acted on by thrombin forms fibrin. In circulating blood there is a material called antithrombin and it prevents the combination of kinase and calcium on prothrombin and hence retards clotting. Too small an amount of antithrombin may be the cause of clotting. Too much retards coagulation." When moving blood coagulates, the third corpuscles or platelets first settle out and form a nucleus about which the leukocytes gather. This is known as the *white* or "*antemortem*" *thrombus*—the clot of moving blood. Thrombi from moving blood are rarely pure white; they contain some red corpuscles, forming *mixed thrombi*. White thrombi and mixed thrombi are stratified and are at first soft, but harden as they age. The *red thrombus* plugs

vessels which are cut across or ligated; it also occurs in septic processes and is the thrombus formed after death. A *primary thrombus* remains in the original region of clotting. A *secondary thrombus* forms about an embolism. A *propagating* or *spreading thrombus* extends a considerable distance from the seat of initial disturbance. A thrombus soon undergoes a change. An aseptic clot usually "organizes"—that is, the clot is absorbed and is replaced by fibrous tissue. The walls of the injured vessel become filled with leukocytes, leukocytes invade the clot, the vascular endothelium proliferates, and the young cells follow the colonies of leukocytes into the thrombus. The thrombus is gradually removed by leukocytes and replaced by fibroblasts, the new tissue is vascularized and becomes granulation tissue, the granulation tissue is converted into fibrous tissue, and the fibrous tissue contracts. In some instances a thrombus is implanted on the wall of the vessel and the tube is not permanently occluded. Such a condition may be obtained by the application of a lateral ligature about a small tear in a large vein. In most instances, after the formation of an intravascular thrombus, the vessel is converted into a narrow cord of fibrous tissue. A thrombus may degenerate and break down (fatty degeneration), giving rise to emboli, or a thrombus may undergo calcification. A calcified thrombus in a vein is known as a *phlebolith*. An infected thrombus may undergo liquefaction, infective emboli being set free (Fig. 60).



FIG. 60.—Infected thrombus of a vein (schematic).

A clot may propagate in both directions, that is, toward the periphery and toward the heart It was taught for many years that when an artery had been ligated a thrombus quickly formed and reached to the first collateral branch above. This view was formulated in pre-antiseptic days. It is now known that when aseptic ligation is performed the thrombus is small and rarely reaches the first collateral branch, and is often actually absent, vascular obliteration being obtained by proliferation of connective-tissue cells and of cells from the endothelial coat. If an infection takes place the clot may reach the first collateral branch. The old rule of surgery was as follows: If an artery is cut near a large branch, tie the branch as well as the artery, in order to permit of the formation of a lengthy clot. This rule is no longer followed unless infection exists or is anticipated.

A clot in a vein often extends a long distance. The author has seen in a postmortem examination a venous thrombus reaching from the ankle to the vena cava. A common example of thrombus in a vein is the clot formed in the uterine sinuses in a condition of puerperal sepsis, a clot which tends to extend into the iliac and femoral veins. Infective thrombosis of the lateral sinus causes clot formation, and the clot tends to extend up to the torcular, into other sinuses, and down into the jugular. *Phlegmasia alba dolens*, or *milk-leg*, is a condition in which the leg or the leg and thigh are swollen and painful because of venous thrombosis or sometimes lymphatic thrombosis (see page 116).

Lymphatic thrombosis occasionally occurs in the thoracic duct, axillary lymphatics, or inguinal lymphatics. It is most common in the uterine lymphatics during puerperal fever. Lymphatic thrombosis may be due to infection, to cancer, to tuberculosis, or to change in the lymph itself.

General Symptoms.—The symptoms are dependent on the seat of the obstruction and the presence or absence of infection. An organ or a part of an organ may exhibit functional aberration. The local signs in a vessel accessible to touch or sight are the presence of a clot; if it be in an artery, anemia and the absence of pulse below the clot; if it be a vein, swelling and edema below it. There is usually pain at the seat of trouble, and anesthesia below it. Moist gangrene may follow venous thrombosis, and dry gangrene, arterial thrombosis. Thrombosis of the mesenteric vein is followed by gangrene of the bowel. Infective thrombophlebitis is a spreading inflammation of a vein. A septic thrombus forms and the condition is an early step in pyemia. We see this condition sometimes in the lateral sinus of the brain as a result of suppuration in the middle ear; in any of the cerebral sinuses after infected compound fracture of the skull; and in the uterine veins during puerperal sepsis. Portal pyemia results from thrombophlebitis of branches of origin of the portal system (see page 1020). Thromboarteritis is a spreading inflammation of an artery in which a septic thrombus forms or in which a septic embolus lodges. It occasionally attacks an aneurysmal sac. In infective thrombophlebitis and in arterial pyemia the symptoms are, of course, those

of pyemia. A great danger of venous thrombosis is embolism; pulmonary embolism if the clot is in a systemic vein, portal embolism if it be in a vein of the portal system.

Infective Thrombosis of the Lateral Sinus.—(See page 765.)

Thrombosis of the Jugular Vein.—This condition is usually infective and secondary to infective thrombosis of the lateral sinus or sometimes of the petrosal sinus. It is occasionally due to cancer, tuberculosis, acute rheumatism, or pyemia, taking origin from a distant focus. If it is infective, the chills, the high and fluctuating temperature, and the great exhaustion proclaim the existence of pyemia. Locally the vein feels hard, the adjacent tissues are edematous, the branches of the jugular are visibly distended, there may be linear discoloration over the course of the jugular, and the head is held stiffly with an inclination to the diseased side.

Thrombosis of the Mesenteric Vessels (see page 973).—The arteries are affected much more commonly than the veins, and the superior mesenteric artery far more often than the inferior. Vascular disease is the cause of arterial thrombosis, and arterial thrombosis occurs chiefly in those beyond middle life. Venous thrombosis may be primary and has been observed after splenectomy, the clot having propagated to the mesenteric veins. It may occur as a result of any gastro-intestinal or general infection (pyemia, appendicitis, typhoid fever). Secondary venous thrombosis is due to portal obstruction or accompanies arterial mesenteric thrombosis.

Mesenteric thrombosis usually produces sooner or later gangrene of the gut, but does not always do so.

The period at which gangrene develops after blocking is uncertain; it may arise in thirty-six hours, it may not arise for two weeks or more. The gut becomes distended, bloody serum exudes into the peritoneal cavity, and in most cases into the lumen of the bowel. The mucous membrane undergoes necrosis and perforation occurs. The area involved varies greatly in different cases. In some cases it is very limited, and is rather apt to be in the large intestine. In other cases it is very extensive, and is apt to be in the small intestine. In a case of the author's in the Jefferson College Hospital practically the entire ileum was gangrenous and numerous perforations existed.

In mesenteric thrombosis pain arises rather suddenly and rapidly becomes severe. It is a persistent pain with paroxysmal exacerbations and is usually generalized, though in many cases it has an area of peculiar intensity. The pain is accompanied by rapid pulse, growing exhaustion, distention, subnormal temperature, tenderness, a mass appreciable by palpation in the region of the mesentery, free fluid in the peritoneal cavity, nausea, and vomiting. The condition suggests intestinal obstruction. The vomited matter consists first of the contents of the stomach, then of bile, finally becomes stercoraceous, and sometimes contains blood.

In nearly one-half of all cases blood in considerable quantity passes from the rectum.

Ballance points out that cardiac disease or arterial degeneration suggests the artery as the seat of thrombosis.

The only chance for recovery without operation is the establishment of the collateral circulation, and as the superior mesenteric vessels are terminal vessels this seldom occurs (in only about 5 per cent. of cases). (See Intestinal Obstruction from Mesenteric Thrombosis.)

Postoperative Thrombosis.—This complication is occasionally encountered, may involve the iliac, the femoral or the saphenous vein, and is most often met with in the left side, even when the operation has been in the middle line or the right side. It is a rare complication, occurring, according to Professor Clark, 35 times in a series of 3000 operations. In 5835 operations performed in the Mayo Clinic, Beckman states there were 16 cases of phlebitis ("Annals of Surgery," May, 1913). In three-fourths of the cases the left femoral or left internal saphenous was involved. In one-fourth the lesion was on the right side. Both sides may be involved.

Many explanations have been given to account for it. A great many surgeons regard it as the result of infection, but many cases certainly are not. The most common cause is sepsis, but clotting can occur without sepsis. Clark believes it is due to injury of the deep epigastric vein, forcible and prolonged separation of the wound edges by retractors being a common cause. The free anastomosis between the epigastric veins of the two sides accounts for the appearance of thrombosis on one side after operation on the other. It is most common after gall-bladder and pelvic operations. It is believed that after gall-bladder operations there is particular risk of toxic destruction of blood corpuscles. It is held by McCann ("Brit. Med. Jour.," March 9, 1918) that transfixion of a vascular area is an influential cause of thrombosis and embolism. "By trans-

fixion vessels are liable to be punctured and bleed either externally or into the tissues; the transfixing ligature is tied to arrest the bleeding, and the result may be that the ligature remains in the lumen of the vessel. Now, if this ligature is of doubtful asepticity or becomes subsequently infected, the natural process of clotting in the vessel may be arrested, the clot liquefying and becoming detached in portions or in its entirety" (McCann, Ibid.). It is probable that in many slight cases the condition is not recognized, and it will not be recognized unless the clot reaches the femoral vein, and it requires one or two weeks to reach this vein if it does reach it at all. When a clot forms in the femoral vein a milk-leg develops. The entire extremity swells below the seat of thrombus, the part is painful, the temperature is usually normal, but may be distinctly elevated. Embolism may follow. Embolism may be pulmonary, cerebral, or coronary.

Thrombosis in General Infections.—In *typhoid fever* a thrombus may form in the heart, the veins, or the arteries. Thrombosis may occur in pneumonia, in influenza and in other fevers, and in tuberculosis. The vessels of a limb, a lung, the brain, or the mesenteric zone may suffer. The condition follows bacterial infection, the veins are most prone to suffer, and gangrene may ensue. Both arteries and veins may be involved and in pneumonia are apt to be.

Thrombosis in Appendicitis.—In about 2 per cent. of cases of appendicitis, according to Sonnenberg, this complication is noted. It may affect the femoral or saphenous vein of either side or of both sides, the portal vein or the vena cava, and may occur during an acute attack, but is more often noted in an interval.

It is not very unusual to find liver abscess follow appendicitis, the infection being carried by the portal vein and the condition being known as *septic pylephlebitis* (see page 1020).

Treatment.—If an aseptic thrombus forms in a large vessel of a limb, raise the limb a few inches from the bed, keep it perfectly quiet to avoid detachment of fragments (emboli), apply a bandage lightly from the toes up, and place bags of warm water about the extremity. Maintain rest for four or five weeks. The great danger in venous thrombosis is the formation of emboli, hence movements and rough handling are to be avoided. Gangrene is another danger, hence it is wise to favor venous return and the development of the collateral circulation by warmth, elevation, and bandaging. In infective thrombophlebitis, if the vessel is accessible, tie it above and below the clot, open the vessel, remove the clot, irrigate, and pack the wound with iodoform gauze. The general treatment for a septic condition should be stimulating and supporting. Massage is unsafe in any condition of thrombosis, and is particularly dangerous in septic thrombosis. In a man with a large hematoma of the loin massage caused fatal pulmonary embolism. In thrombo-arteritis treat as in the thrombophlebitis. If gangrene of an extremity follows thrombosis, treat as previously directed (see page 91). Gangrene of the intestine in mesenteric thrombosis if not too extensive is treated by resection (see p. 976).

The treatment of infective thrombosis of the lateral sinus is set forth on page 766

Embolism signifies vascular plugging by a foreign body (usually a blood-clot) which has been brought from a distance. The foreign body is called an *embolus*. An embolus usually consists of a separated or ruptured portion of a thrombus, atheromatous material from a diseased artery, or a bit of fibrin from a diseased heart valve. In some cases an embolus consists of bacteria, of air, of fat, of a fragment of a tumor, or of parasites. In severe burns the blood undergoes changes and jelly-like matter is often precipitated and may cause embolism. Emboli vary in shape, in size, and in consistency. Emboli are divided into *simple*, *bland* or *aseptic* and *infective*, *toxic* or *septic*. Emboli may arise either in the venous or in the arterial system, but are particularly prone to arise in the veins; they lodge in an artery, in capillaries, or in the veins of the liver. An embolus taking origin in one of the systemic veins passes through the right heart and lodges in a terminal branch of the pulmonary artery. If at this point it disintegrates, smaller emboli pass to the left heart and enter the arterial circulation to be deposited, as are emboli originating in the heart or arteries, in the arteries of an extremity, the kidneys, spleen, or brain. Emboli of the portal circulation lodge in the liver or perhaps pass through that organ and reach the lungs. An embolus is arrested when it reaches a vessel the diameter of which is less than its own. It is usually caught just above a bifurcation. When an embolus lodges, it at once partially or entirely obstructs the circulation and increases in size by thrombosis. Figure 61 shows an impacted embolus. A non-septic embolus when lodged usually "organizes," as does a thrombus, and, as described on page 117, is replaced ultimately by fibrous

tissue. A soft embolus may disintegrate and permit the re-establishment of the circulation. An embolus may cause an aneurysm. A septic embolus breaks down, forms a metastatic abscess, and sends other emboli onward in the blood-stream. It may arise in typhoid fever.

An embolus is more serious than a thrombus: it causes sudden plugging, which makes dangerous anemia inevitable, and it will produce gangrene if the collateral circulation fails. Embolism of the mesenteric artery causes necrosis of the intestine. In organs with terminal arteries (spleen, kidney, brain, intestine, and lung) there is no collateral circulation and embolism causes *infarction*. For instance, if an embolus lodges in the lung it produces an area of ischemia; the removal of all propulsion upon the venous blood causes it to flow back and stagnate, and vascular elements exude and form a wedge-shaped area of red tissue, the embolus being the apex of the wedge. This is known as *hemorrhagic* or *red infarction*, and is often seen in the lung (Fig. 62). The *white infarction*, seen in the brain and kidney, is not due to retrogression of venous blood, but is due to ischemia resulting in coagulation necrosis. A septic embolus causes septic thrombosis and a septic infarction, and a septic infarction is followed by suppuration and the production of a pyemic abscess. That emboli of the systemic venous circulation usually lodge in the lungs explains the occurrence of pulmonary embolism after certain operations upon and during certain diseases of the regions drained by the systemic veins. Emboli formed in vessels of the systemic circulation lodge most often in the lungs, brain, kidney, or spleen. It is because emboli which



FIG. 61.—Embolus impacted at bifurcation of a branch of the pulmonary artery (Green).

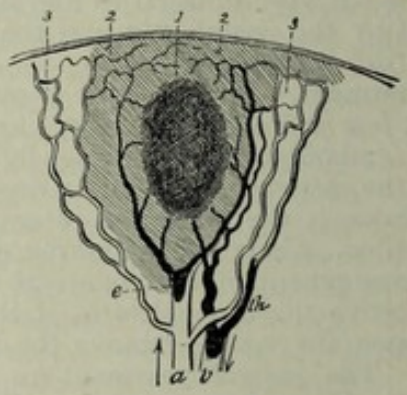


FIG. 62.—Diagram of a hemorrhagic infarct: *a*, Artery obliterated by an embolus (*e*); *v*, vein filled with a secondary thrombus (*th*); 1, center of infarct, which is becoming disintegrated; 2, area of extravasation; 3, area of collateral hyperemia (O. Weber).

pass into the portal vein lodge in the liver that operations upon the rectum may be followed by hepatic embolism and abscess of the liver.

General Symptoms.—The symptoms depend upon the organ involved and the presence or absence of infection. They are sudden in onset, and are due to loss of function, which may be permanent or which may be followed by inflammation, softening, or gangrene. In a septic embolus there are symptoms of infection and abscess forms at the seat of lodgment. In the course of pyemia a chill usually means the occurrence of embolism. Embolism of the cerebral arteries may cause aphasia, paralysis, or coma. Embolism of the pulmonary artery may cause almost instant death. An embolus in a large artery of a limb produces symptoms similar to those of a thrombus, except more sudden and decided. Below the obstruction the pulse is absent and the limb is swollen with edema, is cold, is first pale and then discolored. There is pain in the limb below and probably also at the seat of obstruction. In embolism of the popliteal artery the chief pain is in the calf. This condition is frequently followed by gangrene. Embolism of the superior mesenteric artery produces symptoms similar to those caused by acute intestinal obstruction, and results in gangrene of a portion of the intestine.

Postoperative Embolism.—It may result from clotting in varicose veins, from veins of a uterine fibroid, from pelvic veins when an ovarian cyst exists, and from a clot in a cerebral sinus. It may occur from cancer or tuberculosis. Cases of pulmonary embolism have resulted from mammary cancer, uterine cancer, and prostatic cancer.

It may follow a facial infection, a fracture, a dislocation, and gonorrhea in the female. It may result from any operation, but is especially apt to follow operations on the gall-bladder and the female genitalia. In most cases, but not in all, there is sepsis. In the Mayo Clinic during the years 1899–1911 inclusive, there were 63,573 major operations and 47 fatal cases of embolism (L. B. Wilson in "Annals of Surgery," Dec., 1912). There were 2 deaths after operations on blood-vessels, 2 after operations on the thyroid, 1 after an operation on the mouth, 3 after operations on the stomach or duodenum, 9 after operations on the gall-bladder, 1 after operation on the small intestine, 4 after operations on the appendix, 5 after operations on the colon and rectum, 5 after operations for hernia, 1 after a kidney operation, 4 after operations on the prostate, 10 after operations on the uterus, tubes, and ovaries. In 36 cases the embolism was pulmonary, in 10 cerebral, and in 1 coronary. A large hematoma is a danger, as embolism may result. Hence a large hematoma should be evacuated. Careless hemostasis in an abdominal or pelvic operation leads to the formation of a large blood lake. A thrombus forms and emboli may result. Transfixion of a vascular area may lead to embolism.

Pulmonary Embolism.—This condition occasionally follows operations and injuries and sometimes develops during certain diseases. I have seen a case after an operation for appendicitis, a case after an operation for varicocele, a case after an operation for hydrocele, a case after operation for perforated duodenal ulcer, a case after gastrostomy, and a case in a man with a large lumbar contusion to which massage was injudiciously applied. It arises in most cases from ten to twenty days after the operation. In one of Mayo's cases it arose on the sixty-fourth day. The patient is thought well or almost well. If the wound is examined postmortem it will be found to contain some liquefied blood-clots. Absorption of these altered clots is probably the cause of the condition. Welcker puts forth this view and maintains that failure to ligate all the veins leads to bleeding after the wound has been closed and disintegration of the blood-clots causes embolism ("Deutsche Gesellsch. f. Chir.," 1914). McCann regards transfixion of a muscular area as causal ("Brit. Med. Jour.," March 9, 1918). It is not very common. Albanus ("Beiträge klin. Chir.," xl) in 1140 abdominal operations found 23 cases. The emboli may be aseptic or septic. The condition is more common as a result of thrombosis of the veins of the lower extremities, appendicitis, gall-bladder operations, operations on the female pelvic organs, and strangulated hernia. Certain postoperative pneumonias are embolic. Very small aseptic emboli may cause no symptoms or slight symptoms. When aseptic hemorrhagic infarction occurs there are symptoms. These symptoms are a chill or chilly sensations, moderate fever which may be transitory, dyspnea, rapid pulse, pain in the chest, sometimes rapidly advancing signs of consolidation, often a pleural friction sound, and bloody expectoration. If the embolus is large (occluding embolus) there may be immediate or very rapid death. The mortality is always large (80 per cent.). I am satisfied that it is a much more common condition than we formerly supposed, and that some cases in which the emboli are very small are not diagnosticated and recover.

A septic embolism causes metastatic abscess and usually suppurating pleuritis, the condition being known as septic embolic pneumonia. Recovery is rare, but occasionally occurs. The symptoms are those of pyemia with the physical signs of consolidation and of pleuritis.

Embolism of the Mesenteric Arteries.—The superior mesenteric is the vessel usually affected. It may arise in pyemia, septicemia, arterial or cardiac disease. The symptoms are practically identical with thrombosis of the mesenteric vessels, except that they arise suddenly. There is usually endocardial disease (see page 969).

Treatment.—Murphy performed arteriotomy and removed an embolus from the femoral and iliac arteries through an incision in the femoral artery, and then sutured the incision ("Jour. Amer. Med. Assoc.," May 22, 1909). The operation was too late to prevent gangrene, but it emphasizes the truth that an aseptic embolus in a large artery can be treated by incision of the artery, removal of the clot, and suture of the vessel. This plan has been followed by others, in fact there are over 50 cases in literature. It is suitable to early cases. It must be done within twenty-four hours to promise help. The vessel is opened above and below the clot, the obstruction removed, and the wounds in the artery sutured with fine silk anointed with sterile vaselin. (See Key on Embolectomy in "Surg., Gyn., and Obstet.," March, 1923.) If gangrene is threatened, consider the advisability of arteriovenous anastomosis (page 94). The treatment long in vogue was as follows: In a limb, keep the part warm in order to stimulate the collateral circulation, elevate the extremity several inches from the bed, apply a bandage lightly from the periphery, and insist on perfect quiet.

Massage is unsafe. If gangrene ensues, await a line of demarcation and, when it forms, amputate. In septic embolic arteritis in an accessible region it would be good surgery to act as in septic thrombophlebitis. After an operation upon veins (as the operation for varicocele, for varix of the leg, or for hemorrhoids), after any cutting operation, and after the infliction of a fracture, avoid as much as possible and for some time movements or handling, as fragments of thrombus may be detached.

In mesenteric embolism exploratory laparotomy may disclose a perforation which can be closed or a portion of gangrenous gut which can be resected.

In aseptic pulmonary embolism enforce absolute rest, give strychnin and morphin hypodermically, and inhalations of oxygen. Trendelenburg has suggested operation for occluding pulmonary embolism (see page 888).

In septic embolic pneumonia pursue the conservative plan of treatment unless a large pulmonary abscess forms or an empyema arises. In either case operate to remove pus.

Fat-embolism in the human being was first noted by MacGibbon, of New Orleans, in 1856, and was first thoroughly described by von Recklinghausen in 1884, although Magendie, in 1827, and Virchow, in 1856, developed it experimentally in animals. It is a process which leads to an accumulation in the capillaries of liquid fat after injury to adipose tissue, high tension having forced the fat into the open mouths of veins. Fat may be forced into open veins by muscular action, by efforts at repair, or by concealed bleeding. Fat may perhaps get into the blood by means of the lymphatics and it can also enter by way of the synovial membrane. Wilms believes that fat reaches the veins by way of the lymphatics and the thoracic duct. Fat in the blood is quite a common condition, but seldom produces serious trouble, although it is occasionally fatal and is responsible for some otherwise inexplicable sudden deaths after fractures and surgical operations. Imperfect arrest of wound bleeding increases the danger of fat-embolism. Fat-embolism may arise during osteomyelitis, after extensive bruises, crushes, lacerations, amputations, fractures, resections, or rupture of the liver.[1] The condition is most apt to arise after bone injury. In a fatal case of mine it developed as a result of manipulation of a fracture of the neck of the femur. In another fatal case it followed amputation for cancer of the breast of a very fat woman. Immobilization of a damaged part is important in the prevention of fat-embolism. This fluid fat accumulates especially in the capillaries of the lungs and brain. It may plug systemic capillaries. If the patient recovers, he does so because the fat has been forced through the vessels; if he dies, the death results from mechanical hindrance to function and nutrition. When the emboli are widely scattered, are not large, and when they do not lodge in vital parts of the brain or cord they may produce no symptoms and do no real harm. Normal blood contains a small amount of finely emulsified fat (from 0.5 to 0.85 per cent.). In a number of physiologic and pathologic conditions the circulating blood contains considerable free fat. It may be found in a pregnant woman, a nursing baby, a fat individual, or in anyone during digestion. "It has been noted in the following conditions: chronic alcoholism; diabetes mellitus; certain diseases of the liver, heart, and pancreas; chronic nephritis; splenitis; tuberculosis; malarial fever, typhus fever; Asiatic cholera, and poisoning by phosphorus and by carbon monoxid. Lipemia commonly occurs as the result of lacerated wounds of the blood-vessels situated in fatty tissue, and after fractures of long bones involving injury of the fatty matter" ("Clinical Hematology," by John C. DaCosta, Jr.). In many cases of fracture in adults fat is found in the urine. I have had this demonstrated by repeated observations. When we recall how rarely simple fracture causes death it becomes evident that a moderate amount of fat in the blood is not dangerous or only becomes dangerous if it fails to flow out. In lipemia fatty embolism may occur if the amount of fat becomes excessive or if vascular damage favors plugging. We know that oil

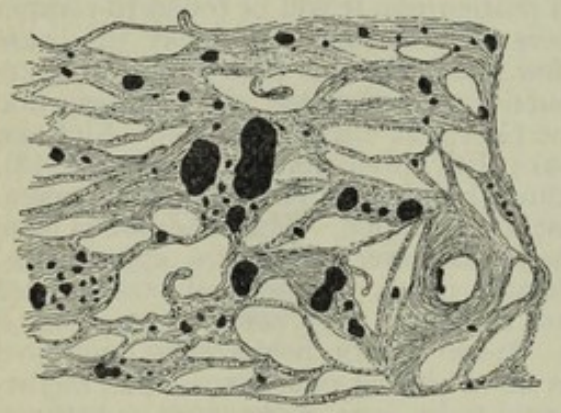


FIG. 63.—Fat embolism of the lung after fracture of the femur. The fat globules and masses, stained black with osmic acid, lie in the capillaries of the lung; × 150 (Hektoen).

[1] G. H. Makins in "Heath's Dictionary."

in blood increases the viscosity of the circulating fluid, slows the blood-stream, and favors blocking (Gauss, quoted by Sutton in "Annals of Surg.," Nov., 1922). At my suggestion Dr. Wm. Carrington conducted an investigation to determine the frequency of lipuria after fractures (Essay Awarded the Surgical Prize in Jefferson Medical College in 1908). He determined that fracture of a large, long bone invariably causes lipuria, fracture of a small bone seldom does; that after fracture of a long bone fat appears in the urine "on different days, in different amounts, and in different forms" (this curious periodicity was first observed by Scriba in 1878); that when fat is present albumin is almost always present and blood is occasionally found; that the urea percentage falls as the fat content rises and rises as the fat content falls; that the condition is rare in young children and that fat-embolism, as a rule, is a benign process; that about the fifteenth day after a fracture fat usually disappears from the urine. Carrington, in 1908, found in literature 276 reported cases of fat-embolism. Buerger thinks that fat emboli are much more common than we have suspected ("Progressive Medicine," Dec., 1916. Article on "Shock").

Symptoms arise only when many emboli block numerous capillaries of an organ, when a large embolus lodges, or when the capillaries of a vital region of the brain are blocked (the medullary centers). Emboli are most apt to form after or during handling of the wound or seat of injury or after exhausting movement of the patient. Hence one peril of transportation after an accident, of early massage, of frequent changes of dressings, and of getting up too early after operation (Groendahl, "Deut. Zeitsch. f. Chir.," 1911, cxi). "It was a common observation during the war that many of the wounded, especially those with fractures, who were transported great distances before proper surgical measures could be taken, suffered from pulmonary fat-embolism. I noticed this complication particularly in one location. In the exigency of war two armies were placed side by side. The ambulance corps was just behind, drawing wounded from each. One army had ample splints to use, the other had none. Almost without exception the patients with non-splinted fractures of large bones were found in very poor condition. The ordinary resuscitation methods aided these patients but little, and even in cases with poorly splinted fractures the mortality was high. I performed necropsies in 8 fatal fracture cases and found an astonishing amount of fat in the lungs in all" (Sutton in "Annals of Surg.," Nov., 1922). The fat tends particularly to lodge in and accumulate in the lungs. The symptoms are those of edema of the lungs and exhaustion, often with coma or delirium, and sometimes, in the beginning, are wrongly thought to be due to shock. There are restlessness, dyspnea, rapid and weakening pulse and rapid respiration, contracted pupils, and pallor, followed by cyanosis. The temperature is usually elevated, but may be normal or subnormal. Many coarse râles are heard in the chest, but percussion gives a clear note. The expectoration contains fat and blood. Minute hemorrhages may arise in the skin of the chest. If pulmonary edema becomes marked, the patient spits up a bloody froth and there is cyanosis. If life is prolonged a day or two, oil may be found in the urine. Small amounts of oil may be found in the urine after serious injuries or operations when no symptoms of embolism exist. Nevertheless, the presence of the oil is always a cause of anxiety and is often a warning. If blood is drawn by venous puncture it may be found to contain fat. It is maintained by Groubé that the amount of fat in the urine is in inverse ratio to the amount in the blood; the greater the amount excreted in the urine, the less the amount retained in the blood. Hence, fat in the urine makes the surgeon anxious, and a *sudden* diminution of the amount in the urine is a sign of grave danger if there develops increasing difficulty in respiration ("Rev. de Chir.," July, 1895). The inverse ratio said to be maintained between fat in the blood and fat in the urine, if it really exists, is similar to a finding of Lépine in diabetes, that is, if a diabetic is given diuretics, the sugar in the urine increases and the sugar in the blood decreases. Fat-embolism is one of the possible causes of symptoms of shock after injury. Cases of fat-embolism may present symptoms like those of shock (Bissell, "Jour. Amer. Med. Assoc.," Dec. 23, 1916). The symptoms of fat-embolism seldom occur until at least twelve hours after an accident, and rarely before the third day, but may occur much earlier. In a case of mine it occurred during the manipulation of a fracture of the femur and the condition was first thought to be due to ether. The man never regained consciousness and died in a couple of hours. As a matter of fact fat-embolism very seldom arises until at least three hours after an injury, the symptoms occurring at a later period than those of shock and at an earlier period than those of ordinary embolism of the lung. The important point emphasized by Carrington is that after the reaction from shock, if there has been shock, and for hours or days

after the injury in any case, there is a period of freedom from all alarming symptoms, and that the symptoms of fat-embolism come on suddenly and without warning. If some of the oil is forced through the vessels of the lung, it will lodge in other regions and produce other symptoms. Oil may appear in the urine as above stated. Urinary suppression may occur. Delirium may arise, there may be twitching, convulsions or paralysis, or the patient may pass into coma. Cases with delirium are sometimes diagnosticated delirium tremens. The eye-ground may show choked disk, hemorrhage, and fat in the vessels (Connel's case and Czerny's case). Cases of fat-embolism with severe symptoms are commonly fatal; milder cases are often recovered from. In mild cases the symptoms last but a few days, in severe cases the condition may prove fatal in from a few hours to seven days after the injury, and in from a few to forty-eight hours after the appearance of symptoms. A patient may have two or three attacks. Connel's patient had three attacks, there being an interval of a week between the first and second and between the second and third attacks.

Treatment.—It will aid in the prevention of fat-embolism if transportation be accomplished as gently and rapidly as possible. In a case like a crush or a compound fracture the application of an Esmarch band favors clotting, and clots tend to prevent the entrance of fat into the vessels. Early and free incision of a crushed area or amputation of the extremity will probably prevent fat-embolism. (See Buerger's views and Bloodgood's comments in "Progressive Med.," Dec., 1916.) In every surgical operation arrest hemorrhage most carefully. Immobolize a damaged part. Do not get the patient out of bed too soon. Avoid early massage.

Wilms, acting on his belief that fat enters the lymphatic duct and from there gets into the venous circulation, treated one case of fat-embolism successfully by making a fistula in the thoracic duct. This operation might be justifiable when dangerous brain symptoms are known to be due to fat-emboli. The usual treatment consists in absolute rest of the diseased or injured part and the administration of stimulants, such as strychnin, alcohol, and carbonate of ammonium, the use of external heat; the employment of oxygen by inhalation, and the administration of diuretics and of nitroglycerin hypodermically. Artificial respiration may tide a patient over a crisis. Intravenous injections of normal salt solution are used by some. Czerny gave 2 per cent. solution of sodium carbonate intravenously. It seems to lessen dyspnea. If an external wound exists, free drainage must be established, and the diseased or damaged parts should be thoroughly immobilized if possible. In order to prevent fat-embolism after a severe injury insist on rest. Massage used, very early after some injuries, is dangerous, as it may force fluid fat into the vessels. Getting up very early after operation is not safe. Frequent changes of dressings are undesirable. When severe contusion causes the formation of a large cavity filled with blood, Groubé wisely advises incision to lessen the danger of fat-embolism.[1]

Air-embolism.—Air may enter a vein during a surgical operation or it may be injected accidentally while giving a hypodermic injection, hypodermoclysis, or a saline infusion into a vein. It has followed irrigation of the pleura with hydrogen peroxid. In caisson disease it is taught by some that nitrogen is set free in the blood. It may occur when a cerebral sinus is opened, and some say in the uterine veins, if the uterus does not remain contracted after delivery. Brouardel denies emphatically that air enters the uterine sinuses ("Death and Sudden Death"). Dupuytren and Bérard claimed that in wounds of the neck air could enter the veins, and if it did so instant death would follow. It is very seldom that any symptoms follow. It was long thought that such an accident must be always extremely dangerous. The experiments of my colleague, Professor Hare, indicate that quantities of air may be injected into the veins of a dog without apparent harm. The entry of a small amount of air into the veins of a human being will not be apt to induce dangerous symptoms, but may cause dangerous symptoms and even death. The more rapidly it is introduced and the greater the amount, the greater is the danger. The manner in which it can induce death is doubtful. Some maintain that it causes blood in the right side of the heart to froth, and thus prevents normal action of the valves, the heart becoming unable to propel blood through the lungs. Others maintain that air reaches the cerebral capillaries and so causes cerebral anemia. Some believe cardiac failure results from the presence of air in the pulmonary capillaries. The first view is the most probable. If a surgeon divides a large vein, air may be sucked in, and there is particular danger in such an accident if a vein at the root of the neck or a cerebral sinus is torn or incised, or if the damaged vessel lies in scar tissue and cannot collapse.

[1] "Rev. de Chir.," July, 1895.

Symptoms.—When during an operation air enters a large vein there is a sucking sound, air-bubbles may be noted in the wound, and serious symptoms may or may not follow. Twice I have wounded the subclavian vein and have heard this sound, but no alarming symptoms developed. If serious symptoms are produced, they arise suddenly, and consist of extreme failure of circulation, a curious whirring or churning sound synchronous with cardiac systole and audible even without a stethoscope, deadly pallor or cyanosis, gasping for air, convulsions, and possibly death.

Treatment.—Compress the vein with the finger and clamp the venous wound quickly. Suspend the anesthetic, lower the head, employ artificial respiration, give inhalations of oxygen, hypodermic injections of strychnin, and intravenous infusion of normal salt and adrenalin.

VIII. FOCAL SEPSIS. SEPTICEMIA AND PYEMIA

Focal Sepsis.—By focal sepsis we mean an area of infection which is or may become responsible for some distant or general disease. If, on examining a sufferer from some form of arthritis, the surgeon discovers a running sinus or a suppurating gland, he at once suspects that the joint trouble may have resulted from the suppuration. But if, in a like case of joint disease, he sees no discharging pus he must not conclude that pus has no hand in causing the condition, as there may be concealed suppuration. Our habit has been to regard the secondary disease as the disease, but, as Daland says, "Concealed pus is the danger" (Judson Daland, "Dental Cosmos," May, 1916). Bacteria taken up from a region of concealed suppuration may cause various diseases—for instance, septicemia, pyemia, arthritic inflammation, chorea, purpura, abscess of the liver, endocarditis, nephritis, pancreatitis, abscess of the brain, cholecystitis, or rheumatoid arthritis. Again, a concealed suppuration may undermine the general health, may produce anemia, may cause certain nervous maladies, and may be responsible for grave disease of the eye, middle ear, or internal ear.

A number of years ago Rosenau pointed out that streptococci increase in virulence as oxygen is diminished, so that a mild streptococcus may become very virulent. In further studies he has shown that a certain variety of streptococcus wherever lodged has an affinity for certain tissues. Some varieties have an affinity for joints, some for the pericardium, some for muscles, some for the endocardium, etc. This fact explains the diverse maladies which may arise from a focal infection. (See Rosenau in "Jour. Amer. Med. Assoc.," Nov. 7, 1908, and Nov. 29, 1913. Rosenau and Davis, "Jour. Amer. Med. Assoc.," April 15, 1915, and Frank Billings, "Jour. Amer. Med. Assoc.," Sept. 12, 1914).

Focal infections may exist in the genito-urinary tract, the gastro-intestinal tract, the mastoid and middle ear, the nasopharynx, and the air sinuses. Intestinal stasis is thought to be a not uncommon cause of distant trouble. So are chronic appendicitis, chronic cholecystitis, and prostatitis.

The tonsil, the prostate, the sinuses, and the mouth are the commonest regions involved. Beyond doubt *oral sepsis* is the most common focal infection. In 1859 Chassaignac claimed that a putrid condition of the gums could cause septicemia. In 1889 Miller, of Germany, pointed out that oral sepsis can cause distant disease. There may be pyorrhea alveolaris, decay of teeth, disease of pulp, exposure of bone between the teeth, exposure of a root to the tip, abscess about the apex of the root, apical granuloma, accumulation of foul matter under bridge-work, or a deficient crown to a dead tooth. The *x*-rays are of enormous service in finding abscesses about tooth roots. In every case of disease in which focal sepsis might be the cause, *x*-ray pictures of the teeth should be taken, a skilled dentist should examine the teeth and gums, and every region in the body in which a cause might reside must be investigated carefully by surgeon and specialist. Only thus can we reach the cause of many obscure cases of arthritis, empyema, nephritis, pericarditis, endocarditis, cholecystitis, brain abscess, etc.

When a source of infection is found it must be excised or the area must be drained. This is the very basis of all treatment. A culture from the focus informs us as to the causal organisms. A blood culture should also be made. The organisms found are identical with those present in a secondary disease. A vaccine made from an initial focus should be administered in chronic cases.

Septicemia, or sepsis, is a febrile malady due to the introduction into the blood of pyogenic organisms or the products of saprophytic bacteria. There is no one special causative organism, and any microbe which produces inflammatory and febrile products may cause it. Either streptococci or staphylococci may be present. Pneumococci

are a not very unusual cause. Septicemia arises by absorption of septic matter by the lymphatics. Clinically, we distinguish two forms of septicemia: (1) sapremia, septic or putrid intoxication, and (2) septic infection, true or progressive septicemia. In these conditions the area of infection is usually discovered by the surgeon; but when it cannot be located, the disease is called by the Germans cryptogenetic septicemia.

Sapremia, Septic or Putrid Intoxication.—This condition is due to the absorption of poisonous ptomains from a putrefying area. The bacteria do not enter the blood, but their toxins do, and as these toxins are active poisons the condition is comparable to poisoning by successive alkaloidal injections, the symptoms and prognosis depending upon the dose. Not unusually there is absorption not only of the toxins of saprophytic bacteria but also of the toxins of pyogenic micro-organisms. Even if some of the bacteria enter the blood, they do not multiply in this fluid. Slight symptoms and recovery follow a small dose of toxin; grave symptoms, even death, follow a large one. The poison does not multiply in the blood, and a drop of the blood of a person laboring under putrid intoxication will not produce the disease when introduced into the blood of a well person; in other words, the disease is not infective. Considerable putrid material must be absorbed to cause sapremia. What is known as surgical fever is due to the absorption of a small amount of putrid or fermented wound fluid, and is, in reality, a mild form of sapremia. If sapremia arises, it does so soon after the infliction of a wound, and after a large rather than small wound when a considerable amount of wound fluid is pent up under pressure. It may follow labor where putrid fluid is retained in the womb, may follow an injury of or an operation upon a joint, may follow amputation where decomposing blood-clot or wound fluid is locked up within the flaps, or may ensue upon an abdominal operation or injury. In sapremia there always exist a considerable absorbing surface and a large amount of dead matter which has become putrid. Roswell Park[1] pointed out that sapremia arises from putrefaction of a blood-clot or wound fluids which are retained like foreign bodies in the tissues, and does not arise from putrefaction of the tissues themselves. He speaks of the condition as due to the absorption of poison from a "putrid suppository." Sapremia will not occur after granulations form. The term "putrefaction" is used because this is the usual change, but any fermentative organism may cause the disorder. Sapremia is a malignant form of surgical fever, and its existence means an ill-drained wound, and a fermenting and probably putrid collection of blood-clot or wound fluid.

In sapremia there is congestion of the stomach, intestines, and other abdominal viscera, particularly the kidneys, and also of the brain, and numbers of red blood-cells disintegrate.

Symptoms.—The patient often seems to react incompletely from the injury; he feels miserable, complains of headache, nausea, and pain in the back and limbs; or he may react and in a day or two develop this condition of malaise. In some cases an aseptic fever is directly succeeded by sapremia. In most cases of sapremia, between twenty-four hours and two or three days after labor, after an injury, or after an operation, there is usually a chill or a chilly sensation, though in some cases this is wanting. The temperature rapidly rises to 103° F. or even more. There are severe headache, dry and coated tongue, rapid and weak pulse, nausea and often vomiting, diarrhea, great prostration, restlessness, muscular twitching, and active delirium. The wound is found to be foul, and sometimes there is drying up of wound discharge. There is diminution or suppression of urine, and a strong tendency to congestion of various organs. Jaundice is not unusual. Petechial spots are frequently noticed upon the skin. They occur also upon mucous membranes and serous surfaces, and result from the plugging of small vessels with detritus of broken-down red corpuscles and consequent vascular rupture. Great elevation of temperature often precedes death. In some cases the dose of poison is so large that the patient passes into rapid collapse without preliminary fever. Some cases recover if the initial dose is not overwhelming and if additional doses are not absorbed. Many cases die of exhaustion. Some become linked with fatal pyemia or septicemia. Hemoglobin and red blood-corpuscles are rapidly and notably diminished. Distinct leukocytosis exists except in those cases in which the organism is overwhelmed with the poison and is unable to react. Cover-glass preparations do not show organisms in the blood, and cultures from the blood are sterile.

Treatment consists in at once draining and asepticizing the putrid area and administering very large doses of alcohol and large medicinal doses of strychnin and digitalis. The patient should be purged and diaphoresis favored. The hot bath is val-

[1] "Treatise on Surgery by American Authors."

uable to cause sweating. The action of the kidneys must be maintained if possible. Quantities of water are given by the mouth if it can be retained. Otherwise hypodermoclysis, proctoclysis, or even intravenous infusion of salt solution is employed. Purgatives, diuretics, and diaphoretics are given to aid in removing the toxin, and stimulants are used to sustain the strength of the patient during the elimination of the poison. Vomiting is allayed by champagne, cracked ice, calomel, cocain, or carbolic acid with bismuth. Food should be administered every three hours. The patient is fed on milk, milk and lime-water, milk punch, beef-juice, and other concentrated foods. Quinin in stimulant doses is of value. Antipyretics are useless. The use of saline fluid by enteroclysis, hypodermoclysis, or intravenous infusion dilutes the poison and stimulates the heart, skin, and kidneys to activity. Visceral complications must be watched for and should be promptly treated if discovered. Among the possible visceral complications are nephritis, cholecystitis, enteritis, hepatitis, peritonitis, pleuritis, empyema, bronchopneumonia, pericarditis, and endocarditis. Antistreptococcic serum is useless in sapremia.

Septic Infection, or True Septicemia.—This condition is a true infective process. In sapremia the blood contains toxins of fermentative or putrefactive bacteria, but not the bacteria themselves. In septic infection the blood contains both pyogenic toxins and pyogenic bacteria, the bacteria perhaps being free in the blood or in white cells. In sapremia the causative condition is putrid material lodged like a foreign body in the tissues. In septic infection the tissues themselves are suppurating, and both bacteria and toxins are being absorbed by the lymphatics. Of course, septic infection may be associated with septic intoxication or may follow it. In suppurative fever the tissues suppurate, but only the pyogenic toxins are absorbed, and not the pyogenic bacteria. In septic infection both the pyogenic bacteria and toxins enter the blood, and, it is usually taught, the bacteria multiply in the blood and produce continually increasing amounts of poison. The symptoms of sapremia depend on the dose. In septic infection only a small number of organisms may get into the blood, but they are alive on entrance and may multiply enormously. It is often stated that in septicemia the blood contains multiplying bacteria, whereas, in bacteremia the bacteria are being transported in the blood-stream, but are not multiplying in it (Wassermann). In either case organisms enter the blood from a focus of infection, and the blood, for a time at least, resists them. It may succeed in its resistance and the patient recover. It may fail and the blood-organisms begin to multiply in that fluid. In both cases the bacteriologist may obtain positive blood-cultures. To make the distinction made by Wassermann between bacteremia and septicemia is shown by Walton Martin to put us in difficulties. He says: "We exclude, probably, all cases of subacute and chronic sepsis and, possibly, even the early stages of acute sepsis . . . and there are numerous cases grouped clinically, as septicemia, in which pathogenic bacteria, like the hemolytic streptococcus, have been repeatedly isolated from the circulating blood and in which recoveries are reported as soon as a definite nidus of infection has been removed or shut off from the stream. It has also been shown that the serum and leukocytes of patients suffering from subacute and chronic septicemia possess powerful opsonic action against the organisms causing the infection." (See Martin's able article in the "Annals of Surgery," Oct., 1922.) It is evident that the finding of bacteria in the blood does not prove that they are multiplying there. Again, in cases which are clinically septicemia, many blood-cultures are negative. For some of these negative results faults of technic may be responsible. In others the culture has been taken during an interval of freedom from bacteria (Martin). In very acute or terminal cases blood-cultures are usually positive. The pus microbes cause true septicemia, and reach the blood chiefly through the lymphatics, but to some degree by penetrating the walls of vessels. A drop of blood from a man with septic infection will reproduce the disease when injected into the blood of an animal; hence the disease is truly infective. The wound in such cases is often small, but may be large, and is commonly punctured or lacerated, and the disease begins later after the infliction of a wound than does sapremia. No wound may be discoverable, the infection having arisen from an unrecognized focus of suppuration—for instance, gonorrhea, middle-ear disease, dental caries, apical dental abscesses, tonsillar suppuration, appendicitis, prostatic suppuration, etc. Infection from posterior urethritis is not very uncommon. The initial atrium of infection may or may not be discovered.

The bacteria which exist in the blood and organs in septicemia are usually staphylococci or streptococci, often both. The commonest organisms are the hemolytic

streptococcus and the Streptococcus viridans. Pneumococci or colon bacilli in some cases are causative. The blood is found to have lost much of its coagulating power; it remains fluid for some time after death, quantities of red corpuscles are destroyed, and minute hemorrhages take place in the brain, mucous membranes, skin, serous membranes, muscles, and various viscera. There may be inflammation of synovial and serous membranes. There is congestion of the gastro-intestinal tube and of the abdominal viscera. The lymph-glands are larger than normal and the spleen is notably enlarged. The wound contains numbers of bacteria.

Symptoms.—The type of this condition is met with in puerperal septicemia or in septicemia from an infected wound. When septicemia arises from an infected wound, red lines due to lymphangitis are usually seen about the wound, and there is enlargement of related lymphatic glands. In some cases, however, the wound and the parts about it look normal. A supposed aseptic fever after an injury may continue for an undue time and the surgeon may find that septicemia has developed. Septicemia may arise during the existence or after the abatement of sapremia, or may arise when the aseptic fever has passed away and when there has been no putrid intoxication. It begins in from four to seven days after labor or an injury, usually with a chill, which is followed by fever, at first moderate, but soon becoming high. In some cases there is a chilly sensation, but no distinct chill. There is always great prostration even before the chill. The fever presents morning remissions and evening exacerbations, and may occasionally show an intermission. When the remission begins there is a copious sweat. As the case progresses the temperature may fluctuate, and it often rises very high before death. The pulse is small, weak, very frequent, and compressible. The tongue is dry and brown, with a red tip. Sordes gather on the teeth and gums. Vomiting is frequent, and, as a rule, there is diarrhea. Low delirium alternates with stupor, and coma is usual before death. The great prostration is a noticeable and characteristic feature of the sufferer from septicemia. There are *subsultus tendinum* (twitching of the muscles of the hands and feet) and *carphologia* (picking at the bedclothing), and often hiccup. Toward the end the face often becomes *Hippocratic* (hollow temples, pinched nose, sunken eyes, livid skin, lead-colored and cold ears, and relaxed lips). Visceral congestions occur. The spleen is enlarged, ecchymoses and petechiæ are noted, urinary secretion becomes scanty or is suppressed, and the wound becomes dry and brown. Blood examination detects a rapid and great diminution in red corpuscles and hemoglobin. The anemia is in many cases profound. There is marked leukocytosis except when the system is overwhelmed by the poison. What is known as pyoculture (Delbet's method) is the cultivation of bacteria from wound secretion. In septicemia it should be practised. It is of great value in the diagnosis of pyogenic processes. Cover-glass preparations made from blood may show bacteria, but often fail to do so. Cultures from the blood are sterile in most cases, but not in all. Of 67 patients with marked infections, only 21 were positive (Loygue and Abrami in "La Presse médicale," April 16, 1917). A negative finding does not disprove the existence of septic infection; a positive finding is of much diagnostic and of high prognostic value. Colon bacilli may be found. Bacillus perfringens has been reported. Pneumococcic septicemia is extremely violent in manifestation. In some cases death ensues before the lung has consolidated. If it is not so rapid, endocarditis, arthritis, peritonitis, parotitis, meningitis, or osteomyelitis may develop. A septicema may be acute or subacute, or may become chronic and linger indefinitely. It is particularly apt to become chronic in bone disease. It may be chronic from the start.

The *prognosis* of true septicemia is very unfavorable, and in some malignant cases death occurs within twenty-four hours, but mild cases often recover. Welch points out that finding the Staphylococcus pyogenes albus in the blood is not particularly ominous, but the presence of other pyogenic cocci, especially streptococci, is exceedingly threatening. Pyoculture is of prognostic value. Endocarditis, pericarditis, peritonitis, pleuritis, bronchopneumonia, empyema, nephritis, arthritis, cholecystitis, hepatitis, meningitis, and pyelitis are among the complications which may arise.

Treatment.—If possible drain any focus of infection. Treatment in general consists in the frequent administration of beef-juice, milk, or pancreatinized milk, alcoholic stimulants, strychnin or digitalis, and plenty of water by mouth, if possible, or as salt solution by bowel, subcutaneously or perhaps intravenously. I believe profoundly in the value of alcohol in considerable doses. Iced brandy or iced champagne is very useful. I know that this teaching is a sort of heresy according to those eminent scientists, the prohibition politicians, but I believe it in spite of Volstead, and hence it is my duty to say so. The bowels should be kept open. Glucose by procto-

clysis is of service (as Litchfield advises, give 250 to 500 c.c. two or three times in forty-eight hours). Blood-cultures are to be made invariably. Antistreptococcic serum is employed, but the exact value of this method is as yet disputed. It does not do any harm. It may do good. Sometimes the results seem brilliant, but often nil. It is proper to use it, but not to the exclusion of other remedies. It should be injected into the abdominal wall. Because of uncertainty as to the causative organisms polyvalent serum is used by some. I have felt that Dr. Joseph Sailer's plan is the best. I have seen improvement follow its use even when blood-cultures were negative. If there is a mixed infection with staphylococci and streptococci, staphylococcus vaccine is used hypodermically and polyvalent antistreptococcic serum intravenously. In a pure streptococcic infection polyvalent antistreptococcic serum is used intravenously. A strong indication for the use of the serum is a positive blood-culture. First an intradermic injection of the serum is given to determine the patient's sensitiveness, then an intravenous injection of the serum is given daily until the temperature of the patient becomes normal or nearly so. The dose is 100 c.c. If the treatment should be interrupted for several days it must not be resumed without first testing anew the sensitiveness of the individual. To do otherwise might cause anaphylaxis. It is wise to obtain at one time a sufficient amount of serum of the same number as to preparation. Then the patient receives at each dose an identical serum and escapes dangerous phenomena. Even when every care is taken the patient after seven or eight days may develop a pseudo-anaphylactic reaction. Of course, in all cases, besides giving serum, thorough drainage must be secured. Some use bacterial vaccines. Autogenous vaccines seem the most promising, but there is seldom time to prepare them. Petre has injected fresh warm horse-serum to stimulate leukocytosis. Jayle ("La Presse médicale," 1905, p. 722) and Federman have also used it. All sera and vaccines are as yet of undetermined value in septic infection. Depage and Nolf inject peptones. In chronic septicemia some surgeons use transfusion of immunized blood (Hooker in "Annals of Surgery," Nov., 1917). Washing the blood by the intravenous infusion of salt solution often produces distinct improvement, which, unfortunately, is usually temporary. Dr. C. C. Barrows commends formalin used intravenously. The strength of the solution is 1 part of formalin to 5000 parts of salt solution. The dose is 500 c.c. I have had no experience with formalin in septicemia. Corrosive sublimate, colloidal silver, phylacogen, ammoniosulphate of copper, phenoiodin, magnesium sulphate. and other chemicals have been employed intravenously by various clinicians. Piper has obtained some notable results in puerperal sepsis from the intravenous use of mercurochrome ("Amer. Jour. of Obstet. and Gynec.," Nov., 1922). He was the first to use this drug for septicemia. The dose is 25 to 50 c.c. of a 1 per cent. solution of the drug. One dose, two doses, or more may be given. The dose is never to be repeated as long as any remains in the urine or bowel movements. There is always a strong, sometimes a violent, reaction. Piper points out that during the first hour after a dose has been given there may be vomiting. In less than two hours diarrhea will begin. Usually during the first six hours there will be a chill and the temperature will rise to 105° F. In from twenty-four to forty-eight hours the temperature and pulse should gradually reach normal or nearly normal. It seems certain that mercurochrome will sterilize the blood and that it is of much value in local infections. The drug comes in ampules, must be perfectly clear, should be given with a fine needle, and at a temperature of 100° F. Piper believes that the reaction is analogous to that caused by serum or bacteria, that the drug probably inhibits and possibly destroys circulating germs, that it increases the activity of leukocytes, and that it attacks organisms at the seat of infection (Piper, Ibid.). There may be danger in it, but the disease is more dangerous still, and its use is justifiable in septicemia from any cause.

Pyemia is a condition in which metastatic abscesses arise as a result of the existence of septic thrombophlebitis, clot formation, breaking off of portions of the clot, and lodgment of bits of septic clot in distant places, the disease being characterized by fever of an intermittent type and by recurring chills. It is not actually due to free pus in the blood, but to the passage into the blood of the clots filled with toxins or, far oftener, of clots infected by streptococci, staphylococci, or both. After a wound is inflicted blood clots in the divided veins. If suppuration occurs, the clots may become filled with the toxins of pyogenic bacteria or be invaded by the bacteria themselves. Thus it becomes evident that pyemia may develop with septicemia. It may also develop when there is suppuration in a wound, but not septicemia, no lymphatic absorption of bacteria or toxins having occurred. A suppurating focus about a vein may cause thrombophlebitis and clot formation even when no wound exists. This is seen

in thrombophlebitis of the lateral sinus secondary to suppuration of the middle ear, also in prostatitis with thrombosis of the prostatic plexus of veins. It would seem probable that clot formation, more or less extensive, occurs about every region of infection, and from any such area emboli may at any time be dislodged. Reverdin ("Recherches sur les causes de la gravité particulière des anthrax et des furuncles de la face," 1870) dissected the veins of a patient who died of sepsis due to carbuncle of the lip. A clot ran from the focus of infection and projected into, but did not close, the jugular vein. Bits of infected clot had been broken off from time to time.

A vessel thrombus runs up in the lumen of a vein, and the apex of the clot softens, a portion of it is broken off by the blood-stream and carried as an embolus into the circulation. Many of these poisonous emboli enter into the blood and lodge in some vessels which are too small to transmit them, and at their points of lodgment form *embolic*, *secondary*, or *metastatic abscesses*. If the embolus contains only pyogenic toxins the danger is infinitely less than if it contains bacteria. The secondary abscess if caused by a clot containing toxins only may not lead to further dissemination of disease. If the embolus contains bacteria, thrombophlebitis occurs about it, and new infected emboli form and are sent throughout the system. Wounds of the superficial parts and bones produce pyemic infarctions and metastatic abscesses of the lungs. When these infarctions break into fragments, particles may return to the heart and lodge, or may be sent out through the arterial system to form other foci in distant organs. Infected areas connected with the portal circulation (intestinal injuries, appendicitis, or suppurating piles) may produce *portal pyemia* and multiple abscesses of the liver (see page 1020). Wounds of bones which open the medullary cavity or diploic structure are particularly apt to be followed by pyemia, and the disease may follow labor, phlegmonous erysipelas, and other conditions. Boils and carbuncles of the face and lip are particularly dangerous. Malignant endocarditis is called "*arterial pyemia*," and is due to endocardial embolic infection. In this disorder infected emboli lodge in the kidneys, the spleen, the alimentary tract, the brain, and the skin (Osler). Idiopathic pyemia is a misnomer. Some primary focus of infection must exist, as was pointed out when discussing septicemia.

Symptoms.—The wound often becomes dry and brown, and sometimes also offensive. A severe and prolonged chill or a succession of chills ushers in the disease; high fever follows, and drenching sweats occur. The chills recur every other day, every day, or oftener. A chill arises from the liberation and lodgment of emboli. During the sweat the temperature falls and may become nearly normal, normal, or actually subnormal. The temperature often oscillates violently. The general symptoms of vomiting, wasting, etc., resemble those of septicemia. In some cases the mind remains clear, in many the delirium is purely nocturnal. The skin frequently becomes jaundiced and a profound adynamic state is rapidly established. The blood changes are like those of septicemia. The spleen is enlarged. The lodgment of emboli produces symptoms whose nature depends upon the organ involved. Lodgment in the lungs causes shortness of breath and cough, with slight physical signs. Lodgment in the pleura or pericardium gives pronounced physical evidence. Lodgment in the spleen produces severe pain and great enlargement. The parotid gland not unusually suppurates.

In a suspected case of pyemia always examine an existing wound, and if there is no wound, remember that the infection may arise from gonorrhea, osteomyelitis, suppuration in the middle ear, appendicitis, dental caries, tonsillar suppuration, abscess of the prostate, etc. Chronic pyemia may last for months; acute pyemia may prove fatal in three days. The chief complications are joint suppuration, bronchopneumonia, pleuritis, empyema, endocarditis, pericarditis, peritonitis, nephritis, cholecystitis, pyelitis, parotitis, venous thrombosis, and abscesses. Take cultures from any wound or suppurating area; also take blood-cultures.

Treatment is the same as for septicemia. Open, drain, and asepticize any wound and any accessible secondary abscess. The remarks made as to the use of mercurochrome, sera, and bacterial vaccines in septicemia apply also to pyemia.

Ligation of veins for pyemia following thrombophlebitis is favored by statistics. In the lateral sinus infections it is of acknowledged value. Zueful, in 1880, did it on the lateral sinus. Braun has ligated successfully in pyemia following appendicitis. Trendelenburg had a recovery from puerperal sepsis after ligation of the ovarian veins and vena cava. The operation should be done in infectious thrombosis of the veins of the extremities, and the earlier the better. The operation, if done early, may prevent

pyemia. In infective thrombosis of varicose veins of the leg, tie the saphenous vein. In infections of the lip, ligation may prevent thrombosis of the cavernous sinus.

Erysipeloid (*reticular lymphangitis, crab cellulitis*) was described by Rosenbach in 1887, although like cases were reported nearly fifteen years before by Morrant Baker under the name of erythema serpens. Gilchrist, in 1904, reported 329 Baltimore cases. I have seen a number of cases in the Jefferson Hospital. The condition is due to infection from handling putrid animal matter, especially fish; bites of crabs, and sticks of fish fins. Rosenbach claimed to find a special organism resembling but larger than a staphylococcus, but other observers fail to find it. The period of incubation is from a few hours to two days. Jopson describes the disease as follows ("Amer. Jour. Med. Sciences," May, 1908): "It appears as a swelling with elevated, sharply defined edges, which soon affects the entire circumference of the finger; and is commonly described as of a dark red color, with purplish or even livid edges. The finger is tense and only moderately painful, but itching and burning are prominent symptoms. Sections of tissue excised show an inflammation of the entire corium and, to a slight extent, of the subcutaneous tissue, with infiltration of polynuclear leukocytes and small lymph-cells; edema of the epithelial cells of the epiderm, and inflammatory changes, especially marked around the sweat-glands and blood-vessels (Gilchrist). It has a characteristic tendency to spread from its usual point of origin, near the end of the finger, toward the palm, the primarily affected area fading from red to yellow, and thence to normal. Reaching the palm, it may spread over it; but commonly, it soon affects the neighboring finger; and, when untreated, it may gradually spread to all the fingers and to the back of the hand. There is no fever or other constitutional disturbance, and the lymph-glands are almost never involved. It is more or less self-limited, commonly lasting from ten days to three weeks; and during this time there is a well-marked tendency to relapse. There is no suppuration, pustulation or vesiculation, and no scaling follows."

It is treated by applications of lead-water and laudanum, ichthyol or compresses soaked in a saturated solution of Epsom salt. Jopson applies tincture of iodin, and Gilchrist, 25 per cent. salicylic acid plaster.

IX. ERYSIPELAS (ST. ANTHONY'S FIRE)

Erysipelas is an acute, contagious, spreading capillary lymphangitis due to the streptococci of erysipelas, which grow and multiply in the smaller lymph-channels of the skin and the subcutaneous cellular layers and also in the lymph-channels of serous and mucous membranes. Erysipelas, though contagious, is, as a matter of fact, seldom conveyed as such from one patient to another. Pantou and Adams ("Lancet," Oct. 9, 1909) present this truth convincingly. In St. Thomas' Hospital from 1896 to 1905 erysipelas cases were kept with other cases in the septic wards. In 1906 isolation was begun. The records of 1907 show that isolation had no effect in diminishing the number of cases of erysipelas arising in the septic wards. *Cutaneous erysipelas* is characterized by a rapidly spreading, acutely beginning dermatitis, by a remittent fever due to absorption of toxins, and by a tendency to recurrence. It is always preceded by a wound, a scratch, or an abrasion, which may have been trivial and may never have been noticed. The so-called idiopathic erysipelas is preceded by a breach of surface continuity so small as to escape notice. The initial point of infection may be in the mouth, the nostril, the pharynx, the auditory meatus, between the fingers or toes, at the margin of a nail, or in a cutaneous furrow. The involved area in cutaneous erysipelas seldom suppurates, but sometimes does, very thin, watery pus being formed. If thick pus forms it means mixed infection with staphylococci, but the formation of thin pus does not require a mixed infection, as the streptococcus of erysipelas is identical with the *Streptococcus pyogenes*. In some cases of erysipelas staphylococcus infection follows and even actually replaces streptococcus infection. The rapid spread of erysipelas is due to the fact that the streptococci prevent coagulation of exudate and are not actively attacked by leukocytes. Erysipelas is most common in the spring and fall, and is most usually met with among those who are crowded into dark, dirty, and ill-ventilated quarters; it attacks by preference the debilitated and broken-down (as alcoholics and sufferers from Bright's disease). The disease may become endemic in special places or localities. The poison of erysipelas will produce puerperal fever in a lying-in woman. The streptococcus was first obtained in pure cultures by Fehleisen. This organism is widely diffused.

Forms of Erysipelas.—Ambulant, erratic, migratory, or *wandering* erysipelas is a form which tends to spread widely over the body, leaving one part and going to another.

Bullous erysipelas is attended by the formation of bullæ. In *diffused* erysipelas the borders of the inflammation gradually merge into healthy skin. *Erythematous* erysipelas involves the skin superficially. *Metastatic* erysipelas appears successively in various parts of the body. *Puerperal* erysipelas begins in the genitals of lying-in women, producing puerperal fever. *Erysipelas simplex* is the ordinary cutaneous form. *Erysipelas neonatorum* begins in the unhealed navel of a newborn child and spreads from that point. *Typhoid* erysipelas occurs with profound adynamia. *Universal* erysipelas involves the entire body. *Cellulitis* is often erysipelas of the subcutaneous layers. *Phlegmonous* erysipelas involves the skin and the cellular tissues, and causes suppuration, and often gangrene. *Edematous* erysipelas is a variety of phlegmonous erysipelas with enormous subcutaneous edema. *Lymphatic* erysipelas is characterized by rose-red lines due to lymphangitis. *Venous* erysipelas is marked by the dark color of venous congestion. *Mucous* erysipelas involves a mucous membrane. Erysipelas may attack the fauces, producing the very grave condition known as *faucial* erysipelas.

Clinical Forms.—The clinical forms are cutaneous erysipelas, cellulocutaneous or phlegmonous erysipelas; cellulitis, and mucous erysipelas.

Cutaneous erysipelas most frequently attacks the face. A fever suddenly appears, rises rapidly, reaches a considerable height, is remittent in type and sometimes distinctly fluctuating, and usually terminates in four or five days by crisis. At the time of febrile onset spots of redness appear on the skin. These spots run together, and soon a large extent of surface is found to be red and a little elevated. Any wound, ulcer, or abrasion which exists becomes dry and unhealthy, and its edges redden and swell. The erysipelatous area of redness and swelling extends either in spots with intervening healthy skin or in an uninterrupted line. The margin is usually sharply defined from the healthy skin, and the color fades at the original focus as the disease advances at the periphery of the red area. The border shows the most intense redness, the most marked inflammatory swelling (if there is swelling), and the greatest pain. The point of origin shows the least redness, the least swelling, and the least pain. Thus erysipelas reverses the rule of an ordinary inflammatory process. Milian calls this tendency of erysipelas "the law of centrifugal maximum" ("La Presse médicale," Nov. 5, 1910). The color fades at once on pressure and returns at once when pressure is removed. There is burning pain, which is most intense at the border and which is increased by pressure. In the hyperemic area vesicles or bullæ form, containing first serum and later it may be seropus, but there is rarely genuine suppuration in cutaneous erysipelas. Edema affects the subcutaneous tissues, producing great swelling in regions where there is much loose cellular tissue (as in the eyelids). Anatomically related lymphatic glands may become large and tender. If they do so it means that pus has formed. In an ordinarily strong person the color of an erysipelatous area is bright red or, more rarely, dark red. A dusky color precedes suppuration. A blue color precedes gangrene or indicates profound cardiac or pulmonary involvement. Erysipelas spreads now in one direction, now in another, influenced, according to Pfleger, by the furrows of the skin. As facial erysipelas spreads it involves the ear. All subcutaneous inflammations stop short at the ear and cannot invade it because of the close adhesion of the skin to the cartilage. Milian calls this the "ear sign." When the disease ceases to spread, the swelling and redness gradually abate, and after they disappear desquamation takes place, and the blebs become dry and crusted.

In strong subjects the constitutional symptoms of cutaneous erysipelas are often slight. In the old and debilitated the symptoms are typhoidal, there is a dry tongue, dyspnea and hebetude, delirium comes on, and death is usual. Possible complications are meningitis, pneumonia, septicemia, pleuritis, pyemia, myocarditis, endocarditis, arthritis, and albuminuria. Erysipelas neonatorum is very fatal. The mortality in infants is certainly 50 per cent. (Sir Watson Cheyne's "Weightman Lecture for 1908"). In some instances an attack of erysipelas will cure an old skin eruption, a new growth, an ulcer, or an area of lupus. This is the *erysipèle salutaire* of our French confrères.

Treatment.—It is the custom to isolate the patient. Asepticize the wound, if there be a wound. Examine to determine if there is diabetes or Bright's disease. Administer a purge. Cases of cutaneous erysipelas occurring in a fairly healthy, young or middle-aged subject, tend to get well without treatment. The late J. M. DaCosta advocated the administration of $\frac{1}{8}$ to $\frac{1}{6}$ gr. of pilocarpin at intervals. Debility absolutely contraindicates this drug. If a person is debilitated, free stimulation is necessary. Tincture of chlorid of iron is usually administered in doses of from 20 to 40 min. well diluted, and

given three or four times a day. Tonic doses of quinin are also given. Nutritious food is given at intervals of three or four hours. For sleeplessness or delirium use chloral or the bromids; for very high temperature cold sponging is required. Early in an attack, when the area is limited, the application of Bier's cup may do good. To prevent spreading some have advised injection of the healthy skin near the blush with a 2 per cent. carbolic solution or with fluid containing 1/16 gr. of corrosive sublimate. A band of iodin painted on the skin may arrest the progress of the disease, and so may a ring streaked around a limb or about an erysipelatous area by lunar caustic. Kraske has suggested a method of preventing the spread of cutaneous erysipelas which is sometimes effective. The patient is anesthetized. At about 2 inches from the margin of the redness a series of cuts are made into the skin, to a sufficient depth to cause free oozing. Each cut is crossed by another cut and a ring of scarifications is made to surround the region of the erysipelas. After the oozing ceases the scarified area is soaked for one hour with a solution of carbolic acid (1 : 20) or corrosive sublimate (1 : 2000). The part is dressed with pads wet with carbolic acid (1 : 40) or corrosive sublimate (1 : 2000). This operation causes the formation of a protective barrier of leukocytes. For a number of years I have used with satisfaction a treatment taught me by my old master, Prof. S. W. Gross. It is as follows: Paint the part and well around the part once or twice a day with a mixture of equal parts of tincture of iodin and alcohol. If a wound exists, keep it open and disinfect it with the 2 per cent. iodin once a day. Cover the part with lint wet with lead-water and laudanum, and if an extremity is attacked, bandage it from the toes or fingers to well above the erysipelatous area. The iodin is germicidal and quickly enters the lymph-spaces. The lead-water and laudanum allays the burning pain. Saturated solution of Epsom salt is a useful preparation. It is applied on gauze which is kept constantly moist. It quickly allays the burning pain and seems to limit the spread of the infection. Some advocate a daily inunction of Credé's soluble silver. A useful application is a 50 per cent. ichthyol ointment with lanolin. A very useful method is von Nussbaum's. The author applies it somewhat modified, as follows: Wash the part with ethereal soap, irrigate with a solution of corrosive sublimate (1 : 1000), dry with a sterile towel, apply an ointment of ichthyol and lanolin (50 per cent.), and dress with antiseptic gauze. Some use iced-water cloths, but cold is injurious. Hot fomentations are harmful in cutaneous erysipelas. Some apply borated talc or salicylated starch. Ringer advised painting every three hours with a mixture composed of 30 gr. of tannic acid, 30 gr. of camphor, and 4 dr. of ether. Antistreptococcic serum has been used in erysipelas, and most beneficial results have been claimed for it. It is asserted that under its influence the temperature soon becomes normal. My personal experience with the serum treatment has not convinced me of its value, although some cases seemed to have been benefited. The method of using antistreptococcic serum is set forth on page 129. Antidiphtheric serum is praised by Polak. Schorer studied 100 cases of erysipelas in Bellevue Hospital and determined the opsonic index and its relation to treatment by inoculation of dead streptococci. He concluded that a vaccine does not prevent migration or recurrence, but seems to shorten the duration of the disease ("Amer. Jour. Med. Sciences," Nov., 1907). Ross and Johnson regard treatment by a specific vaccine as very efficient ("Jour. Amer. Med. Assoc.," March 6, 1909). Some advocated treated by injection of serum from one convalescent from erysipelas (Jordan and Dustin in "Jour. Amer. Med. Assoc.," March 15, 1924).

Cellulocutaneous or **phlegmonous erysipelas** is characterized by high temperature (104°–106° F.), the rapid onset of grave prostration, irregular chills, sweat, and a strong tendency to delirium. The constitutional condition may be one of suppurative fever, sapremia, septicemia, or pyemia. The parts are red, as in cutaneous erysipelas, and the tumefaction is vastly greater. The swelling is brawny, comes on early, increases with exceeding rapidity, induces a high degree of tension, and frequently becomes associated with sloughing or even cutaneous gangrene. The lymphatic glands are swollen, but the inflamed lymphatic vessels are hidden by the tumefaction. In most cases suppuration occurs, and when this happens the parts become boggy and the pus is widely disseminated in the subcutaneous and intramuscular tissues, and even into muscle-sheaths and tendon-sheaths (*purulent infiltration*). When the disease abates sloughs form, which leave ulcers upon being cast off. In bad cases muscles, vessels, tendons, and fascia may slough away. The commonest complications are suppression of urine, bronchopneumonia, congestion and edema of the lungs, meningitis, congestion of the kidneys, and acute pleurisy. Septicemia or pyemia may occur. We sometimes meet with this form of erysipelas after extravasation of urine. It is not a pure

streptococcic infection. There is a mixed infection with other pyogenic cocci, and often with organisms of putrefaction.

Treatment.—At once asepticize and drain any existing wound, and dress such a wound with hot antiseptic fomentations. If there are inflamed lymph-vessels or glands above the area of cellulocutaneous infection, paint the skin above them with iodin and smear it with blue ointment or rub in Credé's ointment of soluble silver. Make numerous incisions into the inflamed tissues. These incisions should be near together, and each cut should be 2 or 3 inches long. Spray the wounds with hydrogen peroxid by means of an atomizer, wash with a solution of acetate of aluminum (2 per cent.), and pack each wound with iodoform gauze. Dress with many layers of gauze wet with a hot solution of acetate of aluminum (2 per cent.). The gauze is covered with a rubber-dam and a hot-water bag is laid upon the dressing. If sloughs form, cut them away and employ hot antiseptic fomentations. Change the dressings often. In some cases it may be necessary to employ continuous irrigation with warm antiseptic fluid, or continuous immersion in a hot aseptic or antiseptic bath. Probably the Dakin-Carrel treatment will give the best results. Sometimes it is necessary to operate for the removal of enlarged lymphatic glands. The Bier treatment is a valuable addition to our resources. In rare cases amputation is demanded. When granulations begin to form, treat as a healing wound. The constitutional treatment is that previously set forth as applicable to septicemia, viz., purgation, the use of diuretics and diaphoretics, the administration of strychnin, quinin, digitalis, alcoholic stimulants, and nour-

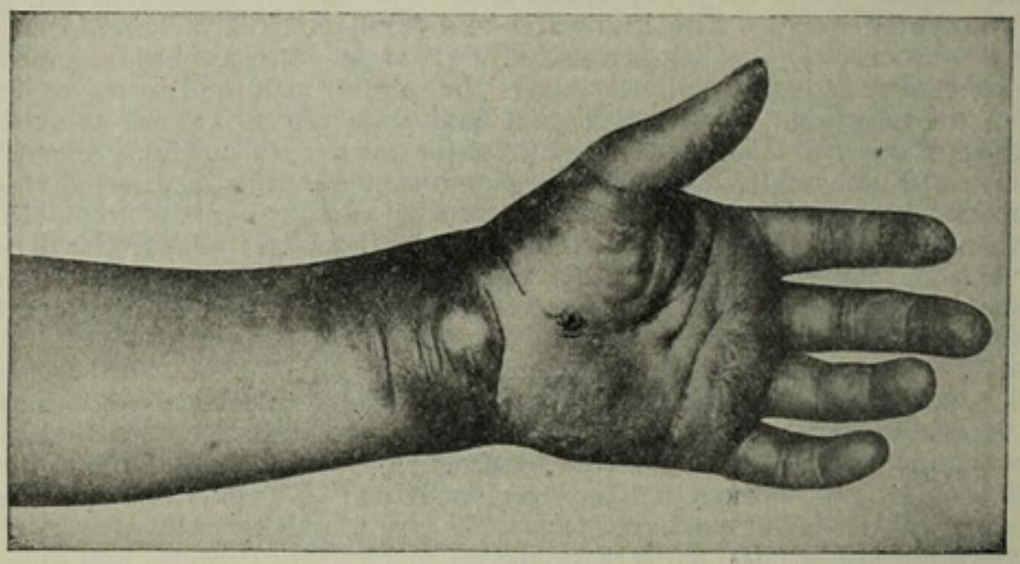


FIG. 64.—Acute cellulitis of palm and forearm following a slight wound.

ishing food. In severe cases employ hypodermoclysis or saline infusion into a vein. Antistreptococcic serum may be employed (see page 129).

Cellulitis (Fig. 64) is a microbic inflammation of the cellular tissue. It may be due to staphylococci, to streptococci, to other pyogenic bacteria, or to mixed infection with two varieties of pyogenic organisms. The commonest form is streptococcic infection, and this is a variety of erysipelas. A streptococcic infection may be followed and replaced by a staphylococcic infection. Infection with the *Bacillus aërogenes capsulatus* may cause muscle infection and gangrene followed by *gangrenous cellulitis*. Cellulitis is prone to arise in damaged tissues, for instance, in a crushed part, a limb the seat of a compound fracture, or tissue containing extravasated urine. In tissue the resistance of which has been lessened by diabetes, Bright's disease, irritating discharges, or trophic lesions, cellulitis is rather apt to develop. In cellulitis of the subcutaneous tissue the micro-organisms find entrance by means of a wound. Swelling precedes redness. The swelling is not so marked as in phlegmonous erysipelas, and the redness is darker and is less distinct than in cutaneous erysipelas. The redness of cellulitis is about the wound; it spreads, but does not fade at the center as does ordinary erysipelas; red lines due to lymphangitis ascend the limb from the infected wound, and the anatomically associated lymphatic glands enlarge. In the wound and its neighborhood there is severe throbbing pain. The constitutional symptoms of infection develop rapidly. In trivial cases the lymphatics dispose of the poison and suppuration does not occur. In severe cases pus forms about the wound and lymphatic glands may sup-

purate. In staphylococcic infection pus is thick, in pure streptococcic infection it is thin. Phlegmonous erysipelas may develop, and septicemia or pyemia may arise.

Treatment.—Open, disinfect, and drain the wound. Paint iodin upon the skin over inflamed lymphatic vessels and glands and cover with ichthyol ointment, or rub Credé's soluble silver ointment into the skin over the inflamed lymph-glands and vessels. Dress the wound and the adjacent inflamed area with hot antiseptic fomentations. The Dakin-Carrel treatment may be used. Secure rest of the part. It may be necessary to make incisions as in phlegmonous erysipelas. In some cases it is necessary to remove breaking down glands. The constitutional treatment is that employed for septicemia. Antistreptococcic serum or mercurochrome may be employed (page 129).

X. TETANUS, OR LOCKJAW

Tetanus is a microbic disease invariably preceded by some injury or focus of infection and characterized by spasm of the voluntary muscles. The wound may have been severe, it may have been so slight as to have attracted no attention, it may have been inflicted upon the alimentary canal by a fish-bone or other foreign body, or may have been situated in the nose, urethra, rectum, vagina, or ear. Infection can occur through a mere abrasion of a mucous membrane or skin. Excoriations in the nasopharynx, infection of the tonsil, infection of the middle ear, ulcer of the leg, suppuration at a tooth root, abscesses in various regions, a frost-bite or a burn may be responsible (Postoperative Tetanus, Kellogg Speed in "Surgery, Gynecology, and Obstetrics," April, 1916). Cephalic tetanus occurred in a patient with whooping-cough (Ponce de Leon, Abstract in "Jour. Amer. Med. Assoc.," Vol. II, 1922). Sir David Semple has recently sought to demonstrate that tetanus does not of necessity depend on spores or bacilli introduced at the time of the injury. He believes that spores may be taken up from the intestine and deposited from the blood in the anaërobic area created by a wound or contusion ("Lancet," May 20, 1911, March 9, 1912). We know that the intestine of man may contain tetanus bacilli and spores (page 137). This explains tetanus arising after an operation upon the appendix or intestine. It has long been taught that so-called idiopathic tetanus is either not tetanus at all, or the term expresses the fact that we have not found the traces of an injury which did exist. Sir David Semple maintains that spores may enter into trivial wounds and remain in the healed area for months, possibly to become active as a result of exposure to great heat or cold, to fatigue, or to bruising of the part. Semple's view would explain so-called idiopathic tetanus (see "Lancet," May 20, 1911). They may also explain some of the cases of tetanus which develop late after a wound and in spite of a prophylactic dose of antitetanic serum, the serum protection having worn out. Tetanus arises most frequently after punctured and particularly after lacerated wounds of the hands or feet. In a surgical experience of over thirty years in connection with the Philadelphia Fire Department I have known hundreds of firemen to injure their feet by stepping on nails, and not one developed tetanus. In fact, the only case of tetanus among them since 1871 arose in a man who lacerated his hand with glass. Morowitz ("Med. Record," March 31, 1917) points out that wounds of parts nearest the ground are most liable to infection. In 106 cases of tetanus, 27 followed wound of the foot, 26 wound of the leg, and 21 wound of the thigh. Before tetanus appears a wound is apt to suppurate or slough; but in some instances the wound is found apparently clean or soundly healed when the tetanus begins. The toy pistol produces a peculiarly dangerous wound. In the United States many cases of tetanus have followed the celebration of the Fourth of July, a large percentage of the causative wounds having been from the toy pistol. In Philadelphia in 1880 there were 30 deaths from Fourth of July tetanus and in Baltimore in the same year there were 20 deaths (S. D. Gross, "A System of Surgery"). The Fourth of July, 1903, was responsible for 466 reported and no one knows for how many unreported cases in the United States. Since that date the prophylactic use of antitetanic serum has become the rule of practice in suspected injuries and there has been a notable diminution in the number of cases of Fourth of July tetanus in the United States. In 1909 there were 150 cases; in 1910 there were 72 cases; in 1911 there were 18 cases; in 1912 there were only 7 cases ("Jour. Amer. Med. Assoc.," Sept. 7, 1912). Of the 7 cases, 6 died (86 per cent.).

The fact that the bacillus of tetanus is anaërobic explains the comparative frequency with which punctured and lacerated wounds are attacked, for in such wounds the bacilli are deeply lodged in recesses or cavities into which air does not penetrate or are covered with discharges which exclude air. Suppuration favors the growth

of tetanus bacilli because the pyogenic organisms consume oxygen. Occasionally, though fortunately very rarely, tetanus follows vaccination. It is essential that vaccine virus should be carefully selected and prepared. When care is taken the operation is absolutely safe. When tetanus follows vaccination, it arises from infection of the wound either at the time of vaccination or, as is far more common, at a later period from scratching or some other fouling. The tetanus organism is not introduced in the vaccine, but obtains entrance during or subsequent to the operation of vaccination, because of utter neglect of the vaccine lesion and in consequence of the accumulation of filth upon and about it. In no reported case have the symptoms of tetanus appeared earlier than two weeks after vaccination (Wm. N. Welch, "N. Y. Med. Jour.," Jan. 16, 1909). The organisms or their spores have never been discovered in tubes or in points, and, as Rosenau points out, the organism cannot grow and cannot form toxins on dry points or in glycerinated virus. The most scrupulous care is taken to prevent contamination of vaccine virus, and it is examined for tetanus toxin and tetanus bacilli before it is placed on the market. Tetanus has followed the injection of gelatin. Commercial gelatin often contains the bacilli and should never be used without careful fractional sterilization. Roberts reports a case of fatal tetanus in a patient with chronic ulcer of the leg ("Lancet," vol. i, 1912). Evler infected himself while operating on a case of tetanus ("Berliner klin. Wchnschr.," Sept. 12, 1910). Tetanus has followed a burn, a frost-bite, child-birth, abortion, and the use in a wound of contaminated catgut. Most cases of postoperative tetanus depend upon infected catgut. The disease sometimes arises when no catgut was used (J. B. Smith's case, "Brit. Med. Jour.," May 6, 1911). Cases have arisen from such trivial operations as ligation of piles and hypodermic injection of quinin. Peterson ("Jour. Amer. Med. Assoc.," Jan. 8, 1910) collected 49 cases of postoperative tetanus reported since 1890. In 40 the peritoneal cavity had been opened. In only 18 cases suture material was named (catgut, 3; catgut and kangaroo-tendon, 2; catgut with other material, 7; silk, 4; silk and silkworm-gut, 1; silk and silver wire, 1). No case appeared before the fourth day, most began on the ninth day. Drainage should tend to prevent it. In 1909 Matas pointed out that tetanus was most apt to follow operations in regions exposed to the danger of fecal contamination ("Tr. Amer. Surg. Assoc.," xxvii). Speed says that man may be a tetanus carrier. He believes that bacilli and spores may at times enter the blood. He would thus account for some cases of postoperative tetanus ("Surg., Gynec., and Obst.," April, 1916). Colombino believes there are tetanus carriers. He has examined many wounds in men who had received prophylactic injections of antitoxin and who had never showed signs of tetanus. A number of times he found spores of tetanus (as Bérard and Lumière had done before) and also bacilli (Presse médicale, Aug. 2, 1917). If any operation were done on such a man, for instance for appendicitis, the lowering of resistance would be apt to lead to the development of tetanus unless antitoxin was given before operation. Tetanus may appear within twenty-four hours after an accident, but it may not arise until many days or even several weeks have elapsed. Rose reported a case which began within twenty-four hours. Kuhn ("Berliner klin. Wchnschr.," 1901) reports a fatal case of tetanus beginning twelve hours after an injection of gelatin. Such a rapid case could only be due to the gelatin having contained a large quantity of tetanus toxin (Schuckmann). Jacobson and Pease are of the opinion that "such cases as have been recorded with periods of incubation under three days must be accepted with considerable reserve" ("Annals of Surgery," Sept., 1906). Samuel D. Gross, in his "System of Surgery," speaks of 1 case occurring in a man five weeks after injury, and another in a girl four weeks after injury. Late cases are due to modification by one dose of protective serum, or arise when dormant bacteria or spores lying in the wound or in the tissues are roused into action by a traumatism, which may be very trivial (see Sir David Semple's views on page 135). It seems certain that tetanus bacilli or at least spores may live in uncontaminated tissue, for instance a healed wound, for months without propagating and without inducing symptoms. Were these same bacteria lodged in devitalized tissue tetanus would arise. One case of tetanus is recorded as arising on the fifty-third day after the injury (Bowling, "Brit. Med. Jour.," March 4, 1916). Antitetanic serum may greatly delay but not prevent the onset of tetanus. In order to prevent these late cases three injections of serum should be given, an interval of seven or eight days intervening between doses. Any muscular contraction after a wound, however late it appears, should excite apprehensions of tetanus. Many such late cases are now on record. Tetanus is more common in the tropics than in the temperate zone; it prevails more in certain localities than in others, but it is met with all over the world from

the Arctic Zone to the Tropics, and may arise in either sex, in any race, and at any age. Colored people are very susceptible, and the disease may exist endemically, and does so in certain portions of New Jersey and of Cuba. In our country the greatest prevalence, according to Anders, is in Pennsylvania, northern New York, Long Island, Virginia, Georgia, and Louisiana. Anders collected 1201 cases and Pennsylvania stands first on his list with 224 cases ("Jour. Amer. Med. Assoc.," July 29, 1905). It is stated that in certain districts of Nigeria the soil contains so many tetanus spores that the natives poison their arrows by sticking them into the ground (Allan C. Parsons in "Brit. Med. Jour.," Jan. 23, 1909). The soil of Belgium contains multitudes of tetanus spores. In the Civil War one case of tetanus arose among every 450 wounded men ("Agnew's Surgery"). The proportion in the Crimea was about the same. During the early months of the World War tetanus was a disastrous scourge. It has been stated that during those months 7 per cent. of the wounded developed tetanus. In the British Army in October, 1914, "the ratio of cases of tetanus to wounded men was 32 per 1000." Thorough prophylaxis has brought about an immense improvement in the ratio (page 141), many observers have agreed with Larrey that sudden changes of temperature favor the development of tetanus. After the battle of Bautzen the wounded lay exposed to a cold storm. The day after the battle Larrey found 100 cases of tetanus. Tetanus is due to the growth in a wound of a bacillus which was first described by Nicolaier and was first cultivated by Kitasato. It is the most widely distributed of all the pathogenic bacteria. It is very difficult to cultivate and cannot be cultivated at all unless air is absolutely excluded. Tetanus bacilli or their spores are found particularly in garden soil, in the dust of walls, walks and cellars, in street dirt, and in the refuse of stables. There is much suggestive evidence that virulent tetanus bacilli come from the intestinal canal of animals; that the bacteria lose their virulence when they have been long outside of the intestinal canal; and that the highest degree of virulence is obtained by those which have passed frequently through intestinal canals. The above view is known as the fecal theory and was strongly advocated by Somani.[1] Many animals, especially herbivorous animals, are tetanus carriers. Men, too, may be carriers. Tenbroeck and Bauer ("Jour. Exper. Med.," Sept., 1922) examined the stools of 78 healthy men and found tetanus bacilli in 34 per cent. of them. A single stool may contain millions of spores. Bacilli or spores may be found even when the carrier has been on sterile diet for a month. It is stated that one-third of the male population about Pekin are tetanus carriers. (Editorial in "Jour. Amer. Med. Assoc.," Vol. II, 1922.)

It is usually taught that in tetanus the bacilli do not enter into the blood, and toxic products produced by them are not directly absorbed by the blood or lymph. Porter and Richardson ("Boston Med. and Surg. Jour.," Dec. 23, 1909) in 2 cases obtained cultures of the bacilli from lymph-glands which received drainage from the wound region. This is a highly important observation. The toxic products alone without any bacteria enter the muscular end organs of motor nerves, ascend along the perineural lymph sheaths, and reach the spinal cord and medulla (Brunner, Marie), become fixed in the nerve-cells of the spinal cord and medulla, and produce the symptoms of the disease. Metchnikoff found tetanus toxin in the cord. Emulsion made from the region of the masticatory nuclei of the floor of the fourth ventricle is peculiarly rich in highly potent toxin (Trosier and Georges Roux, quoted in "Lancet," Jan. 15, 1910). Tetanus is an intoxication and not an infection, and a drop of blood of an animal with tetanus, if injected into another animal, will not produce the disease. Tetanus toxin poisons the nervous system as would strychnin or some other vegetable alkaloid. It is probably the most powerful of known poisons. It has been estimated that 1/278 gr. is sufficient to kill an adult weighing 165 lbs. ("Amer. Med.," Nov. 30, 1901). The great power of the poison is shown by the report of Dr. Nicholas's case ("Comptes rendu de la Société de Biologie," 1893). Dr. Nicholas had been using a syringe to inject filtered cultures of the bacilli of tetanus, and he accidentally pricked his finger with the needle. In four days tetanus began, and he barely escaped with his life in spite of the fact that the fluid was free of bacteria and the dose of toxin was extremely minute. The nature of the virulent poison which is produced at the seat of inoculation is uncertain. Some believe it to be alkaloidal, like the vegetable alkaloids; some, that it is a toxalbumin; others maintain that it is an enzyme or ferment (Nocard, Courmont, and others). In a very few instances the injection of perfectly sterile antidiphtheric serum into human beings has caused death with all the symptoms of tetanus. The serum must have been obtained from horses in whom tetanus was incubating, and the blood-serum

[1] "Verhandl. d. X internat. med. Cong.," Berlin, 1890, Bd. v, Abth 15, p. 152.

injected must have contained a fatal dose of tetanus toxin. In tetanus an ascending neuritis occasionally, though seldom, exists in the peripheral nerve near the lesion. The toxin is carried to the cord by the motor nerves only, and it is not only absorbed by the lymph-channels of the nerve, but ascends along the axis-cylinders of the nerve itself and reaches the motor cells of the spinal cord (Meyer and Ransom in "Arch. exper. Path. u. Pharmakol.," 1903). On reaching the cord it attacks the motor nerve-cells, producing changes similar to those produced by certain infections, and ascends in the motor tracts of the cord to the medullary nerve-centers. While toxin is ascending the axis-cylinders a certain amount is taken up by the lymphatics, enters the blood, and reaches the spinal cord by other nerve-fibers (Jacobson and Pease in "Annals of Surgery," Sept., 1906). The essential basis of tetanus is spreading irritation of the motor portion of the spinal cord accompanied by extreme reflex excitability which is due to poisoning of sensory neurones (Meyer and Ransom). The irritation of the motor cord produces tonic contraction of the muscles; the excitation of the sensory neurons is responsible for clonic convulsions. Lumière ("La Presse médicale," March 29, 1917) reports the case of a man wounded with shrapnel and given antitoxin who developed tetanus on the sixteenth day. In spite of various doses of antitoxin he got another attack on the sixty-seventh day and died on the seventy-fourth day. If this were a real second attack of tetanus, it is a surgical rarity, as second attacks are extremely unusual, but it is not believed that one attack confers any prolonged immunity.

Trismus neonatorum (*trismus nascentium*) is the lockjaw of the newborn. It is due to infection of the stump of the umbilical cord and practically is invariably fatal.

Cerebral tetanus has only been seen as a result of animal experiments. It is caused by injecting tetanus toxin into the brain and is characterized by mental symptoms (Roux and Borrell in "Annals Inst. Pasteur," July, 1897).

Tetanus dolorosa is experimental tetanus produced by injecting toxin into the posterior roots of the spinal nerves. It is characterized by violent spasms of pain and absence of motor symptoms.

Local Tetanus.—In some cases local symptoms arise in a muscle, a muscle group, or a limb, and either remain limited or are predecessors. Spasm may arise in the masseter muscles, spread from there, and precede wide-spread evidences of tetanus. There may be local spasm in a limb for two or three days before general symptoms arise. In some cases the symptoms remain local. These last cases constitute true local tetanus. Experimental tetanus in animals "exhibits almost without exception as its earliest manifestations those of a purely local character and which are at first restricted to the neighborhood of the inoculation." This is now understood to be due to the absorption of the toxin by the perineural lymphatics of the motor nerve of the part. Local tetanus is a modified genuine tetanus. A number of cases were seen in the World War, in which a single preventive dose of antitoxin greatly modified, but did not entirely prevent, the disease. There are four forms of it.

1. *Cephalic, Hydrophobic or Head Tetanus.*—In this condition the contractions are confined chiefly to the face, neck, and pharynx, although the abdominal muscles may also be rigid. There may be no paralysis, but paralysis may involve the facial nerve, the oculomotor nerve, or the hypoglossal nerve (Burrows in "Lancet," Jan. 27, 1917). Cephalic tetanus follows head injury.

2. *Splanchnic Tetanus.*—This occurs after thoracic or abdominal wounds. The muscles of deglutition and respiration are those which are involved. General spasms are absent.

3. *Local Tetanus of the Extremities.*—A single group of muscles, one limb, or two corresponding limbs may suffer. The condition follows injury of an extremity or of extremities.

4. *Abdominodorsal Tetanus.*—In this condition rigidity is limited to the abdomen and back. It follows injury of the chest or back.

Professor Osler saw 9 cases of local tetanus and he cautions us that every muscular spasm arising after a wound is not of necessity tetanus because reflex spasm and neurotic spasm may occur. Local tetanus was not infrequent during the World War. Bruce found 201 cases of the local malady among 1458 cases of tetanus ("Jour. of Hygiene," 1920–21). In local tetanus the condition is apt to arise late after the infliction of the wound (over seven days) and in those who were given but one prophylactic injection of antitetanic serum soon after the infliction of the wound. Widal speaks of it as the tetanus of incomplete immunization. The serum after injection of an ordinary dose reaches its highest antitoxic power in two to three days, remains at high power until about the fifth day, and then the power begins to decline. Between the

eighth and twelfth day all the antitoxin will disappear. If while the antitoxin is disappearing tetanus toxin is still being absorbed, modified tetanus will occur. If toxin pours in when antitoxin is all gone, general tetanus may occur.

We might prolong the immunity by giving a much larger dose than 500 units, but, as MacConkey and Homer say ("Lancet," Feb. 17, 1917), it is "quite impracticable to use for man doses corresponding to some of those we have given to guinea-pigs, and we must content ourselves with smaller doses, even though the protection does not last as long as we would wish."

Many surgeons now recommend repeating the dose of protective serum once, twice, or even three times at intervals of seven or eight days. There may perhaps be some danger of anaphylaxis, but care in giving the injection will lessen the danger and we had better run the small risk of anaphylaxis arising than let the patient have the dreadful risk of tetanus. (See Berard in "Bull. de Acad. de Méd.," 1915, lxxiv. Vaillard, "Bull. de Acad. de Méd.," Sept. 5, 1916. Report on injections of serum, made by Committee of Société Médicale des Hôpitaux de Paris. Published in "Bull. Société," Nov. 19, 1915, MacConkey and Homer in "Lancet," Feb. 17, 1917; Burrows in "Lancet," Jan. 27, 1917.) The conditions favoring the local appearance of tetanus are a short motor nerve, as in head injuries; an injury to a nerve-trunk permitting the rapid absorption of a large amount of toxin; the production of a meager amount of toxin or the presence of something which prevents the admission of a large amount of toxin into the circulation (Nathan Jacobson and Herbert D. Pease, Ibid.). Cases with local symptoms in the beginning are apt to have had long periods of incubation, are apt to be cured, and usually endure a considerable time.

Mortality.—It is a very fatal disease. Acute tetanus has a mortality of from 75 to 90 per cent.; chronic tetanus, from 40 to 50 per cent.; postoperative tetanus, of over 85 per cent. (Peterson's estimate in "Jour. Amer. Med. Assoc.," Jan. 8, 1910).

Local tetanus is apt to terminate in recovery. Tetanus produces death by overwhelming the patient with toxin, by exhaustion resulting from repeated convulsions, by spasm of the glottis, or fixation of the respiratory muscles.

Symptoms.—Acute tetanus begins within ten or twelve days of an accident. The usual period of incubation is from three to five days. Evler had the rare and dreadful experience of contracting the disease from a victim of tetanus on whom he was operating, and the extreme good fortune to recover. He reports his own case and says that various short and transient early symptoms occur which the patient is apt to attribute to the healing wound. Among these he mentions restlessness, sleeplessness, bad dreams, oppression of breathing, frequent and difficult micturition, headache, fatigue, vertigo, chilliness, darting pains in various regions, and perhaps pains about the injured part. If an extremity is the seat of wound, it may swell and remain swollen even when elevated, and it feels hot, but is not discolored. Before long the wound becomes tender and glands often swell. There may be painless contractions and tremors of the injured extremity. Single groups of muscles may undergo tonic contraction ("Berliner klin. Wchnschr.," Sept. 12, 1910). In most cases of tetanus the first symptom noted by the patient is stiffness of the jaw on opening the mouth. In some cases the first symptom is stiffness of the neck, and the patient believes he has "caught cold." In other cases the stiffness begins in the abdomen. In any case the jaw and neck soon become stiff, and finally both the neck and jaw become as rigid almost as iron. The fixation of the jaw is called *trismus*. The muscles of deglutition become rigid on attempts at swallowing. The muscles of the back, legs, and abdomen are thrown into tonic spasm, but the arms rarely suffer. If the infected injury is on the hand or foot, that extremity usually is found to be rigid. Spasm of the face muscles causes the *risus sardonicus*, or sardonic smile (contraction particularly of the *musculus sardonicus* of Santorini). The contraction of the muscles of the back is often so powerful as to bend the patient into a curve like a bow and allow him to rest only on his occiput and heels. This condition is known as *opisthotonos*. If he is bent forward, so that the face is drawn to the legs, it is called *emprosthotonos*. If his body is curved sideways, it is designated *pleurosthotonos*. An upright position is *orthotonos*. The spasm may be so violent as to cause muscular rupture.

The characteristic condition in tetanus is one of widely diffused tonic spasm, aggravated frequently by clonic spasms arising from peripheral irritations. These irritations may be drafts, sounds, lights, shaking of the bed, attempts at swallowing, contact of the bedclothing, the presence of urine in the bladder or of feces in the rectum, or various visceral actions. The clonic spasms begin early in the case and become more frequent and more violent as the disease progresses. The muscles become more rigid

and the attitude produced by the tonic contraction of the muscles is temporarily exaggerated. The forcible contraction of the jaw may loosen or break teeth. The spasms of the diaphragm, of the glottis, and of the muscles of respiration may produce death and always produce great dyspnea. Attempts at swallowing produce spasmodic contraction of the muscles of deglutition. The respirations are rapid and shallow because of muscular rigidity. Every now and then the contracted thoracic muscles are thrown into clonic spasm and then cyanosis occurs. In well-developed tetanus when the muscles exhibit only tonic contraction the condition is as follows: The jaws are rigidly locked. The eyes are fixed and stare wildly. The nostrils are distended. The angles of the mouth are retracted. The lips are flattened and the teeth are exposed. All the facial lines are accentuated. The expression is a mingling of fear and pain. At this time there is severe thirst, general muscular soreness, and often torturing pain in the precordium. When a clonic convulsion occurs the condition is suddenly and acutely aggravated. The man laboring under a tetanic convulsion presents a dreadful picture: he is bent into some unnatural attitude, the face is cyanotic and wet with drops of sweat, the lips are covered with froth which is often bloody, the eyes bulge and are suffused, and the countenance expresses deadly terror and suffering. Some of the teeth may be broken and the tongue lacerated. The agonizing "girdle pain" or precordial pain so often met with is due to spasm of the diaphragm. Each clonic spasm causes a hideous scream by the constriction of the chest forcing air through a contracted glottis. During the progress of the disease constipation is persistent and retention of urine is the rule (because of sphincter spasm). The urinary secretion is scanty. The mind is almost invariably entirely clear until near the end—one of the worst elements of the disease. Delirium may arise. I have seen it in 3 cases, due, I fancy, in each case, to the drugs administered. It may, of course, be due to previous alcoholism. There is obstinate insomnia. Headache is common. Hearing, at first hyperacute, is later impaired. Deafness may arise. Pulse is seldom above 80 or 90 until shortly before death, when it may become 150 or more. Usually the pulse is of high tension. Swallowing in many cases is impossible. Talking is very difficult and usually it is impossible to project the tongue. The muscles throughout the body feel very sore. The temperature may be normal, but may be a little elevated, and always rises just before death. Hyperpyrexia sometimes occurs (108°–112° F.), and the temperature may even ascend for a time after death. An injection of serum raises the temperature several degrees. In about 85 per cent. of fatal cases of acute tetanus death occurs within five days, and many of these patients die within two or three days. Very few puerperal cases recover and practically no cases which follow abortion recover. Of late years the mortality in acute tetanus has slightly diminished. If a patient lives a week, his chance of recovery is good. In the Civil War the mortality was 89.3 per cent. In the Franco-Prussian War it was about the same. Ashhurst and John, in 1913, collected 435 cases, with a mortality of 60 per cent. ("Amer. Jour. Med. Sciences," June, 1913). I believe that if modified cases and cases of chronic tetanus are excluded and we count only acute general tetanus in which the incubation period was brief, the mortality is still at least 80 per cent. Early in the World War the mortality among tetanus cases who had not received prophylactic injections was 91 per cent. when the incubation was short and 50 per cent. when it was delayed (Bruce, "Brit. Med. Jour.," Oct. 23, 1915). Death may be due to exhaustion, to respiratory failure, to carbonic-acid narcosis from spasm of the glottis or fixation of the respiratory muscles, or to pneumonia.

Chronic tetanus comes on late after a wound (from ten days to several weeks). The symptoms are not so severe as in acute tetanus. The muscular spasm is wide-spread, but it may not be persistent, intervals of relaxation permitting sleep and the taking of food. Chronic tetanus long had a mortality of 40 or 50 per cent., but modern methods of treatment, it has been claimed, have considerably reduced it. According to the report of Jacobson and Pease it is from 35 to 50 per cent. ("Annals of Surgery," Sept., 1906). The disease may last for some weeks.

Diagnosis.—Tetanus may be confounded with strychnin-poisoning, with hysteria, with tetany, or with hydrophobia. Wood's table (see page 141) makes the diagnosis clear between tetanus, strychnin-poisoning, and hysteria.[1]

Tetany is distinguished from tetanus by the milder nature of the spasms, by the greater limitation of the rigidity, by the fact that spasms begin in the hands or feet, not in the jaw and neck, and in most cases by periods of distinct intermittence.

In hydrophobia tonic spasm does not exist, and if clonic spasms occur they are secondary to suffocative attacks.

[1] "Nervous Diseases," by Prof. H. C. Wood.

Tetanus.	Hysteric tetanus.	Strychnin-poisoning.
	Commences with blindness and weakness.	Begins with exhilaration and restlessness, the special senses being usually much sharpened. Dimness of vision may in some cases be manifested later, after the development of other symptoms, but even then it is rare.
Muscular symptoms usually commence with pain and stiffness in the back of the neck, sometimes with slight muscular twitching; comes on gradually. Jaw one of the earliest parts affected; rigidly and persistently set.	Muscular symptoms commence with rigidity of the neck, which creeps over the body, affecting the extremities last. Jaws rigidly set before a convulsion, and remain so between the paroxysms.	Muscular symptoms develop very rapidly, commencing in the extremities, or the convulsion when the dose is large seizes the whole body simultaneously. Jaw the last part of the body to be affected; its muscles relax first, and even when, during a severe convulsion, it is set, it drops as soon as the latter ceases.
Persistent muscular rigidity very generally, with a greater or less degree of permanent opisthotonos, emprosthotonos, pleurosthotonos, or orthotonos.	Persistent opisthotonos and intense rigidity between the convulsions and after the convulsions have ceased, the opisthotonos and intense rigidity lasting for hours.	Muscular relaxation (rarely a slight rigidity) between the convulsions, the patient being exhausted and sweating. If recovery occurs, the convulsions gradually cease, leaving merely muscular soreness, and sometimes stiffness like that felt after violent exercise.
Consciousness preserved until near death, as in strychnin-poisoning.	Consciousness lost as the second convulsion comes on, and lost with every other convulsion, the disturbance of consciousness and motility being simultaneous.	Consciousness always preserved during convulsions, except when the latter become so intense that death is imminent from suffocation, in which case sometimes the patient becomes insensible from asphyxia, which comes on during the latter part of a convulsion and is almost a certain precursor of death.
Drafts, loud noises, etc., produce convulsions, as in strychnin-poisoning; may complain bitterly of pain.	Crying spells alternating with convulsions.	The "slightest breath of air" produces convulsion. Patient may scream with pain or may express great apprehension, but "crying spells" would appear to be impossible.
Eyes open and rigidly fixed during the convulsion.	Eyes closed.	Eyes stretched wide open.
	Partial spasm in the leg, producing in Wood's cases crossing of the feet and inversion of the toes. If all the muscles were involved, eversion would occur, as the muscles of eversion are the stronger.	Legs stiffly extended with feet everted, as the spasms affect all the muscles of the leg.

Treatment.—Far better even than to treat tetanus well is to prevent it. Careful antisepsis will banish it as a sequence of surgical operations as thoroughly as it has banished septicemia provided no dormant bacteria of tetanus and no tetanus spores are lodged in the traumatized tissues. Every infected wound must be disinfected with the most scrupulous care. Every punctured wound is to be incised to its depths and thoroughly cleaned and drained. In a very suspicious wound, such as a Fourth of July injury or a wound from a dung fork, or the entrance into the tissues of a splinter from a stable floor, after the removal of foreign bodies and thorough antiseptic cleansing, give a subcutaneous injection of 1500 U. S. A. units (9 cm. of horse serum) of tetanus antitoxin and repeat within ten days. It is certain that tetanus antitoxin has prophylactic power; in fact, Jacobson and Pease say that "as a prophylactic measure it merits our fullest confidence" (loc. cit.). The procedure is not a certain preventive. Reynier injected antitoxin into a patient on whom he was about to operate because there was a case of tetanus in the wards, and yet this man developed tetanus ("Gaz. des Hôpiteaux," July 16, 1901). Many cases have been reported in which prophylactic injections failed to prevent the disease. When in spite of such injections the disease does arise, it is apt to be mitigated in violence. Nevertheless it is sure that

animals can be rendered immune to tetanus, and the prophylactic power of antitoxin is warmly advocated by many eminent men. It is extensively and most successfully used by veterinarians to prevent tetanus after castration of horses, and this success is a guide-post to us. The following table is most suggestive (quoted by Heineck in "Surgery, Gynecology, and Obstetrics," Jan., 1909, from Scherck's article in "Jour. Amer. Med. Assoc.," 1906, vol. xlvii, p. 500). It sets forth the Fourth of July injuries treated in St. Louis dispensaries:

Years.	Number of cases.	Antitetanic serum as a preventive.	Deaths from tetanus.
1903	56	no	16
1904	37	yes	none
1905	84	yes	none
1906	170	yes	none

War experience on an immense scale proved the prophylactic value of antitetanic serum. In the British Army, active during the World War, after universal immunization was introduced, the ratio of cases of tetanus to wounded men fell from 32 per 1000 to 2 per 1000 (David J. Davis in "Scientific Monthly," Nov., 1917).

In the World War all wounds were regarded as infected. A wound of war requires immediate incision, disinfection, and drainage. It may be disinfected with iodin or some chlorin preparation and should be dressed antiseptically.

As soon as the soldier came from the firing line he was given a subcutaneous injection of 500 U. S. A. units represented by 3 cm. of horse-serum. In seven or eight days he was given a second injection and in seven or eight days more a third. The injection was made very slowly, and if, in giving a second or third injection, the slightest sign of anaphylaxis was noted, injection was at once arrested.

An admirable memorandum on "The Prevention and Treatment of Tetanus" was issued by the British War Office ("Brit. Med. Jour.," Nov. 11, 1916). In 1918 the British surgeons changed their plan and substituted one dose of 1500 units. At present the U. S. Army advises one dose of 1500 units. Repeat in less than ten days. This is a good rule in civil life. Is there any danger of anaphylactic shock? "The British statistics show that more than two million prophylactic injections of tetanus antitoxin were given during the war and only 11 instances of anaphylactic shock occurred, and all of the patients recovered" (Willard J. Stone in "Jour. Amer. Med. Assoc.," June 24, 1922). Intravenous use exposes the patient to the greatest danger of anaphylactic shock.

Puerperal tetanus is prevented by antiseptic midwifery, and tetanus neonatorum by the antiseptic treatment of the stump of the cord. In order to obviate all danger of the development of tetanus after vaccination perform the little operation with cleanliness and care properly for the wound and for the pustule. The skin should be cleansed with soap and water, rubbed with alcohol, and washed with boiled water. It should be gently scraped with a knife (which has been boiled) until serum exudes. The virus, taken from a hermetically sealed tube, is applied to the raw surface and allowed to remain exposed to the air until dry. A piece of sterile gauze is laid over the part and is held in place by a bandage. This dressing is changed as may be necessary, and is used until granulation begins, at which time the use of any simple ointment is admissible. Do not apply a shield. The evil of shields is pointed out by Robert N. Willson ("Amer. Med.," Dec. 7, 1901).

When tetanus exists, always look for a wound, and if one is found, open it widely and to the very depths; if there are sloughs, cut them away, paint the wound with tincture of iodin, and secure drainage by leaving the wound open. Dry dressings are indicated.

Surgeons of a former day were accustomed to amputate for tetanus if the wound was upon an extremity. This treatment was overthrown by Dupuytren and Sir Astley Cooper. When we reflect that the poison-producers are in the wound and not in the circulation, it seems a reasonable treatment. As a matter of fact, it never does any good, because, when the symptoms begin, the toxin has already entered into the nerve-cells and become fixed. Kitasato has shown that if a mouse is inoculated with tetanus near the root of the tail, excision of the tail and cauterization of the stump will not prevent tetanus unless it is performed within one hour of the inoculation. Nocard inoculated sheep near the root of the tail with tetanus spores, and although the moment symptoms appeared he amputated well above the point of inoculation, the animals died of the disease. We must regard amputation as a useless method

of treatment. The cases of Porter and Richardson in which bacilli were found in adjacent glands suggest the wisdom of removing any enlarged glands which could have received lymph from the wound or the nerve sheaths.

Keep the sufferer from tetanus in a darkened, well-ventilated, and quiet apartment, so as to exclude as far as possible peripheral irritation. Watch for the occurrence of retention of urine, and use the catheter if necessary. Secure movements of the bowels by administering salines, castor oil, croton oil, or enemas. Stimulate freely with alcohol, and give fluids by hypodermoclysis. Give plenty of concentrated liquid food unless swallowing causes convulsions, then feed by the rectum. If swallowing causes convulsions some surgeons give an inhalation of nitrite of amyl before an attempt is made to swallow. If this treatment does not make swallowing possible, then partially anesthetize the patient and feed him by means of a pharyngeal tube passed through the nose. It may become necessary to abandon mouth feeding. Large doses of the bromid of potassium, or of this drug with chloral, give the best results, as far as drug treatment is capable of giving results. If bromid is used, give about 1 dr. every four to six hours. Chloretone has warm advocates. It is given in large doses. It abates rigidity and diminishes the number and severity of clonic convulsions. Other drugs that have been used with some success are gelsemium, morphin, curare, injections and fomentations of tobacco, physostigmin, anesthetics, cocain, and cannabis indica. An ice-bag to the spine somewhat relieves the girdle pain. Hot baths have been advised. It is said that venesection followed by the intravenous infusion of saline fluid does good. This procedure is followed by a free flow of urine and by lessening of the number of the paroxysms. It may be repeated several times during a few days (E. J. McOscar, in "Amer. Med.," Sept. 14, 1901; A. V. Moschcowitz in "Med. News," Oct. 13, 1900).

Years ago Yandell said, in summing up Cowling's report on tetanus:[1] "Recoveries from traumatic tetanus have been usually in cases in which the disease occurs subsequent to nine days after the injury. When the symptoms last fourteen days recovery is the rule, apparently independent of treatment. The true test of a remedy is its influence on the history of the disease. Does it cure cases in which the disease has set in previous to the ninth day? Does it fail in cases whose duration exceeds fourteen days? No agent tried by these tests has yet established its claim as a true remedy for tetanus."[2] Yandell's statement is true today.

It is now claimed by some observers that we have a remedy which fulfils the requirements of Yandell in the tetanus antitoxin serum. Behring and Kitasato succeeded in immunizing animals, and Tizzoni and Cattani assert that the antitoxin is an enzyme. The antitoxin destroys the activity of the toxin and is obtained from an immunized horse.

If injected subcutaneously it is absorbed very slowly, and even twenty-four hours or more after such an injection a considerable amount remains unabsorbed in the tissues. It is not absorbed at all by the nervous structures. It is eliminated rapidly and unaltered in the urine, feces, and sweat. It seems to be harmless and its immunizing powers are certain. In a huge majority, but not in all persons, it will prevent the disease. Its curative power is very much less certain. Hypodermic injections are practically useless therapeutically. Intravenous injections are of more service, but even then the antitoxin only grasps the toxin in the blood and fails to reach that in the nerves, nerve-cells, and nerve-tracts. Some practice intramuscular injections, but 7 acute cases so treated died, a mortality of 100 per cent. (Jacobson and Pease, "Annals of Surgery," Sept., 1906). Injection into the theca of the cord (intrathecal injection) by means of lumbar puncture is an attractive method, but the inability of nerve-elements to absorb antitoxins when the pia intervenes is an argument against it, though in 1 violent acute case of my own, occurring in a boy, recovery followed this method. In 7 acute cases treated by this method the mortality was 57.1 per cent. (Jacobson and Pease, Ibid.). John Rodgers injected antitoxin into the cauda equina and nerves, and apparently hopeless cases recovered ("Med. Record," July 2, 1904). Injection into a nerve (intraneural injection) has been practiced, but even this plan is only of service in localized tetanus, the main nerve about the part tetanized being injected (Küster in German Surgical Congress of 1905). Some have injected serum under the cerebral dura. Others have injected it into the brain. These latter plans have been abandoned by most surgeons. However antitoxin is given, the dose must be large if any good is to be done.

The value of the tetanus antitoxin in acute tetanus has been doubted. In the

[1] "American Practitioner," Sept., 1870.

[2] Quoted by Hammond in his "Diseases of the Nervous System."

Russo-Japanese War its use was abandoned, and d'Autma found it of no value in the tetanus cases which followed the Italian earthquakes of 1908. Statistics of the World War indicate the value of the serum and also show that prophylactic injections, even if they do not prevent the disease, defer it and cause the cases to be much less fatal. Willard J. Stone says ("Jour. Amer. Med. Assoc.," June 24, 1922): "The death-rate before the introduction of tetanus antitoxin was about 85 per cent. The British war statistics have shown that among 1437 patients treated in England, 501, or 34.8 per cent., died. These patients had comparatively long incubation periods owing to the earlier prophylactic injection. Those who did not receive the prophylactic injection or whose incubation was shorter (averaging from twelve to thirteen days) were treated in the hospitals in France. Among 715 such patients, 510 died, a mortality rate of 71.2 per cent. The British total figures show that 2152 soldiers developed tetanus during the World War, with 1011 deaths, or 47 per cent.

"Many factors enter into a study of the mortality rates reported from different hospitals. For example, Gessner, who studied 367 case reports from the New Orleans Charity Hospital for the period 1906–18, has expressed the pessimistic opinion that since the mortality was 70.7 per cent. 'we must admit that we have progressed but little in the treatment of the disease.' Such a conclusion seems hardly justified, for it may be pointed out that a high mortality of 71 per cent. among 121 patients who did not receive more than 10,000 units of antitoxin would not be unusual in view of the method and size of the dose administered. His own figures show that among 23 patients who received more than 10,000 units of antitoxin the mortality was 56.5 per cent. It should be recalled that, in any series of instances of this disease (the acute cases of short incubation), the patients may die before there is time to administer antitoxin in sufficiently large doses to save life. In other words, the longer such patients live, the greater the probability that they will receive large and more adequate dosage. Again, it should be recalled that the virulence of the infecting strain may vary with different years. For example, among 7 patients of our series, admitted in 1916, the mortality was 71 per cent., while among 7 patients admitted during 1917, the mortality was 14.3 per cent. Again, among 9 patients treated during the year 1920, the mortality was 44.4 per cent., while among 10 patients treated during 1921 the mortality was 70 per cent." A serum injection in tetanus raises the temperature and may cause depression of the circulation, severe headache, vomiting, diarrhea, perhaps, in very rare cases, death. In almost half the cases a serum rash will appear from the eighth to the tenth day. Under its use the mortality from acute tetanus is said to fall from nearly 90 to 75 per cent. The figures do not indicate that the mortality in chronic tetanus has been greatly influenced by it. If tetanus antitoxin is to be of service it must be when used early and in large doses. It can be used subcutaneously, intramuscularly, subcutaneously or intraspinally. There is no proof that antitoxin can reach nerve structures from cerebrospinal fluid, but nevertheless clinical results are best from injection of the cord theca. Stone's plan of treatment is the best ("Jour. Amer. Med. Assoc.," Ibid.). Give 1 c.c. of serum subcutaneously to desensitize the patient. If in half an hour there is no dyspnea or cyanosis, and if the pulse remains about as before, give 20,000 units intravenously. If signs of anaphylaxis occur, stop the injection. After the intravenous dose an adult is to be given 20,000 units intraspinally; a child, 10,000 units. On the second day 20,000 units are given intravenously and 20,000 intraspinally. The same is done on the third day. On the eighth or ninth day give 10,000 units intramuscularly or subcutaneously. At the time serum treatment is begun the wound is cleansed and 5000 units of antitoxic serum are injected about the wound. Stone (Ibid.) calls attention to the fact that if a patient has opisthotonos he must be etherized before he is given an intraspinal injection. Otherwise the needle may be broken. If anaphylactic shock arises give a subcutaneous injection of 1/100 gr. of atropin or 15 minims of a 1:1000 solution of chlorid of epinephrin (Stone, Ibid.).

A lumbar puncture is made, 20 c.c. of spinal fluid are permitted to flow away, and 20 c.c. of serum are slowly injected. The injection should be repeated each day for four or five days and during the same period serum should be given subcutaneously or intramuscularly in the doses previously directed (see "Memorandum on Tetanus" issued by British War Office, "Brit. Med. Jour.," Nov. 11, 1916).

Kitasato has claimed that injections of iodoform render animals immune, and Sonnani has maintained that this drug placed in a wound prevents the disease. If antitoxin is not obtainable, give hypodermic injections of iodoform, 3 to 5 gr. t. i. d., or use Bacelli's treatment.

Bacelli's treatment was introduced by Bacelli, of Rome, in 1892. It consists in the

hypodermic injection of carbolic acid, which is thought to grasp tetanus toxin and mitigate its virulence or even make it inert. The drug is also thought to be sedative and to lower temperature. Tetanus toxin is destroyed by carbolic acid (shown by Tizzoni and Cattani in 1890). Kitasato pointed out in 1891 that cultures of tetanus bacilli can be rendered sterile in thirty minutes by a 5 per cent. solution of carbolic acid. The usual dose is 15 minims of a 3 per cent. solution every two hours. Three times this amount can be given in a day. To avoid irritation Maragliano uses a 5 per cent. solution in sterile olive oil. Favorable results are claimed for the plan. Bacelli has collected 190 cases (all severe or very severe). There were 94 severe cases and 92 recovered (2½ per cent. mortality). There were 38 very severe cases and 22 recovered (see Bacelli in "Berliner klinische Wochenschrift," June 5, 1911). Even the occurrence of carboluria does not cause the surgeon to suspend the treatment. These results are the best ever given in tetanus, but others have not had such fortunate results. A patient of mine with acute tetanus recovered under the treatment.

The "Memorandum on Tetanus" by the British War Office, quoted above, says: "There is no convincing evidence that the carbolic acid treatment of tetanus has any curative effect whatever or any action upon the course of the disease."

The hypodermic injection of an emulsion of fresh brain matter has been advocated on the ground that brain matter and tetanus toxin have a mutual affinity (Krokiewicz). The results are not conclusive.

Mathews reports cure in 2 cases following the very gradual introduction into a vein of a solution containing sodium chlorid, sodium citrate, sodium sulphate, and chlorid of calcium ("Jour. Amer. Med. Assoc.," Aug. 29, 1903). Cure of acute tetanus has followed the intraspinal injection of a solution of magnesium sulphate, which drug, Meltzer has shown, strongly stimulates inhibition. Blake has reported such a case ("Jour. of Surgery, Gynecology, and Obstetrics," May, 1906). If magnesium sulphate is used, 5 c.c. of a 25 per cent. solution are injected into the subarachnoid space of the cord, after first removing an equal quantity of cerebrospinal fluid. Some hours after such an injection there is marked muscular relaxation lasting a number of hours. Not unusually there is lowering of respiratory rate. When the improvement ceases another dose is given. Heinecke (Ibid.) reported a successful case and collected 12 other cases so treated, 7 of which died. Smithson used this drug and, although the patient died, there was not a convulsion after the injection. Kocher was of the opinion that the treatment reduced greatly the mortality. There are grave dangers in the method. It may arrest respiration by causing paralysis of the respiratory center. The "Memorandum on Tetanus" quoted above rejects the magnesium sulphate treatment, saying that it can only arrest spasm temporarily and its use is a great risk.

Murphy reports the recovery of a case after spinal puncture and injection of morphin and eucain into the theca of the cord ("Jour. Amer. Med. Assoc.," Aug. 13, 1904). I have seen but four recoveries from acute tetanus. Two cases of acute tetanus recovered after intraspinal injection of antitoxin. One acute case recovered after the subcutaneous use of antitoxin. One acute case recovered after Bacelli's treatment. I have known 4 cases of chronic tetanus to recover: 1 was treated by chloral and bromid only, 3 were treated by chloral and bromid and antitoxin subcutaneously.

XI. SURGICAL TUBERCULOSIS

(Assistant Professor Elmer H. Funk, who is in charge of the tuberculosis department of the Jefferson College Hospital, did me the great favor to revise this section.)

Tuberculosis is an infective disease due to the deposition and multiplication of tubercle bacilli in the tissues of the body. The term *surgical tuberculosis* is applied to all of those numerous tuberculous lesions that may demand surgical treatment. Such lesions may exist in different structures, often seem clinically to be strictly localized processes, and in many instances may be extirpated, drained, or sterilized. Among the conditions placed under the heading of surgical tuberculosis are: Tuberculosis of glands, of bones, of joints, and of the skin. These lesions are most common in children, the majority of cases are curable, and they are not so often associated with or followed by pulmonary tuberculosis as are some other tuberculous lesions. They tend in many cases to remain local and, beyond doubt, a considerable number of them are due to infection with bovine bacilli. Tuberculosis is characterized either by the formation of tubercles or by wide-spread cellular proliferation (diffuse tubercle) or by fibrinous exudation, which is very rich in cells. Tuberculous conditions tend to caseation, sclerosis, or ulceration.

A *tubercle* is a non-vascular infective focus, appearing to the unaided vision as a semitransparent gray or yellowish mass the size of a mustard-seed. The microscopic tubercle is, except the bacillus, the most characteristic evidence of the disease. The microscope shows that a gray tubercle consists of a number of cell clusters, each cluster constituting a *primitive tubercle*. A typical primitive tubercle shows a center consisting of one or of several polynucleated giant-cells surrounded by a zone of epithelioid cells which are surrounded by an area of leukocytes. When the bacillus obtains a lodgment the fixed connective-tissue cells multiply by karyokinesis, forming a mass of nucleated polygonal or round cells. These cells are connective-tissue cells and are derived particularly from endothelium and are called *epithelioid cells* from their resemblance to epithelial cells. Early in the development of a tubercle blood-channels lined with epithelioid cells exist, but continued cell proliferation blocks the channels and at the same time the blood-supply of the growth is further limited by the pressure of proliferating perivascular cells and the proliferation of the endothelial cells of adjacent vessels. Some of the epithelioid cells proliferate, and others attempt to, but fail for want of blood-supply. Those which fail to multiply succeed only in dividing their nuclei and enormously increasing their bulk (giant-cells). Giant-cells, which may also form by a coalescence of epithelioid cells, are not always present. Giant-cells are not certain evidence of tuberculosis, for they occur in syphilitic lesions. The presence of irritant bacterial products induces surrounding inflammation and numbers of leukocytes gather about the epithelioid cells (Fig. 65).



FIG. 65.—Synovial membrane, showing giant-cells (Bowlby).

The bacilli, when found, exist in and about the epithelioid cells, and sometimes in the giant-cells. When bacilli enter the tissues they are often killed. If they enter in large numbers or are peculiarly virulent, or if resistance is low they induce chronic inflammation, granulation tissue forms, and the cells of the focus often have the characteristic arrangement described above. The bacilli are not pyogenic and suppuration means secondary infection. If mixed infection of any considerable area occurs, the patient is apt to develop fever and to perish from exhaustion, amyloid disease, dissemination, or a terminal infection. In rare cases the tuberculous area is destroyed and cure is brought about. A tuberculous focus tends strongly to degenerative changes because of the local anemia and the presence of bacilli. If numerous active bacilli are present *caseation* takes place. This is coagulation necrosis due to the action of bacteria upon a non-vascular area. It starts at the center of a tuberculous focus and spreads toward the periphery and finally forms masses like cheese. When caseated material is mixed with serum *tuberculous pus* is formed.

A caseated focus may be surrounded or encapsulated by fibrous tissue. When this happens the tuberculous process may remain latent for months or years, perhaps awakening into activity as the result of a traumatism or lowered general resistance. A caseated focus may be cured by growth of fibrous tissue which replaces the tuberculous focus. A caseated area may calcify. Even when tuberculous pus forms, encapsulation may occur, the fluid being absorbed, and the remains being surrounded by fibrous tissue. Whenever tubercle bacilli consume all available food they die or remain latent. If they die, the granulations are converted into fibrous tissue and the part is healed. If they remain latent they may at any time become again active. Infiltrated tubercle is due to the running together of many minute infective foci, or to wide-spread infiltration without any formation of foci. Infiltrated tubercle tends strongly to caseate. The description of a tubercle previously given relates to the common *reticulated tubercle*. Two other varieties exist.

The *fibrous tubercle* is much richer in dense connective tissue than is the ordinary tubercle. It forms when bacilli are greatly weakened or killed. When this happens embryonal cells cease to degenerate, and ordinary inflammation results in fibrous tissue formation. Fibrous tubercle is evidence of an effort at cure.

Hyaline tubercle results from hyaline degeneration of the reticulum of an ordinary tubercle and is the early stage of coagulation necrosis.

From experimental studies we have learned that the tissue reaction to a first infec-

tion by tubercle bacilli is radically different from that of a second or superinfection in an animal in which the original infection has not died out. When the normal guinea-pig, for example, is inoculated for the first time with tubercle bacilli nothing happens at the site of inoculation for about a week or ten days, after which a small nodule appears on a non-inflammatory background. Microscopically the lesion is characterized by proliferative phenomena rather than by those of inflammation. The adjacent lymph-nodes are involved and after a time the nodule ulcerates; and if the dose of tubercle bacilli was large the guinea-pig dies of progressive and generalized tuberculosis. If the dose of tubercle bacilli was small, so that the guinea-pig apparently recovered from the tuberculosis, although still harboring tubercle bacilli, the response to a second injection, as stated above, will be characterized by a radically different picture. At the point of inoculation a rapidly developing inflammation occurs. Its intensity will vary with the number of bacilli inoculated, the inflammatory phenomena reaching their height within twenty-four to forty-eight hours, and eventuating in severe cases in necrosis, and sloughing. The adjacent lymphatic glands are not involved. The constitutional symptoms are severe. To repeat, a first inoculation in a healthy guinea-pig is characterized by a proliferative lesion of slow evolution without inflammatory phenomena, with progression to cure, latency, or progressive disease and death, depending upon the number of tubercle bacilli inoculated; a second infection in a tuberculous animal is characterized by an inflammatory lesion of rapid evolution, with exudative phenomena, with localized changes of varying severity, depending upon the number of bacilli inoculated, without involvement of the adjacent lymph-glands, and usually with recovery if the dose has not been excessive. This striking and rapid exudative response of a tuberculous animal to reinfection is due to a condition of hypersensitiveness of the tissues which Pirquet calls allergy. This hypersensitiveness which is dependent upon the existence in the body of living tubercle bacilli is manifested by all of the tissues of a tuberculous animal, and either the tubercle bacillus or its dissociated protein products (tuberculins) can bring about the allergic reaction. The hypersensitiveness disappears when the original focus of infection is eradicated. Another infection occurring in such an animal acts like a first infection.

Clinically, the knowledge of the differences in tissue reactions to a first and second inoculation, that is, a primary infection and reinfection on allergic soil, is of first importance in the understanding of the diverse phenomena of tuberculous disease. Chronic tuberculosis is probably the result of the slow evolution of a first infection. Acute tuberculosis is never the result of a first infection, but always the expression of a reinfection from within or without. An acute tuberculous pneumonia is the result of the implantation of bacilli on the sensitized lung tissue of a patient who has an old lesion at the apex or in the lymph-nodes, etc. The acutely inflamed testicle, or joint, etc., which precedes the development of the characteristic clinical picture of chronic tuberculous orchitis or arthritis, etc., is an evidence of "the allergic reaction of bacilli on sensitized soil."

The Incidence of Tuberculosis.—Tuberculosis is the most wide-spread of diseases, being particularly common in northern countries, in civilized regions, and in great cities. Both men and domestic animals suffer from it, and it is occasionally met with in captive wild animals. It may even occur in cold-blooded animals. It is rare in savage races still spared to lead the lives for which they were intended, and is extremely rare in wild animals dwelling under natural conditions. Savage races suddenly subjected to the blighting influence of material progress die in hordes from tuberculosis. Wild animals placed in captivity are prone to die of it. The negro race if removed from the tropics or the subtropics to the temperate zone or farther north is predisposed to tuberculosis. The Hebrew race has become to a considerable extent immune to tuberculosis. For many generations Jews lived largely in the Ghettos of European cities, and those predisposed to tuberculosis died. The descendants of Jews of the Ghetto have a relative immunity. If a Jew becomes tuberculous, the lesion is apt to be slow in evolution, to be local, and to tend to cure.

Many people possess lesions of tuberculosis who present no clinical evidence of it. Careful necropsies, with microscopic studies and observations with the aid of tuberculin, prove this. The greatest death-rate of those infected is in childhood and early adult life (Burkhardt, in 1903, quoted by Hamman and Wolman in their book on "Tuberculin").

How many persons die of tuberculosis is a much debated point. Some writers claim that consumption of the lungs alone kills one-third of all that die; and if the deaths from various other tuberculous lesions are added to this, it will be seen what

an enormous part the disease plays in the mortality tables. Many observers hold that one-third of the human race suffer from tuberculosis, and that in every country the remaining two-thirds free from the disease are every moment in danger of acquiring it.

In discussing tuberculosis incidence the distinction between tuberculous infection and tuberculous disease must be kept in mind. Most human beings have at one time or other a tuberculous infection, that is, have tubercle bacilli lodge in the body. This infection usually dies out or remains latent. In most instances it does not eventuate in disease, that is, it does not give rise clinically to local or general manifestations of disturbance of structure or function. Tuberculous disease cannot happen without tuberculous infection, but tuberculous infection often occurs without tuberculous disease. The tuberculin test which reveals the presence of tuberculous infection shows that at maturity 80 to 90 per cent. of human beings have been infected. The sickness rate from tuberculosis is estimated at from 1 to 2 per cent.; that is, at any given time, 1 or 2 out of every 100 of the population have evidences of tuberculous disease. The death-rate from tuberculosis is approximately 1 in 10 deaths among whites, 1 in 4 among negroes, and 1 in 3 among Indians. In the United States 150,000 deaths a year are due to tuberculosis and the country contains at least a million and a half victims of the disease. Evans has maintained that of the 35,000,000 deaths that occur yearly in the world, 5,000,000 are the result of tuberculosis. The incidence of tuberculosis as a cause of death is decreasing in the United States. In the past ten years there has been a decline in the mortality rate of 39 per cent. in the United States registration area. In Philadelphia in 1913 tuberculosis led the list of the causes of death, in 1922 it was fourth, being preceded by organic heart disease, pneumonia, and kidney diseases.

Necropsy experience is fallacious according to Cornet (Nothnagel's "Encyclopedia of Practical Medicine"). This observer states that some pathologists have reported that in one-third of all necropsies tuberculous lesions are found; but that these statistics are obtained from institutions where only the very poor are cared for, and that the percentage of tuberculosis is vastly lower in the better classes of the community. The exact figures, however, are difficult to determine. It is certain that enormous numbers of people are affected with tuberculosis. I believe many affected ones recover, for Naegeli points out that almost all who perish after thirty from non-tuberculous conditions show healed lesions of tubercle. Of 420 adults, 391 (93 per cent.) showed signs of tuberculosis. Bollinger stated that in one-fourth of all post-mortems upon adults evidences of tuberculous disease are found at the pulmonary apices. Baumgarten asserts that one corpse out of every three showed a tuberculous focus, latent or healed. Tuberculin tests confirm the views of Burkhardt and Naegeli and contradict the opinions of Cornet. Franz injected 400 recruits who had passed their physical examination for the army, and 61 per cent. reacted. Von Behring maintains that all of us are "a little tuberculous." Practically every adult who has always been a town dweller has or has had tuberculous lesions. The lesion may have been cured or became latent, in fact, it may never have given rise to any symptoms. The infection of youth when it is cured or becomes latent serves to protect from the disease in adult life. It is a well-known fact that a child who recovers from a tuberculous joint is not apt to develop phthisis. The same is true of a case of cured Pott's disease of the spine and of cured glandular tuberculosis. In the European countries during and after the World War there was a great increase in tuberculosis not only in the armies but at home. In the armies we blame exposure, hardship, psychic tumult, wounds, and illness. In the people at home we blame improper or insufficient diet and depressing emotions. Many of the scheduled cases are supposed cured cases lighted into activity.

The Bacillus of Tuberculosis.—The tubercle bacillus was discovered by Robert Koch in 1882. It is a little rod with a length about equal to one-half the diameter of a red corpuscle. It is non-motile, does not form spores, and requires oxygen in order to grow, but it may obtain oxygen from body cells or fluids. Tubercle bacilli exist in all active tuberculous lesions. They may not be found in a tuberculous area, having once existed, but having died for want of nourishment. For instance, in a cold abscess they are frequently absent. Bacilli may be destroyed by a secondary infection, for example, by a pyogenic infection. Even when present, tubercle bacilli may be overlooked. Differential staining should exhibit the bacilli. Material from an active tuberculous lesion may not show bacilli, but injection of the tuberculous matter into a guinea-pig will be followed by the production of the disease, and in these lesions bacilli can be demonstrated. Bacilli may be widely distributed throughout the body.

It has long been taught that, in cases of acute miliary tuberculosis, they may be demonstrated occasionally, though seldom, in the blood. The bacillus of leprosy, the smegma bacillus, and the tubercle bacillus are similar, but not identical. Each is an acid-fast bacillus; that is, if stained with an anilin color, mineral acids will not wash out the stain. All acid-fast bacilli are capable of producing lesions that, to some extent at least, resemble tuberculous lesions; but the lesions produced by all, except the tubercle bacillus and the leprosy bacillus, tend to recovery. It is possible that all acid-fast bacilli are branches from a common stem.

The tubercle bacilli obtained from different animals differ considerably both in morphology and in virulence. Koch asserted, in 1901, that the bacilli of human tuberculosis differ radically from those of bovine tuberculosis, that human tuberculosis cannot be given to cattle at all, and that it is so difficult to transfer bovine tuberculosis to the human being that the danger from infected cattle is utterly trivial and may be disregarded. Ravenel and others have positively opposed this view of Koch's, and there have been reported what appear to be undoubted cases of the transference of tuberculosis from animals to man. Most writers believe that bovine tuberculosis and human tuberculosis are essentially the same, although the bacilli present temporary differences due to altered environment. The bacilli of bovine tuberculosis are certainly far less dangerous to man than are the bacilli of human tuberculosis, and the bacilli of human tuberculosis are vastly less dangerous to cattle than are the bacilli of bovine tuberculosis. Human bacilli introduced into cattle may produce chronic lesions, but they are always non-progressive. The histologic lesions seen in man and cattle are identical and so are the degenerative changes, and, as Baumgarten showed, tuberculous cattle react to tuberculin obtained from human bacilli.

Nocard reports 2 cases of individuals who wounded themselves while cutting the flesh of tuberculous cattle. Both developed generalized lesions and died. Ravenel strongly opposes the view of Koch and maintains that the bacillus of bovine tuberculosis is highly pathogenic for man ("University of Penna. Med. Bull.," xiv, 238, 1901). The same author has reported 4 cases of undoubted inoculation tuberculosis on the hands of veterinarians. Similar cases have been placed on record by other observers. The entire question is one of immense importance. If Koch is right, there is practically no danger to man in eating tuberculous meat or in drinking tuberculous milk. Most observers endorse the words of the report of the British Commission of 1911. This commission positively maintains that bovine tuberculosis can be communicated to man.

The bacilli of bovine tuberculosis, when they find lodgment in human tissues, are apt to produce local lesions and seldom disseminate, and vice versa. It has been proved that many cases of tuberculous cervical adenitis in children are due to bovine bacilli, In adults the bovine bacilli are not nearly so often responsible. Griffith ("Lancet," Feb. 10, 1917) shows that in children under ten years of age three-fourths of all cases of tuberculous cervical adenitis are due to bovine bacilli—that in persons between ten and twenty years of age bovine bacilli are responsible for one-third of the cases—and for one-fifth of the cases in those over the age of twenty. Fifty per cent. of cases of abdominal tuberculosis in children and 20 per cent. in adults are due to bovine bacilli. Many bone cases and a considerable number of joint cases in children depend on bovine bacilli, but very few in adults are so caused. Pulmonary tuberculosis very seldom depends upon bovine organisms. It is thus clear that human infection with bovine bacilli is most common in the young, and that surgical tuberculosis is far more apt to have such origin than other forms. Such infections frequently tend to spontaneous cure, although in some cases they become generalized and cause death by miliary tuberculosis.

Distribution of the Bacilli.—These bacilli are parasites, and not saprophytes; and the real source of infection is a tuberculous person or animal. Wherever there are tuberculous men or animals the bacilli get into the air. The number of bacilli that enter the air depends upon the number of animals affected, the seat of the tuberculous lesion in each, the care taken by the victims, and the control exercised by the community.

Tubercle bacilli from an infected individual may get into the atmosphere from the urine, the sputum, the feces, the sweat, the milk, or caseous or purulent material. The bacilli from dried sputum enter the dust, in which, fortunately, they are usually destroyed quickly by complete dryness, the fresh air, and the sunlight; but under some circumstances they may retain their virulence for weeks or even for months. The infected area itself is usually the direct source of the bacteria from a given case of tuberculosis, but this is not invariably so; for a tuberculous woman with a healthy

mammary gland may secrete milk containing tubercle bacilli, a consumptive free from genito-urinary tuberculosis may occasionally pass urine containing bacteria, a cow may give tuberculous milk when the udder is not diseased, and tubercle bacilli may enter the bile of a tuberculous patient. The Third Interim Report of the Royal Commission on Tuberculosis states positively that the milk of tuberculous cows may contain bacilli even when the udder is not diseased. It is probable that flies and insects may transmit infection (Lord, in "Boston Med. and Surg. Jour.," 1904, cli); and it is certain that putrefaction does not surely destroy tubercle bacilli. This is proved by the fact that living bacilli may be passed in the feces of an animal that has been fed on tuberculous meat, and that they may be found in the feces of an individual suffering from intestinal tuberculosis. We are thus justified in concluding that slaughter-house waste, if improperly disposed of, is a danger to the community.

Routes of Infection.—An individual may acquire tuberculosis by inhaling tuberculous material (*inhalation tuberculosis*), by swallowing tuberculous material (*ingestion tuberculosis*), and by inoculation with tuberculous material (*inoculation tuberculosis*). Infection of the lungs may be brought about by the inhalation of dried tuberculous sputum or dust carrying tubercle bacilli. Ingestion tuberculosis may follow the eating of tuberculous meat, the drinking of tuberculous milk, or the consumption of uncooked articles on which tubercle bacilli have gathered. It has been shown that the lacteals may take up tubercle bacilli from the intestine, even if there is no intestinal lesion; and that bacilli can pass through the thoracic duct and into the blood, and lodge in some tissue, particularly the pulmonary tissue, so inducing tuberculosis. They are apt to lodge at any point of least resistance; and if not caught up in the lungs, will tend to be arrested in an irritated gland or in some region that has been the seat of a trifling injury—for instance, in an epiphysis that has been strained. It is a peculiar fact that a trivial injury constitutes a point of least resistance; but a severe injury, such as a fracture of a bone, does not do so. Baumgarten was a strong believer in the idea that bacilli enter the organism with the food, and von Behring warmly advocated the same view, teaching that bacilli enter the organism of every person in early life. They may be destroyed by tissue resistance, but if not destroyed have a period of latency and, finally, perhaps after years, become active and cause the disease ("Deutsche Med. Woch.," Sept. 24, 1903). Calmette and Vanstenberg ("Annales de l'Institut Pasteur," 1906) have long insisted that infection is chiefly by the alimentary canal and that inhalation infection is rare. The great source of bovine bacilli is infected milk. Much milk supposed to be uncontaminated is infected. Fraser ("Jour. Amer. Med. Assoc.," Jan. 2, 1915) says that in Edinburgh from 15 to 20 per cent. of the milk samples contain tubercle bacilli. In Washington, D. C., out of 1538 cows furnishing milk to the city, belonging to 104 persons, 16.9 per cent. were tuberculous (Waddell in "Popular Science Monthly," Feb., 1917).

Every now and then from 60 to 80 per cent. of a herd will be found infected.

To get good milk the cow must be healthy and clean, the stable sanitary, the milking must be done outside of the stable, the milker as well as his clothing must be clean, the receptacles must be sterile, and the milk must be kept cool and protected from flies (Waddell, Ibid.).

It is certain that inoculation may be followed by tuberculosis. The inoculation of tubercle bacilli in the intestine may produce intestinal ulceration. It has been shown experimentally that rubbing the bacilli into the nasal mucous membrane may produce a local area of disease. Inoculation of the skin may result from a wound, the bacilli being carried into the wound itself. The victims of cutaneous inoculation are usually butchers, veterinary surgeons, physicians who have made postmortem examinations, and workmen who handle hides. In these cases, as a rule, an ulcer promptly forms at the point of inoculation; but in some few cases the wound heals soundly and tuberculous lesions develop in several or many weeks later in the wound area or in the neighborhood. In still rarer instances no apparent inflammation or ulceration occurs in or around the seat of inoculation, but the anatomically related lymph-glands become tuberculous. In other cases adjacent bone or an adjacent joint becomes tuberculous. Disease of the lungs may follow cutaneous inoculation.

A number of cases of inoculation tuberculosis have been reported. Not a few pathologists have developed anatomic tubercle (see page 177). Schmidt records a case of tuberculous ulcer on a woman's lip due to a bite from her tuberculous husband. It is recorded that a tuberculous person inoculated others while tattooing them, the needle having been moistened with saliva. Letulle's case of inoculation tuberculosis was a woman, who, while scrubbing the floor of the room in which her tuberculous

husband had died, ran a splinter into her hand. The wound became tuberculous. Bosanquet ("Lancet," Jan. 13, 1912) refers to a laundress who infected a whitlow with tuberculosis while washing infected linen. I have treated a physician who inoculated his finger while making culture studies with tuberculous material. In this case the axillary glands became tuberculous and were removed. I have also seen a tuberculous ulcer of the forearm in an attendant of a lunatic asylum who had been bitten by a tuberculous patient. Inoculation tuberculosis occasionally follows circumcision, as practised by an orthodox rabbi, the operator being tuberculous. A ritual operator (as Bosanquet calls him) stops bleeding either by applying his mouth to the wound, or by squirting wine from his mouth upon the wound. There have been reported apparent cases of direct inoculation of the genito-urinary tract during sexual intercourse. If there has been some definite injury of the tissues, inoculation may follow a simple rubbing of tubercle bacilli into a part.

When the mother's ovum is tuberculous the disease may be directly transmitted to the fetus, producing the condition known as congenital tuberculosis. Rosenberger found bacilli in the blood from the umbilical cord of the placenta of a tuberculous mother. This proves that congenital tuberculosis may exist even when the ovum is not known to be tuberculous, and also that a child born of a tuberculous mother is, if not immune to the bacteria, tuberculous from the moment circulation is established between embryo and mother. Baumgarten believes that bacilli may pass the placenta, enter the fetus, and remain latent for years. Latent bacilli have been found in normal lymph-nodes (Harbitz in "Jour. Infect. Diseases," vol. ii, 1904); this proves that latency is possible. A mother who presents no clinical sign of tuberculosis may be the victim of placental tuberculosis and placental tuberculosis may be responsible for fetal, miliary tuberculosis (C. V. Weller in "Arch. Int. Med.," 1916, xvii). However common the direct transmission of bacilli may be, the direct transmission of the disease is unusual, but the transmission of a hereditary predisposition to infection is not unusual. In spite of assertions to the contrary, I believe that there is such a thing as hereditary predisposition to tuberculosis. The experience of the human race uniformly confirms the belief in predisposition. In some cases of tuberculosis we can satisfy ourselves clinically as to the cause of the infection. For instance, when an individual is injured with an object known to carry tubercle bacilli, if an ulcer of the skin forms, and the adjacent lymphatic glands enlarge, the deduction is obvious. In other cases it is impossible to make up our minds as to the cause of a tuberculous lesion. For instance, we can only guess that a person has inhaled tuberculous material or has eaten tuberculous food. If in inoculation tuberculosis no lesion arises at the point of entry, the opinion as to the causation will be founded merely upon guesswork.

A tuberculous individual is thought to be a menace to the healthy. The more closely the healthy are hoarded with the unhealthy, the greater the danger. Fresh air and sunlight are enemies to infection, overcrowding, poor ventilation, dark rooms, and dust are allies of infection. The sputum of a victim of pulmonary tuberculosis brings danger to the healthy, hence kissing is a peril. Sputum which has dried floats in dust, lodges on food, lips, and fingers, will be inhaled, and will be taken into the gastro-intestinal tract. The same may be said of discharges from a tuberculous ulcer, gland, bone, joint, or anal fistula. The above facts are generally regarded as established. One might then infer, without further inquiry, that the wife of a tuberculous husband or the husband of a tuberculous wife would be almost certain to contract the disease. This has been the view of many clinicians, and when one partner develops the disease after the other, the condition is called *conjugal tuberculosis*. Fishberg ("Amer. Jour. Med. Sciences," March, 1917), after a careful study of many cases of phthisis, contradicts this view and says, "the simultaneous or consecutive occurrence of phthisis in husband and wife is extremely rare." In a study of 170 married couples in which one of the partners was tuberculous and who lived under conditions favorable to transmission of the disease, in only 5 were both husband and wife affected. Fishberg considers these few cases as coincidences, "analogous to cases of conjugal diabetes or cancer (cancer á deux)." I believe these statements are strictly correct when applied to partners both of whom are town bred (in other words, who had tuberculosis in youth, recovered from it, and resist reinfection). If the healthy partner was country bred she is prone to become a victim of the disease. Sir Malcolm Morris ("Brit. Med. Jour.," Nov. 16, 1918), in maintaining the thesis that our confidence in contagion as the sole cause has led us away from a study of antenatal and environmental influences quotes Pearson and Goring as follows: Familial infection receives little support from statistics. The mate of a tuberculous individual is no more likely to be

tuberculous than another person, at least among the poor. Higher in the social scale a tuberculous male is more apt to have a tuberculous mate, probably because sexual selection leads like to mate with like. A tuberculous father is twice as likely to have tuberculous children as to have a tuberculous wife. Children of tuberculous mothers are only slightly more liable to be tuberculous than the children of tuberculous fathers. Fishberg (Ibid.) says tests prove that "practically every person living in a large city has been infected with tubercle bacilli" during childhood, though he or she may not have been sick, and further, "tuberculous infection immunizes the individual against exogenic reinfection or superinfection with the same virus."

It seems certain that when the bacilli of tuberculosis enter into the body, if they are not destroyed by the body resistance, they may produce a local lesion at the site of inoculation, or pass to the nearest lymphatic glands or to some point of least resistance, and there establish disease. The first lesion is known as the primary focus, and from this focus disease may be disseminated to the most distant parts. The bacilli enter readily if there is a wound or an abrasion; but if rubbed in they may enter through unbroken skin and undamaged mucous membrane. Any structure may become tuberculous, but some structures are much more liable to do so than others. The lungs are very liable; the conjunctiva is very resistant.

The bacilli are generally distributed by the lymph, but may enter the blood. Those which do enter the blood may pass out in the urine or feces, may produce local lesions, or may induce advancing and wide-spread tuberculosis. Dissemination by the lymph-stream is known clinically to occur, and it means slowly advancing tuberculosis with localization of lesions. In dissemination by the lymph-stream, the dissemination is usually in the normal direction of the lymph-current; but if the lymph-vessels become blocked, lymph regurgitation may occur, and then the dissemination will take place in a direction opposite to the normal flow of the lymph-current.

Latent Lesions.—By a latent lesion we mean a non-progressive or a healing lesion which gives no clinical evidence of its progress. Such a lesion is most apt to be in a lung or in a gland. It may serve to furnish bacilli to distant parts and hence be responsible for secondary lesions. It may give toxin to the blood and thus induce distant trouble. The frequency of latent lesions becomes evident when we test apparently healthy adults with tuberculin. Although we state that a latent lesion causes no symptoms, we had better say presents no symptoms to suggest tuberculous involvement of the part. Hollos, of Hungary, insists that such an area contains toxin-forming bacilli, and that the poisons taken up from it by the circulation cause a chronic toxemia productive of numerous symptoms. Such symptoms are usually thought to be due to anemia or neurasthenia. This subject has been brilliantly discussed by Matas in the "Southern Med. Jour.," Oct., 1911. A lesion long latent may be awakened into activity by traumatism, by severe congestion, by overactivity of the part, or by depression of the general system. A latent focus in the lung may become active after etherization or such a focus in a joint may be lighted up by overuse or traumatism. A large dose of tuberculin may lead to spread of the process. An attack of bronchitis may break down the barriers which kept a tuberculous area from breaking into lung tissue. Numbers of examples could be given. It was a common experience in the World War to find latent areas of tuberculosis or areas supposed to be healed, become violently active. It is curious that gassing was not found to predispose the victim to pulmonary tuberculosis.

Products of the Tubercle Bacilli.—A great variety of products are formed by the tubercle bacilli, and among them we may mention alkaloids, toxalbumins, fatty acids, and ferments. Experimental injection of the toxalbumins produces inflammation; and of the alkaloids, fever. It has been shown by Maragliano that injection of the toxalbumins actually lowers the temperature. Beyond any doubt, the culture material in which tubercle bacilli are growing contains poison; and the bodies of the bacilli themselves contain poison. The poisons in the culture-medium are called *extracellular poisons*, and those within the bacilli are called *intracellular poisons*. It is quite probable that the former poisons are identical with the latter, and have merely passed from the bacilli into the culture-medium.

Tuberculin.—It was proved some time ago that dead bacilli are toxic and, if experimentally injected, will induce a toxic condition in the animal, cause inflammation of the kidneys, and sometimes produce subsequently cold abscess at the seat of injection. In 1890 Koch collected the poison from dead bacteria in the form of a liquid, which he called tuberculin.[1] A number of different methods for extracting such poison

[1] "Deutsch. med. Wchnschr.," 1891, xvii.

have been suggested; hence, there are a number of different tuberculins not one of which contains living bacilli. Koch has made several himself. His early tuberculin was made by making a glycerin-bouillon culture of tubercle bacilli, evaporating on a water-bath to one-tenth of its volume, and filtering out the dead bacilli. The filtrate contained tuberculin mixed with glycerin. It is now known as original or old tuberculin or OT. Later Koch prepared tuberculin from virulent cultures of bacilli, dried, ground up, and mixed with water, the fluid being centrifuged for forty-five minutes. When centrifuged, two layers separate. The upper layer, which is white and opalescent, contains the elements soluble in glycerin, is like the old tuberculin, and is called TO. The lower layer contains an emulsion of insoluble elements of high immunizing power, and is called TR. In 1901 Koch presented another tuberculin of dried bacilli in equal amounts of glycerin and water. It is called bacillary emulsion or BE. This is really a vaccine.

It was discovered by Koch that tuberculous animals are much more strongly affected by an injection of tuberculin than are healthy animals. The most positive reaction is noted in the tuberculous area; but, as a rule, there is also a reaction in the area where the injection was made. There is no reaction from the administration of tuberculin by the stomach,[1] but occasionally a reaction is obtained by the inhalation of the dried tuberculous material. If a moderate dose of tuberculin is injected into a non-tuberculous animal, there may be a trivial redness at the point of injection and a slight and temporary rise of temperature, or there may be no evidence whatever of a local or general reaction. An injection given a tuberculous animal, however, will be followed by distinct inflammation at the seat of injection, and a positive reaction in the tuberculous area. This area undergoes congestion or inflammation, leukocytes collect around it, and the part tends to necrosis and is liable to break down. It is not that the bacilli are killed, but, rather, the tissues containing the bacilli die.

In addition to the changes already mentioned there will be elevation of temperature. If the dose were small, there may be only a slight feeling of coldness to usher in the rise of temperature; but if the dose were large, there will usually be a distinct chill. This chill comes on eight to twelve hours after the injection and is accompanied and followed by elevated temperature. The fever lasts from four to twenty-four hours, and the temperature may be elevated from 2° to 5° F. The febrile condition is accompanied by pain in the head, limbs, and back, with increased rapidity of the circulation, restlessness, weakness, and usually nausea. As the temperature passes to normal all the symptoms disappear. The slight elevation of temperature which may be noted after tuberculin has been injected into a non-tuberculous animal is not ushered in by a chill, and does not exceed 1° F. unless a very large dose has been given. We thus note that the injection of tuberculin may be of the greatest possible value in diagnosis.

A person with a latent lesion may not, one with a thoroughly healed lesion does not, and a far-advanced case will not, react to tuberculin.

Much has been written on the reaction of non-tuberculous human beings to tuberculin. Such reaction is said to occur in leprosy, in convalescents from acute illnesses, in syphilis, and in actinomycosis. Many supposedly healthy people react to tuberculin. Some react to a moderate dose, some only to a large one. We are now convinced that the tuberculin reaction is specific and that any one who exhibits it possesses a tuberculous focus, active, latent, or healing. Reaction means infection, but not of necessity disease with clinical evidences. Very young children, especially infants, are very refractory to tuberculin because young children are seldom actively tuberculous.

A real, complete reaction to tuberculin has three elements:

1. A constitutional reaction manifested by fever.

2. A local reaction manifested by the indication of swelling and redness, a nodule, or an infiltrating area in the region of puncture (stick reaction). Sometimes adjacent glands swelling.

3. A focal reaction, that is, inflammation about the lesion. ("Tuberculin," by Hamman and Wolman.)

A good many observers have grown fearful of injecting tuberculin, believing that it is liable to cause the tuberculous focus to spread, or that it may actually lead to the development of disseminated tuberculosis. Virchow was of this opinion. That such a misfortune may follow the use of large doses seems certain, but moderate or small doses appear to be entirely safe. It is known that in a tuberculous animal certain excretions

[1] Latham and S. Solis-Cohen claim results from oral administration. Moller and Heinemann seem to demonstrate that those clinicians are mistaken, "Deutsche med. Woch.," Oct. 5, 1911.

(urine) and serous exudates contain tuberculin. Mérieux and Baillon show that if a tuberculous person is blistered the fluid of the blister, injected into a tuberculous animal, produces a definite reaction. A fluid containing tuberculin comes from the blister upon the tuberculous person and he is proved to be tuberculous by injecting the blister fluid into another tuberculous animal. Wildbolz, using a special method for concentrating the urine of a tuberculous person, was able to obtain more sensitive diagnostic reactions to the intradermic inoculation of the urine than with tuberculin. The auto-urine test of Wildbolz has been variously criticised.

Resistance of Bacilli.—Among the antagonistic elements we have mentioned oxygen, dryness, and sunlight. Moist heat, at the temperature of boiling water, is rapidly fatal to bacilli. A 5 per cent. solution of carbolic acid is one of the most powerful of germicides. Full-strength alcohol is next in point of power. Corrosive sublimate is not a satisfactory germicide. Formaldehyd is fatal only after long exposure. Iodoform and ether is a reasonably powerful mixture.

That the virulence of tubercle bacilli varies under different circumstances is sure. Under some circumstances they may be extremely powerful; under others, nearly innocuous. The liability to infection depends, probably, in part, on individual predisposition, and certainly, to a great extent, on the number and the virulence of the bacteria.

Immunity.—It seems likely that some persons are immune to tuberculosis. Such persons may come from an ancestral line in which all the predisposed died of tuberculosis, so that the immediate ancestors of the line were non-susceptible. As a race the Jews have a considerable degree of immunity. The tendency to immunity may be strengthened by proper marriages, and may be weakened by improper marriages; or immunity in a line may be destroyed by the continuance of unfavorable conditions. In health there are no antibodies lying in wait for tubercle bacilli and ready to destroy them. Antibodies can only arise when bacteria enter the blood or lymph, that is, when infection already exists. It is sometimes noticed that during the progress of a localized tuberculous infection a deep-seated tuberculosis (for instance, phthisis) improves. This exhibits a progressive development in the powers of the organism to resist infection by stimulation of the apparatus for opposing infection. That numbers of people get entirely well of tuberculosis is certain and that many tuberculous persons have secured prolonged immunity is probable. Paretic dements seem to possess a high degree of immunity to tuberculosis (Rosanoff in "Jour. Amer. Med. Assoc.," Feb. 13, 1909). Of course, the term "immunity" is only relative. No one can be absolutely immune; for when subjected to extremely unfavorable circumstances, or when multitudes of virulent bacilli are introduced, any one may become tuberculous. Attempts to create *artificial immunity* have been failures. Vaccination with living bacteria and vaccination with dead bacteria are alike unsuccessful. No method of specific immunization is known (Theobald Smith in "Jour. Amer. Med. Assoc.," March 10, 1917).

Von Behring sought to immunize cattle by giving living human bacteria by intravenous injection. This is called bovovaccination. It increases resistance for a time only. The human bacilli are relatively harmless to cattle and yet the method is not entirely free from danger to the animal. Reinfection of an animal harboring tubercle bacilli is difficult. The allergic reaction described on page 147 is an immunity phenomenon. Many adults are immune to reinfection because of latent lesions.

Predisposition.—Personally, I believe that there is such a thing as a predisposition toward tuberculosis, just as there is toward many other diseases. Such a predisposed individual possesses temporarily or permanently a condition of the body cells, body fluids, or both, that either makes easy the entrance of the bacilli or prevents strong opposition to their multiplication when they have entered. A person is predisposed to an infectious disease when the opsonic index is low, for this indicates lack of phagocytic power in the leukocytes. Predisposition may be increased by some extraneous circumstance, such as occupation, residence, etc., that brings the individual into frequent or prolonged contact with virulent bacteria.

There is certainly such a thing as antenatal tuberculosis, and any tissue may be involved in the antenatal trouble. The blood in the umbilical vein from the placenta of a tuberculous mother may contain tubercle bacilli. Tuberculosis, even in very early life, is not of necessity of antenatal origin. Young children may develop tuberculosis of the acquired form. According to Professor Behring, all infection dates from early life. Many children become infected with tuberculosis in their early years by the ingestion of tuberculous food; but such tuberculosis often remains latent for a considerable length of time, and then develops. Krause ("Nelson Loose Leaf Med-

icine," 1921, vol. i, 309) points out that the evidences of tuberculous infection are elicited with remarkable regularity soon after birth. From a number of studies in widely scattered localities he has compiled the average results as follows: During the first two years of life about 10 per cent. of children are infected, and at three years, about 15 or 20 per cent. From three to five years there is a big increase; from the 20 per cent. or so of infected children at three, the figures jump to 50 per cent. at five years. At six they read between 50 and 60 per cent. By fifteen they are 75 per cent. or even higher. From these figures it is evident that the infection does not follow a uniformly rising curve during childhood; an abrupt increase existing between three and six years. As Krause points out, this circumstance at once raises a number of questions regarding the soundness and validity of our prevailing ideas of tuberculous infection. Infants under two are surely larger and more frequently consumers of milk than are children between three and six. They are more confined to the house and are in more intimate physical contact with particular individuals than are the latter. They are the offspring or the close associates of just as many tuberculous individuals. Krause believes that contact with raw sputum is perhaps the commonest factor in the great incidence of infection between three and six years. At this age with the perfection of locomotion and introduction to the world at large, outside the home, the child's chances of infection greatly increase; for now it comes directly in contact with more people, but particularly the crude sputum of many people. By acquiring sputum on its hands and introducing the latter into its mouth, it establishes ideal conditions for infection, and conditions at large and the curve and character of childhood infection bear out the presumption that this method of infection is a common one. The theory "that all infection dates from early life should be accepted with caution and reserve" (Theobald Smith in "Jour. Amer. Med. Assoc.," March 10, 1917). It is very likely that frequent reinfections from without are not uncommon.

Do certain individuals possess a special predisposition to develop tuberculosis, and is this hereditary? Hereditary predisposition was once regarded as practically the only cause of the disease, but many thinkers now regard it as of slight importance, although I do not see how we can deny its existence. To do so is to run counter to the experience of the human race in all countries and at all times. We all see how common tuberculosis is in the descendants of tuberculous persons. Hutley studied 432 cases of tuberculosis. In 23.8 per cent. one or both parents had the disease (the father alone in 11.5 per cent., the mother alone in 9.9 per cent., and both in 2.4 per cent.). Some maintain that in 30 per cent. of consumptives, one parent or both parents have been consumptives, and in 60 per cent. a parent or a grandparent has suffered from tuberculosis. Of course, the above statements do not prove that the cases in a family are due to heredity; but that there must be such a thing as hereditary predisposition is indicated by the fact that there are many families living under similar conditions to the tuberculous families, without there having occurred, through several generations, a single case of tuberculosis among their members. A feature that makes us unable to reach a certain conclusion is that tuberculosis is contagious and several members of a family may be infected from one member even when there is no predisposition to the trouble by heredity. The mere living in one house may account for the infection. A fact strongly in favor of the hereditary influence is that in a family whose ancestors have been tuberculous and whose members have not lived together, but have been scattered widely over the earth, member after member may die of the disease. We know little about inheritance, but we do know that physical and mental resemblances, temperament, eccentricity, tricks of mind and body, aptitudes, predispositions, immunities, mental reactions, and aspirations may come to us by heredity. Why should a type of tissue possessing a weak resistance to tubercle bacilli not be born in us? Every dog breeder and stock raiser knows the importance of inherited traits. "It was Dennis O'Kelly's son of Eclipse who won the second Derby, and out of 127 races, including the first, Eclipse's descendants have furnished 82 winners up to 1906." If the influence of heredity is so manifest in a horse, why not in a man? (See "Eclipse and O'Kelly" by Theodore Andrea Cook.)

Unhealthy environment particularly predisposes to tuberculosis; and the element of poverty—leading as it does to taking improper or obtaining insufficient food, dwelling in an unhygienic room or in an overcrowded building, pursuing an exhausting occupation, working for long hours in a dust-laden atmosphere, and getting insufficient amusement and outdoor exercise—also has a most powerfully unfavorable effect. As a class the poor dislike ventilation, take insufficient exercise in the open air, do not get enough sunlight, work in a dusty atmosphere, take insufficient nourishment and eat

improper food, live in damp and dirty rooms, are subjected to grinding competition and cruel anxieties, and many of them drink quantities of whisky. City life is a predisposing cause of tuberculosis for many of the foregoing reasons, and particularly because many city workers follow indoor occupations. The enemies of tuberculosis are sunlight, fresh air, nourishing food, and outdoor exercise, and the limiting of any of these factors favors the development of the disease.

Tuberculosis may occur in any region that man inhabits; although in some regions it is rare, and in others it is excessively common. Its great frequency in some regions is probably due less to climate than to environment, occupation, and heredity; and the greatest predisposition is found in the town dweller. There is much more tuberculosis among males than among females.

Many diseases and conditions predispose to tuberculosis. It is very common in chronic drunkards, in the insane, in the occupants of prisons, almshouses, and reformatories; among negroes in the North, particularly those engaged in indoor occupations; among American Indians subjected to the blighting influences of civilization by formula and routine; and in the sufferers from tertiary syphilis, diabetes, and Bright's disease. Any exhausting malady may be followed by tuberculosis.

Relation of Trauma to Tuberculosis.—(See the author in "Annals of Surgery," June, 1914.) (Inoculation Tuberculosis is discussed on page 150.) This question is often in dispute and has become of much medicolegal importance. Several times of late, in the courts of Philadelphia, it has been the subject of acrimonious controversy. Suitors affirm the relationship, corporations deny it, and experts wrangle till judge and jurymen do not know what to believe.

There can be no doubt that tuberculosis often becomes manifest in a part after that part has been subjected to traumatism. No one denies this. In fact, in over one-sixth of all cases of bone and joint tuberculosis traumatism is set down as casual.

I do not mean that trauma causes the tissue changes characteristic of tuberculosis. Such changes are always and only produced by the action of tubercle bacilli. I do mean that the injury puts the part in such a condition that the bacilli of tubercle attack the injured tissue, having been unable to attack it when it was in a state of health. The injury creates an area of least resistance. In such an area the cellular activities are no longer able to withstand the action of bacteria. Without an injury it is highly improbable that tuberculosis would ever have arisen in the part. At least the injury determined the localization and multiplication of bacilli and the origin of an active tuberculous focus, and to this extent the injury was causal.

Acute osteomyelitis is due to pyogenic cocci. It may arise in a bone subjected to traumatism even when there is no surface wound. Traumatism is stated to be a cause. Why should a tuberculous process be placed in a different category? Where do the tubercle bacilli come from? Some maintain that if tuberculosis follows traumatism of a part, there was a latent and undiscovered tuberculous process in the part before the accident, and that all the accident did was to stir a latent focus into activity; in other words, to precipitate an inevitable event. This contention is true in some few cases; we believe it to be untrue in a large majority of cases.

Some believe that though there may have been no local latent focus, there is, at least, somewhere in the body an area of tuberculosis to furnish the bacilli. This view is true of many, but we do not believe of all, cases. It gains in probability from the established fact that tuberculous bone or joint disease is most apt to arise in those known to have tuberculous infection somewhere about them. It is certain that in many cases there is no demonstrable focus of tubercle anywhere to be found except in the injured part. It is hard to prove a negative, and it is impossible in any case to deny arbitrarily that an unrecognizable distant latent focus may exist.

We know, however, that many cases never give any sign of distant tuberculosis before the accident, and never give any sign of it afterward. We know that bacilli can exist for a considerable time in blood or lymph when there is no demonstrable lesion of tuberculosis. From such blood or lymph bacilli may be deposited in the injured part and become active for harm.

We know that bacilli may live for a long time in glands or bone-marrow without producing any evidence of a lesion of bone or of gland (Petrow, Lannelongue). If bone-marrow or gland containing bacilli is injured, these bacilli become active and establish an area of disease. Without the injury it is improbable that there would have been disease.

Local tuberculosis follows slight rather than severe injury. I have seen it after a strain of an epiphysis, never after a fracture. I have seen it after a sprain of a joint,

never after a dislocation. After a severe injury tissue reaction is so marked that bacilli are destroyed. It is particularly in bone and joint tuberculosis that traumatism is held to be causal. Whitman tells us that out of nearly 3400 cases occurring in the clinics of Bruns, Koenig, Mikulicz, and Hildebrand over 500 were attributed to trauma. I have seen a number of such cases, most of them involving the knee, foot, or wrist. I have seen tuberculosis of the glands of the groin arise after a bruise, tuberculous pleuritis and tuberculosis of the chest wall follow a chest contusion, and sacro-iliac tuberculosis follows a sprain. Tuberculous meningitis has followed head injury. I have seen several cases of tuberculosis of the testicle after contusion. When injury is followed by a tuberculous lesion, the definite signs and symptoms of that lesion do not appear for from three to six weeks after the accident. We may conclude that tuberculosis may arise at the seat of an injury; that in some cases there may have been an antecedent lesion at that point; in some cases there is a distant active lesion; in some cases a distant latent lesion; in some the bacilli must have been lying inactive in the part or must have lodged there from blood or lymph, after the accident and because of it. R. L. Dixon reported a number of such cases ("Physician and Surgeon," Jan., 1909). Hueter and Schüller insist on the tendency of trauma to localize tuberculosis. Ribera Y Sans (quoted in "Practical Medicine Series," vol. in Surgery, 1912, edited by John B. Murphy) states that in 45 per cent. of cases of tuberculosis of the larger joints the condition is preceded by trauma. In an appended note by Murphy we learn that that surgeon believes that tubercle bacilli tend to escape from the circulation at the site of a slight trauma and to light up disease. Bosanquet ("Lancet," Jan. 13, 1912) says that in expressing an opinion "as to the probability of a tubercular lesion being due to a preceding accident, I think we must put disease of joints in a class by itself. There is a considerable mass of evidence, that in some way or other injury does lead to tubercular arthritis, and if the occurrence of the accident is clearly established and it is followed at a reasonable interval by the tuberculosis, we may accept the causal connection as probable." He regards "a reasonable period of time" as not over three months. During the interval there should have been some pain in or stiffness of the joint.

The Term "Scrofula."—Many surgeons positively oppose the use of the term scrofula, but I believe that there is clinical value in retaining it. The surgeons that have entirely abandoned it think that, after all, it is exactly synonymous with tuberculosis. I use it to designate the persons that are predisposed to tuberculosis through possessing a type of tissue of low resisting power. These tissues fall a ready prey to the bacteria of tuberculosis. Such tissue vulnerability is usually hereditary; and, as a rule, one or even both parents are tuberculous, are in ill health, or are themselves predisposed. Occasionally this type of tissue is acquired, a child having at first been apparently entirely healthy, and later, owing to poor food, insufficient fresh air, and bad hygienic surroundings, developing scrofula.

That scrofula is not simply osseous, articular, or glandular tuberculosis is proved by the fact that a person that we recognize as scrofulous may never throughout his life develop a recognizable tuberculous lesion. Some surgeons think that scrofula is latent tuberculosis, and will, under the influence of an exciting cause, burst into activity. This is possible, but unproved. We do know that some so-called scrofulous lesions are not tuberculous; for instance, facial eczema, corneal ulceration, granular lids, and mucous catarrh. These lesions are rather expressive of poor health, improper food, and deprivation of fresh air.

The subjects of scrofula, besides being prone to the non-tuberculous lesions above mentioned, are particularly prone to develop tuberculous lesions; and such a lesion may arise in any part that has been the seat of a slight injury or of a non-tuberculous inflammation. The parts most apt to become tuberculous are the bones, the joints, and the glands.

There are two types of the so-called scrofulous, that is, two types of those that are obviously predisposed to tuberculosis. The common type is known as the *phlegmatic*, or *lymphatic;* and it is this type that was particularly described by our surgical forefathers. In the phlegmatic type the individual is stolid of expression, and has thick, coarse skin, a muddy complexion, dark, coarse hair, a thick neck, thick lips, a thick nose, and a heavy lumbering gait. He is dull of apprehension, with feeble emotional reaction, and but little capacity for concentration or interest. The other type is much more seldom met with. It is what is called the *sanguine type*, or what the elder Gross spoke of as the *angelic type*. Such a child is frequently beautiful and graceful in its movements. Its skin is transparent and clear, and the color comes and

goes. The eyes are blue, the lashes long, and the hair silky. The tendency is to bodily thinness, rather than fat, the mind is not dull, but precocious, and the temperament is nervous. In both these types of scrofula the condition of lymphatism exists.

Lymphatism, or the Lymphatic Constitution (Status Lymphaticus).—The term was introduced by Potain to designate a condition in childhood in which there is a very strong disposition to the development of disease of the lymphatic structures, or in which at birth there was excessive development of these structures. It is a hereditary condition particularly common in tuberculous families, characterized by "certain external peculiarities of configuration by hypoplasia of the cardiovascular apparatus, by hyperplasia of the thymus gland and of the lymphoid tissues in other localities, and, incidentally, by congenital structural defects in different viscera" (Douglas Symmers in "Amer. Jour. Dis. Child.," Dec., 1917).

Most of the cases we see are infants or children, but a number live to adult life. Of 118 "straight-forward" cases which came to autopsy in Bellevue Hospital, 29 were between sixteen and forty years of age (Symmers, Ibid.). In many of the cases the faucial tonsils, lingual tonsils, and pharyngeal follicles are enlarged. In most cases Peyer's patches and the solitary follicles are enlarged. In about one-tenth of the frank cases the axillary glands are enlarged, in about one-tenth the inguinal glands, and in about one-tenth the cervical glands. (See Symmers, Ibid.)

Of the 118 cases cited above, the thymus gland was enlarged in every case and there were 30 per cent. of them in which splenic enlargement existed. In 85 per cent. of them the Malpighian follicles showed hyperplasia.

In the retrogressive form of status lymphaticus the lymphoid tissue is undergoing retrogression. This condition is seldom met with in persons under twenty years of age (Symmers, Ibid.). Of this type 89 cases came to autopsy. In 19 of these the thymus was recognizable, though small, in the others it was replaced by fat. In 28 per cent. of the recessive cases the faucial tonsils were enlarged, in 32 per cent. the lingual tonsils were enlarged, and in 21 per cent. the pharyngeal tonsils. In 68.5 per cent. of cases Peyer's patches were atrophied and there was atrophy of the solitary follicles in 41 per cent. of cases. The spleen was normal in size or small in 71 per cent. of the cases.

Taking all of the cases, that is, 249, Symmers (Ibid.) found the heart small in 51 per cent. In 71 of the cases measurement showed an aorta lessened in caliber. In 31 per cent. of the cases there was increased elasticity of the aorta and in 26.5 per cent. of the cases the aorta was unnaturally thin. In these cases the cerebral vessels, central and meningeal, were very thin and were liable to rupture from slight force or simply from raised blood-pressure. The enlarged glands may become tuberculous. Inflammation of a mucous membrane is very apt to be followed by enlargement of the anatomically related lymphatic glands.

Lymphatic children frequently have rickets and are invariably anemic, yet there is considerable or much subcutaneous fat (Escherich). In infancy it is the bronchial and mesenteric glands that are particularly apt to enlarge; in childhood, it is the glands of the neck. The tonsils are enlarged in many cases and the nasopharynx in many cases contains adenoids. The spleen is sometimes palpable. In lymphatic children there is a persistent, in fact, a hypertrophied thymus gland. The gland, however, is not obvious, but rather hides at the root of the neck (Humphrey in "Lancet," Dec. 26, 1908), and may be missed at necropsy. During life the thymus is sometimes observed as a pulsating mass at the root of the neck. Even if it cannot be seen its presence can perhaps be determined by percussion and by the *x*-rays. In my experience the *x*-rays have been of little or no service in demonstrating enlargement of the thymus. The Mayos and Bloodgood reached this conclusion some time ago. In adult cases the thymus may be persistent, but is usualy replaced by fat. In about half the cases a goiter is obvious, and, as pointed out by Berg, many of those with goiter have symptoms of Graves' disease. As the child increases in age, the visible lymphatic enlargements are likely to disappear unless tuberculous infection has occurred. After a child has reached the age of seven or eight years non-tuberculous glands of the neck cease to enlarge, and by the time of puberty they have usually disappeared. Buxton ("Lancet," Aug. 6, 1910) states that young persons suffering from this condition are tall and thin; possess clear, fair, and pale skins; the temperament is blended, there is mental slowness, yet intelligence, there is shyness and strong self-feeling. I have seen victims of lymphatism who were not thin, but rather stout, gelatinous, pasty, and of a peculiar fish-belly pallor. They cannot withstand cold, are very emotional,

and yet may be able to appear calm. The pulse is normally 50 to 60, but is made rapid and irregular by trifling excitement. Norris, of New York, Neusser, of Vienna, and Douglas Symmers, of New York, have shown that certain structural peculiarities may identify the victims of lymphatism.

In a male subject the bodily conformation resembles that of the female. The beard in the adult is scanty or absent, the same is true of axillary hair. The base of the cluster of pubic hairs is transverse, the waist is narrow, the thighs are graceful and arched, the skin is smooth and soft. In the female the normal feminine attributes are accentuated (Symmers, Ibid.).

I am convinced that one type of the so-called scrofulous child is the victim of lymphatism (see the angelic type of Gross, page 157). The subjects of lymphatism are rather liable to hay-fever, urticaria, purpura, and particularly to tuberculosis. In some cases there are attacks of dyspnea which are spoken of as asthmatic seizures and which may be induced by going about horses or by taking an injection of horse-serum, or by the approach of a cat (cat fear). Bronchial asthma is expressive of hypersensitiveness to foreign proteins (see Sir A. E. Garrod in "Lancet," June 2, 1923). I do not believe that the conditions can be certainly diagnosticated during life. McCardie regards hypertrophied lingual follicles, and the existence of lymphoid masses in the wall of the pharynx, the pyriform sinus, and in the anterior surface of the epiglottis as significant of the existence of lymphatism. Status lymphaticus is particularly frequent in individuals with disorder of certain internal secretions (suprarenal glands, pituitary gland, thyroid gland)—in individuals called scrofulous—in neurasthenics and lunatics. Subjects of lymphatism seem particularly prone to alcoholic and drug inebriety and to suicide.

If an operation is performed on the victim of lymphatism the wound is very liable to become infected, and the bleeding from the wound is very trivial. In many cases of status lymphaticus there is a distinct liability to sudden death. This tendency is said not to exist in recessive cases. The victims of lymphatism are more apt than other persons to die under a general anesthetic, and occasionally one of them dies during natural sleep. Now and then a death occurs in a bath or while exercising actively. Death may follow so slight a procedure as vaccination. (See Dr. Geo. Blumer in the "Bulletin of the Johns Hopkins Hospital," Oct., 1903.) Cases have died from injection of diphtheria antitoxin. This disease accounts for most otherwise inexplicable cases of sudden death in children and young persons. It is generally held that such deaths are respiratory and not cardiac (Humphrey in "Lancet," Dec. 26, 1908), but some observers regard them as syncopal. It is no longer believed that the enlargement of the thymus causes death by pressure on the trachea. It is true that in such cases there is apt to be an enlarged thymus, but that is only expressive of the lymphatism and is not the cause of death.

One cause of sudden death is rupture of a cerebral blood-vessel and the rupture may be traumatic, or may be spontaneous, during an episode of high blood-pressure (Symmers, Ibid.). A central artery or a meningeal vessel may rupture. Very slight force may cause it. Symmers (Ibid.) asserts that anaphylaxis explains most sudden deaths among the victims of lymphatism. If sudden death occurs necrotic changes will be found in lymphoid structures, and, when such changes exist we know that nucleoproteins must have been absorbed during life. Symmers (Ibid.) goes on to say:

"Previous to the expiration of the so-called anaphylactic incubation period the lymph-nodes are subjected to the action of destructive substances which serve to bring about still further disintegration of germinal nuclei, thus providing the requisite quantity of specific protein to complete the anaphylactic reaction. The destructive substances in question may be introduced in the form of antitoxins hypodermically injected, or as vaccines applied by scarification or otherwise, or as substances derived from intestinal absorption, or manufactured in the process of shock induced even by such simple procedures as the prick of a needle, sudden exposure to cold, and a number of similar events. That apparently trivial and negligible affairs are sometimes attended by extraordinary physical or chemical revulsions is a recognized fact in medicine, and is illustrated, among other things, by the almost instantaneous jaundice which sometimes is occasioned by severe fright, so that the occurrence of equally remarkable reactions in status lymphaticus is by no means unprecedented."

The Diagnosis of Tuberculosis.—Whenever he sees a persistent area of chronic inflammation in any structure of the body the surgeon must think of the possibility of its being tuberculous. A thorough investigation must be made into the local disease and the body generally; and it is of particular importance to determine whether there

is any other obviously diseased locality, and whether there is any evidence of tuberculous disease anywhere in the body. The patient's history must be investigated, and any possible tendencies or predispositions inquired into. Tuberculosis does not cause leukocytosis except, perhaps, occasionally and moderately in tuberculosis of serous membrane, and even in this condition there is no increase in polymorphonuclear cells. A mixed infection causes only a trivial increase in polynuclear leukocytes.

In many cases of tuberculosis the diagnosis can be made from purely clinical investigation. This is the case, for instance, in many tuberculous ulcers, abscesses, and glands. In some cases the diagnosis can be made only by making differential stains of material obtained from the suspected focus, or by removing a section of the inflammatory area by Mixter's cannula, and studying it carefully under the microscope. Cultures should be taken from any material obtained from the suspected focus.

In unusually doubtful cases animal inoculation is necessary to make a diagnosis. The material is injected into a guinea-pig; and if the matter be tuberculous, the animal will develop miliary tuberculous within a few weeks. With apparently sterile fluid obtained from a tuberculous focus the disease can be induced in guinea-pigs by inoculation.

In a suspected case of tuberculous meningitis of the brain or of tuberculous disease of the membranes of the cord, the theca of the cord should be tapped (lumbar puncture), and the fluid obtained should be carefully examined. Of course, if in a case of tuberculous cerebral meningitis the foramina in the floor of the fourth ventricle have been blocked by exudate, no characteristic fluid will be obtained by tapping. It is usually found, however, that even in tuberculous cerebral meningitis there is increased tension of the fluid in the subarachnoid space of the cord, that this fluid is present in unnaturally large quantity, and that it is turbid through the presence of pus and lymphocytes. Sometimes it contains bits of fibrin and sometimes blood; and in many cases the bacilli of tuberculosis. Exploratory abdominal incision is sometimes necessary to determine the existence of tuberculous peritonitis.

The *x*-rays are of great aid in making a diagnosis of osseous, articular, and also of certain forms of pulmonary tuberculosis. The area of tuberculosis is lighter than the surrounding healthy structures when seen in a skiagraph.

The Tuberculin Test.—This test may sometimes be used to advantage in making an early diagnosis of recent lesions. Some physicians will not use it, believing that it is very dangerous, but it is safe if used cautiously and in proper cases. However tuberculin is used, it is much more reliable diagnostically in children than in adults. In many adults free from demonstrable signs of tuberculosis tuberculin gives a distinct reaction because many adults have encapsuled, quiescent, or retrogressive lesions of tuberculosis. Some conditions contraindicate its use, among them are the following: Addison's disease, recent pulmonary hemorrhage, and suspected bilateral renal tuberculosis (Hawes and Floyd in "Publications of Mass. Gen. Hospital," 1908). It should only be given when other diagnostic methods fail to give certain information, and is only to be used by a man trained in its use. Too large a dose may cause a severe chill, high fever, and great exhaustion, may arouse a latent focus to activity, and may actually cause dissemination of the disease.

The elements of the reaction following a tuberculin injection are:

1. Constitutional (fever, etc.).
2. Local (redness or nodule at the point of puncture).
3. Focal (inflammation at the seat of lesion).

If fever exists we never seek to obtain the constitutional reaction by an injection of tuberculin. The result would be misleading. We never inject tuberculin when there is mixed infection.

A temperature of 99.5° F. or over, when the patient is quiet in bed, contraindicates the employment of the test. The test should be used as directed by John B. Hawes and Cleveland Floyd (Ibid.). These rules are as follows: Koch's old tuberculin is used and the preparation must not be over two months old. One c.c. (100 mg.) of the material is drawn up in a pipet and is dropped into 10 c.c. of a ½ per cent. solution of carbolic acid. Each cubic centimeter of this solution contains 10 mg. of tuberculin; 1 c.c. of solution No. 1 is mixed with 9 c.c. of a ½ per cent. solution of carbolic acid. Each cubic centimeter of solution No. 2 contains 1 mg. of tuberculin.

One c.c. of solution No. 2 is mixed with 9 c.c. of the very dilute carbolic solution. Each cubic centimeter of solution No. 3 contains 0.1 mg. of tuberculin.

The patient is kept in bed for three days before beginning the test, and also during the test, and during all of this time the temperature is taken every two hours. The

injection is to be made at an indifferent point. The first dose is 0.1 mg. of tuberculin (1 c.c. of solution No. 3). If there is no reaction, wait for three days and then give 1 mg. (1 c.c. of solution No. 2). If No. 2 gives no reaction, wait three days and give 10 mg. (1 c.c. of No. 1 solution); if No. 2 gives a slight reaction, inject 5 mg. (½ c.c. of No. 1 solution).

We have previously described the tuberculin reaction; that is, the temporary local congestion or inflammation in the tuberculous area, and the chilly sensation or chill, followed by marked elevation of temperature (see page 153). The constitutional signs of reaction are chilly sensations or chills, sweats, skin eruptions, headache, pain in the back and joints, diarrhea, nausea, malaise, cardiac palpitation, and dyspnea. Hawes and Floyd regard even ½° F. of fever as significant of reaction if there are also constitutional symptoms and local signs. The focal reaction is the most important. In certain tuberculous lesions we can see the focal reaction; for instance, in lupus. In lupus the diseased skin begins to swell and redden a few hours after the injection. The reddened tissue may actually necrose. The ulcerated area becomes crusted. The swelling and redness disappear in a few days. In joint tuberculosis the skin over the joint becomes red. In a tuberculous ulcer of the mouth we can see the changes; and in a lesion of the larynx the laryngologist can observe them with the laryngoscope. By means of a cystoscope the focal reaction can be seen in a tuberculous ulcer of the bladder.

The tuberculin test should not be used in advanced pulmonary tuberculosis because it is unsafe. In advanced cases it fails to cause any reaction because the tissues are unable to produce antibodies when acted on by toxin (Hawes and Floyd in "Publications of Mass. Gen. Hospital," 1908). As a matter of fact, there is never any need of using the test in an advanced case, because the diagnosis is perfectly clear without it. We should never give extremely large doses in making the tuberculin test. If, after the careful use of tuberculin, there is no reaction, it is usually a safe conclusion that there is no tuberculosis. Because there is always danger of activating tuberculous disease when tuberculin is given in large doses for diagnosis, many men consider its use unjustifiable. Tuberculin in such small doses that the constitutional and focal symptoms are avoided is justifiable because the local reaction at the point of inoculation is without danger. Epstein in 1891 pointed out that the redness and swelling (local reaction) at the seat of injection constitute a specific reaction. The tendency is more and more to use as a diagnostic test the local rather than the constitutional reaction.

Various methods have been devised for obtaining a local reaction (ophthalmo-tuberculin reaction, von Pirquet's reaction, Moro's reaction). The local reaction is obtained without danger of dissemination of infection and can be used even if fever exists.

Calmette's Ophthalmo-tuberculin Reaction.—It was pointed out that when tuberculin is injected into a tuberculous individual a reaction arises at the seat of injection. It has been shown that if tuberculin is placed in the conjunctival sac of a tuberculous individual a reaction occurs, and this method is recommended by some because even a trivial reaction is easily observed. The introduction of tuberculin into the conjunctival sac is usually spoken of as Calmette's method. This test can be used even if fever exists and even if a skin eruption exists. It is not as satisfactory in surgical as in medical cases. The old tuberculin of Koch is used. It is carefully freed from irritant materials, a 1 per cent. solution is made in normal salt solution, and 1 drop of this is placed in the eye. Baldwin regards 1 per cent. as dangerously strong and uses ½ per cent. No constitutional symptoms develop, but in four or five hours, if the subject be tuberculous, the conjunctiva of the lids may become injected, the corneal vessels distend, lacrimation arises, and the lids may swell (Hawes and Floyd, Ibid.). The reaction attains its height in from twelve to twenty-four hours and disappears in from forty-eight to seventy-two hours after its first appearance. In a non-tuberculous person no redness, or only a trivial and temporary redness, is noted. There is never a constitutional reaction even in a case of advanced tuberculosis. Of course, this test is contra-indicated if there is a tuberculous lesion of the lids or eye, if there is ulceration of the cornea, or if conjunctivitis exists. I have never become convinced that the method is entirely free from danger to the eye, and I own that I rather fear to use it. Cases of permanent ocular injury are on record. Baldwin ("Jour. Amer. Med. Assoc.," Feb. 20, 1909) made over 1000 tests. He says that the test has some value in diagnosis, no value in prognosis, and as yet cannot distinguish "active or latent" from healed tuberculosis. He says danger to the eye is slight. I believe that a positive reaction indicates

the probable existence of tuberculosis and a negative reaction indicates the probable absence of that disease.

Von Pirquet's Cutaneous Tuberculin Reaction.—After the skin has been cleansed with alcohol 2 drops of old tuberculin are applied a short distance apart. The skin is then abraded or scarified between the drops and through each drop. The abrasion between the drops is a control experiment. The tuberculin is permitted to remain for ten minutes and is then wiped off. In a tuberculous individual local redness will appear in ten or twelve hours, and in twelve hours more the area will be swollen and perhaps edematous. This condition disappears in a few days, leaving, perhaps, as a legacy a trivial induration. There is very seldom a febrile reaction. This reaction is so sensitive that it does not indicate, except in children, whether a tuberculous area is active or latent. In an adult a negative reaction is a strong indication, though not a proof, that the patient is not tuberculous.

Moro's Cutaneous Tuberculin Reaction.—The material used is 5 c.c. of old tuberculin and 5 gm. of lanolin. It is rubbed into the abdominal skin and if the individual is tuberculous red papules or nodules or numerous vesicles appear in the area where the inunction was made. A severe or a moderate reaction will be noted within twenty-four hours. A slight reaction appears in from twenty-four to forty-eight hours. The eruption of a slight or a moderate reaction disappears in a few days. After a severe reaction the skin may remain red for several weeks. In suspected surgical tuberculosis Moro's reaction is generally used. There is no febrile reaction. A negative reaction is strongly indicative of absence of tuberculosis.

Animal Inoculations.—This method of diagnosis is so slow that it is seldom employed and only in unusually obscure cases. It is the certain method and it is eminently desirable that it shall be so improved that results can be obtained quickly.

Prognosis.—Many cases of tuberculosis are cured. This is indicated by the frequency with which we find healed tuberculous lesions in necropsies on individuals dead of other diseases. We reach the same conclusion from the clinical study of many cases. The prognosis of a single tuberculous focus, especially if it can be extirpated or sterilized, is very good; provided that the general health is good, that there is not much anemia, that the digestive processes are well performed, that mixed infection is absent, that there are no albuminoid changes in the viscera, and that the patient is able and willing to live the life that is necessary for his welfare. Unfavorable prognostic indications are inability to eat sufficient food, disturbance of digestion, deepening anemia, progressive loss of weight, high fever, and sweats. Of course, the prognosis is influenced by the patient's temperament, his willingness to brook control, his monetary status, mode of life, and his habits. The danger is greatly increased by multiple lesions. The dangers of mixed infection and of albuminoid disease have been previously discussed.

In very young children the prognosis is most unfavorable; but in older children it is very much better; in fact, it is better in them than in adults.

Tuberculosis of the skin gives a very fair prognosis; and glandular, bony, or articular tuberculosis is frequently recovered from; but, of course, any tuberculous lesion, however limited in area, is a profound menace.

Another fact to be borne in mind is that many cases apparently cured are not really cured; and that the disease may tend to reappear in the same region or in a near-by region, or to reappear later in another part of the body. We should further remember that in many cases in which there is apparently one lesion only, there are, in reality, distant lesions undiscoverable by clinical methods. In any case of tuberculosis the higher the opsonic index, the better the prognosis; the lower the opsonic index, the worse the prognosis.

Another important fact is that when an individual has a latent focus of tuberculosis, especially if this latent focus is in the lungs, should a surgical operation be performed for some other purpose, and the patient be kept in bed for a considerable length of time, the latent focus may become active. I have always believed that in latent pulmonary tuberculosis the administration of ether or chloroform might awaken the disease into activity. It therefore becomes evident that in such persons operations of necessity are the only ones that should be undertaken. Such an operation, if possible, should be done under nitrous oxid or a local anesthetic; and the patient should get up and get about again at the earliest possible moment.

Treatment.—One of the first thoughts of the surgeon is to provide against the contamination of healthy individuals by the infected. Any infected excretion or suspicious discharge from the patient must be disinfected at once, and dressings that are removed from the patient should be burned.

We are not in this section discussing the treatment of tuberculosis of the lungs, which belongs to the medical man. In cases of surgical tuberculosis, however, the patient may do better in some climates than in others; and the change, by stimulating the appetite and causing sleep and giving renewed hope, will be beneficial. In surgical tuberculosis climate is not the factor that it is in tuberculosis of the lungs; but if there is pure atmosphere, an equable temperature, and plenty of sunlight, the climate will lure the patient out-of-doors, and will thus be greatly to his advantage.

A life in the open air is the most essential thing in the treatment of surgical tuberculosis; but, as Professor Halsted pointed out, it is not of much use to tell a great many persons to live in the fresh air. They will not do it unless they are made to; and it is hard to make them unless they live in quarters especially built with this object in view. Therefore, other things being equal, if patients with surgical tuberculosis have the means, it is a good plan to send them to a sanatorium in the mountains or on the seashore, where they can obtain the persistent, unbroken life in the open air that is the cure of the disease. The patient should spend his days in the fresh air, and he should sleep at night directly exposed to the air; and if the atmosphere is free from dust and foul odors, so much the better. The poorer patients must get the fresh air at home if they cannot be sent to some camp or colony. From large cities adjacent to the ocean even poor people can usually be sent to the seaside for a short time at least. I am a very great believer in the beneficial effects of Atlantic City and other seashore resorts.

It is frequently necessary to operate on a tuberculous patient in a great city, although we operate much less than formerly for these conditions. If an operation is done in a great city, the patient is kept in the fresh air as much as possible during his convalescence. If it is feasible, he is sent away to a colony or sanatorium to recuperate. It would be an excellent thing if, in many of those cases in which operation is necessary, the operation could be performed at the seashore, camp, or the sanatorium. One advantage of the camp or sanatorium is that the patient is watched and regulated daily, and is led to do things that otherwise he would neglect. Many patients endeavor to avoid going out when they should go out because they are afraid of taking cold; many are simply neglectful; some are lazy and do not want to take the trouble to do it.

It cannot be too strongly insisted upon that in surgical tuberculosis fresh air is of as much importance as in tuberculosis of the lungs. It increases the vital resistance, it stimulates opsonic power, and it causes the patient to eat more nourishing food and to sleep better at night. Frequently we see children that have had sinuses for months get rapidly well when they adopt an open-air life; and, although albuminoid changes, when they once exist, will never pass away, further albuminoid changes may not take place if the patient lives properly.

A patient with surgical tuberculosis can have no more injurious environment than a dark, damp room, especially if it is in a crowded tenement and up a narrow court. The value of sunshine in glandular, articular, osseous, and cutaneous tuberculosis is beginning to be appreciated (*heliotherapy*). We know that it limits the growth of tubercle bacilli. It is not the heat that benefits the person, but all the rays, especially the chemical rays of sunlight. These rays have some germicidal influence, have considerable penetrating power, and seem to influence decidedly the nutritive processes. For countless centuries men have used the rays of the sun to disinfect clothing. We know that those who work and reside in sunless apartments are particularly liable to tuberculosis. Pasteur and Miguel demonstrated that Seine water during the day contains fewer bacteria than at night. Downes and Blunt ("Proceed. of the Royal Soc. of London," Dec., 1877) showed that both direct light and diffused light are bactericidal, and that the violet rays are the most efficient germicides. Strauss proved that an exposure of two hours to sunlight kills cultures of tubercle bacilli, and that an exposure of ten minutes kills the bacteria in smears of tuberculous sputum. Tuberculous joints, even when sinuses exist, are often much benefited by exposure to the direct rays of the sun. It is often advisable to expose the entire body except the head. Begin with a three-minute exposure and gradually increase it up to two or three hours. During exposure traction is usually maintained on the joint. This treatment is very valuable even in Philadelphia (a large city in the lowlands). It is especially valuable when used on the sea coast and in mountain regions. Excessive sunlight is, however, not beneficial. In summer it exhausts the patient and even in winter it produces eye-strain and headache. Major Woodruff, U. S. A., insists that excessive sunlight is actually harmful, particularly to blondes ("The Effects of Tropical Light on White Men"). Tuberculosis is dreadfully fatal in certain tropical countries and is more fatal to blondes than brunettes. Treatment by sunlight is

more valuable in winter than in summer, perhaps because cold stimulates respiration and because the winter sunlight is not debilitating. The ideal plan is to send a patient to a sanatorium in a high altitude where his whole body will be exposed to the sunlight while he is in the open air. Rollier follows this plan in Leysin. The method requires great care, but when used in accordance with directions improves metabolism greatly. (See Rollier's treatise on "Heliotherapy.") Rollier's plan cannot be followed in city hospitals. The altitude of all of them is too low. In Philadelphia during the summer the heat is so great as to forbid complete exposure to the sun except in the early hours of the morning, and all the year around the air is foul with irritating smoke and exhalations manifold. Few hospitals boast of a satisfactory solarium, and it is impossible to mingle the sexes nude. Were we to do so for health's sake we would be denounced by the very people who make no assault upon one-piece bathing suits and backless and almost frontless ball gowns. Artificial heliotherapy by the arc lamp is thought by some to be more valuable than by the sun's rays. The entire body is exposed for from half an hour to two hours and a half every other day.

The tuberculous structures require rest. We have long known how disastrous it is to confine a person to bed in a dark, ill-lighted, and improperly ventilated room. We can, however, confine a person to bed with perfect safety if there is a free flow of fresh air. We must confine certain cases to bed; for instance, cases of tuberculous peritonitis, and some cases of bone tuberculosis and of joint tuberculosis. A patient with tuberculosis who has fever ought to be in bed. We can put such patients to bed without any fear of the disease becoming worse or spreading if the supply of fresh air is plentiful and if the patient is kept warmly covered and wears a skull-cap. Of course, a draft is to be avoided. Patients that must be confined to bed do excellently in a tent, in a cottage sanatorium, or on a porch that has been altered for the purpose.

At the very first possible moment the patient should be sent out-of-doors; and in many cases of tuberculous disease (for instance, vertebral disease) the tuberculous part is supported by means of a brace or a splint.

We thus see the twofold nature of the modern treatment of surgical tuberculosis: rest for the tuberculous part and a life in the open air. Exercise is of importance also, although it should never be taken in excess. If the patient is confined to bed, he should be massaged and rubbed with alcohol, the tuberculous part being usually avoided. Forcible manipulation must never be applied to a focus of tuberculosis because it may lead to dissemination. Very gentle massage of a tuberculous part may do good. Wright has shown that it is followed by a reaction like that produced by tuberculin—a reaction due to the absorption of tuberculin from the seat of disease. If a person has fever he must not attempt active exercise, but must be confined to bed.

One should feed fully tuberculous patients if the stomach tolerates it, but not on any single article, or even on any particular one. The diet should contain a sufficiency of fats, proteins, and carbohydrates; and the food should be agreeable to the taste and readily assimilable. Otherwise, disgust will be engendered; and with disgust come indigestion and loss of appetite. The very life of the patient may depend on his remaining able to take a sufficiency of nourishing food. A bad cook may be a murderer.

There is no specific diet for tuberculosis, although many alleged specific diets have been suggested. One of the most valuable foods is milk, taken raw or mixed with other articles, such as lime-water or sodium bicarbonate, and frequently with brandy. Milk with cream is especially useful as the mixture is rich in vitamins. The use of an exclusive diet of boiled milk is to be deprecated, and in children it sometimes leads to the development of scurvy. Boiled milk is deficient in vitamins. Practically anyone can take milk if proper efforts are made.

Soft-boiled eggs are useful; and bread or toast should be eaten with plenty of butter, which is an agreeable form of fat rich in vitamins. Vegetables and fruits are desirable.

If the patient can take cod-liver oil without impairing his appetite or digestion, it should be given, provided the weather is not too hot. Cod-liver oil produces diarrhea in very hot weather. Children learn to take it very well. To many adults, however, it is, and remains, absolutely abhorrent. It was long thought that the chief value of cod-liver oil resided in the fat, and it came to be regarded as improbable that it contained any elements specifically antagonistic to tubercle. We are now sure that cod-liver oil is very valuable in cases of tuberculosis, and that it is useful particularly because it contains important vitamins. A highly purified oil is poorer in vitamins than a cruder product. If used, large doses should not be given, as they will not be digested. The common dose for an adult is a teaspoonful two or three hours after

meals. Thirty drops three times a day is usually given a child, and an infant should receive 15 drops three times a day.

We know of no drug or medicine that can with safety be used at the present time with any real hope that it will specially destroy tubercle. Drugs are, of course, given, but they are of secondary importance.

Tonics are used, and in children the syrup of the iodid of iron has considerable reputation. Remedies may be needed to improve digestion or control night-sweats, etc. I do not believe that beechwood creosote or carbonate of guaiacol internally, or iodoform inunctions, or painting the surface with guaiacol confers any real benefit in tuberculosis.

Alcohol is often required. It is not needed in all cases, but is in many. We should avoid it in children, however, unless there is a particular indication for its use. When a tuberculous patient is weak, milk-punch or egg-nog is of service; and in any case of mixed infection alcohol is required in full doses. If fever exists, and the administration of alcohol makes the pulse more rapid and the delirium worse, and causes flushing of the face, the dose is too large and should be diminished. Any patient that smells strongly of alcohol is getting an overdose.

Tuberculin in Treatment.—Many able investigators in many lands are striving to work out a safe and satisfactory specific treatment for tuberculosis. Landerer proved that immunity to tuberculosis can be produced in the lower animals by injection of living bacilli. We dare not practise this on human beings. Injections of tuberculin finally produce immunity to that product. The original plan of using tuberculin therapeutically was to obtain definite reactions again and again. This plan was founded on the belief that the reaction did the good and that cure might be obtained in this way in a few weeks. This utterly reckless plan was most disastrous, produced many deaths, and caused wide-spread distrust and final abandonment of tuberculin. Tuberculin treatment was not an error; the plan adopted was, as the material was given in large doses to any and all tuberculous patients. Just at present we are witnessing a revival of faith in tuberculin. The object now is to stop short of obvious reaction, believing that reaction is unsafe, as it may at any time get beyond control and do harm. Treatment is begun with very small doses which produce no reaction. Larger and larger doses are very gradually attained until immunity to tuberculin is established.

When an animal becomes immune to tuberculin the body cells resist and finally destroy the tubercle bacilli (Braun in "Boston Med. and Surg. Jour.," July 23, 1908). From six months to a year is required for the treatment. The essence of treatment is the very small dose and the very gradual increase, reaction being scrupulously avoided.

Many different tuberculins have been recommended. The best known ones are Koch's old tuberculin (O. T.), Koch's new tuberculin (T. R.), Koch's bacillary emulsion (B. E.), the bouillon filtrate of Denys (B. F.), von Ruck's watery extract, and bovine tuberculins. There seems to be no sound clinical reason for insisting on the use of any particular form of tuberculin. Bovine tuberculin does not seem more useful than human tuberculin in tuberculosis of the abdomen, glands, and liver, structures so often the seat of infection with bovine bacilli. Whatever form is chosen is given subcutaneously in the back and near to the skin, so that a local reaction may be quickly recognized. If after any dose there is even a slight elevation of temperature or even a trivial local reaction the dose must not be advanced until a like dose can be given without reaction. Loss of weight means that doses are too large. Judiciously small doses are entirely safe even when tuberculosis is complicated. One or two injections are given each week until the maximum dose without reaction is attained. The maximum dose when attained may be given at weekly intervals for months. Another plan is to reach the maximum dose, stop the treatment for months, and then start it again, beginning with the smallest dose.

The initial dose and the maximum dose of certain tuberculins are given in the following table taken from the valuable work of Hamman and Wolman on "Tuberculin." The dose is expressed in cubic centimeters instead of grams:

Tuberculin.	Initial Dose.	Maximum Dose.
O. T.	0.000,000,1 to 0.000,001 c.c.	1 c.c.
T. R.	0.000,001 to 0.000,1 c.c.	2 c.c.
B. E.	0.000,001 to 0.000,1 c.c.	2 c.c.
B. F.	0.000,000,01 to 0.000,000,1 c.c.	1 c.c.
Béraneck's	Of A132, 0.05 c.c.	Of H 1 c.c.

Wright gives very small doses of emulsion of powdered bacilli, not with the idea of causing directly body immunity to tuberculin, but to produce immunity by strengthening the phagocytic power of the leukocytes.

When Wright's plan is followed the dose is determined by the opsonic index, and the dose is only raised to a sufficient degree to establish the positive phase without producing even the most trivial subjective symptoms. One dose causes an increase of immunizing power in the body for about a fortnight, and then another dose is given. Many clinicians deny positively the need of giving the dose by the opsonic index. When tuberculin is given by either of the above plans it is entirely safe, and I believe, beyond doubt, is of value in suitable cases. It is not to be used in advanced cases or in febrile conditions. For lupus, tuberculous glands, tuberculous bones, or tuberculous joints one dose a week is given. It is of real service in these conditions, but general treatment must not be discontinued because tuberculin treatment is employed. It may be used after operation to prevent recurrence. When given in this way it is safe, never produces trouble at the site of injection, seems to arrest some cases of tuberculosis, improves the local trouble in many, and benefits the general conditions of most. According to Trudeau tuberculin strengthens the individual's immunity to tuberculosis. According to Wright it causes an increase in opsonins which were deficient. Tuberculin is of unquestionable value in some cases of lupus, in articular tuberculosis, and in glandular tuberculosis. It can be used in association with open air, Bier's hyperemia, heliotherapy, etc. Many clinicians advocate the use of tuberculin.

Serum Treatment.—Various serums have been prepared, but only two have been used at all extensively.

1. *Maragliano's Serum.*—Maragliano treats tuberculosis with the serum of immunized horses. The immunization is carried on for from four to six months by a mixed toxin. One element of the mixture is prepared from cultures a few days old, filtered and concentrated at a temperature of 30° C. while in a vacuum. The other element is extracted by water from virulent cultures, the bacteria having been killed. The aqueous extract is concentrated on a water-bath for three or four days at a temperature of 100° C. Maragliano believes that the serum contains quantities of antibodies and toxins, and that this highly agglutinative serum, when introduced into the human being, leads to the production of antibodies and toxins. The dose of the serum is 1 c.c. injected subcutaneously every other day for six weeks (Kolmer in "Infection, Immunity, and Specific Therapy"). Some observers believe in this serum, but most look upon its virtues as doubtful.

2. *Marmorek's Serum.*—Marmorek immunizes horses with young tubercle bacilli. When the horses have become immune he injects "pure cultures of streptococci obtained from the sputum of tuberculous patients" (Kolmer, Ibid.). The serum is given once a day subcutaneously (5–10 c.c.) or by rectum (10–20 c.c.). The value of the treatment is uncertain.

The Local Treatment of Tuberculosis.—When certain drugs are directly inserted into a tuberculous focus they possess an antagonistic influence. Iodoform is the most powerful of these drugs; guaiacol, balsam of Peru (Landerer), bismuth, and chlorid of zinc (Lannelongue) have a similar action. Some surgeons inject tuberculous nodules with camphorated naphtol. Iodoform has little or no influence when placed on a free surface exposed to the air, but when in the form of an emulsion it is injected into a tuberculous area, the air being excluded, this drug is powerfully antituberculous. Chlorid of zinc seems to act by causing the development of quantities of fibrous tissue, which encapsulate or, perhaps, replace the tuberculous focus. Every region of tuberculosis requires local rest, perhaps by the use of a splint or a brace.

Special Methods of Surgical Treatment.—The surgeon may endeavor to extirpate a tuberculous focus, or to sterilize the area and drain it. Extirpation is sometimes, although not very frequently, possible. Complete extirpation is a valuable method, but partial extirpation is dangerous. If a part only of a tuberculous focus is extirpated, many lymph-tracts and blood-vessels are opened; and the incomplete operation may lead to the dissemination of the disease. The methods of surgical treatment suited to different forms of tuberculous disease will be discussed in different sections of this book.

Bier's Method by Congestive Hyperemia (see page 44).—Bier believes that passive hyperemia is of the greatest possible benefit. Active hyperemia is obtained by heat, and is especially valuable to induce the absorption of the products of a non-tuberculous chronic inflammation. Passive hyperemia is particularly useful in tuberculosis of joints, tuberculous ulcers, cold abscesses, and tuberculous disease of the tarsus, carpus,

and phalanges. If a limb is affected, passive hyperemia is obtained by placing a rubber band around the limb above the part, the band being applied with sufficient firmness to interfere with venous return, but not so tightly as to block arterial entry. This band should be applied daily, and should be kept in place for an hour or so at each application, but pain should not be produced. In the intervals between the treatments the limb should be at rest. Bier uses special apparatuses for obtaining congestive hyperemia in various parts of the body.

I have seen cure or very great improvement follow this treatment in a number of cases. It is founded on the old idea of Laennec that cyanosis and tubercle are antagonistic. Why this method is beneficial is much debated. Some think that the imprisoned blood takes on increased bactericidal power; some, that the number of leukocytes is greatly increased; some, that quantities of leukocytes migrate; and some, that the amount of bactericidal blood-serum is increased. Bier believes that it depends upon phagocytosis. It would seem possible that the cells in this locality, under the influence of the congestive hyperemia, may form powerful antitoxins.

Heliotherapy.—(See page 163.)

The Finsen Light.—Finsen pointed out that the chemical rays in sunlight are powerfully germicidal, and that this germicidal power can be notably increased if the rays are concentrated on a part by the use of particular apparatus. He also showed that enormous numbers of chemical rays can be obtained from electric light. The Finsen treatment today consists in applying the actinic rays obtained from electric light. They act most powerfully on lupus, but require a very long time to effect a cure.

The *x*-rays are of value in treating certain tuberculous conditions. They are of most use in lupus, their effects in this disease being nearly as powerfully curative as those of the Finsen light, and much more rapid.

The **tuberculous abscess** is called also the *cold*, the *lymphatic*, the *congestive*, the *scrofulous*, the *strumous*, the *wandering*, or the *migrating abscess;* and it is very commonly called the *chronic abscess*. The Germans call it *Senkungsabscess*. Tuberculous abscess is the best designation, as this indicates the cause of the trouble.

The term "cold abscess" is often used because the cutaneous surface over the disease is not warmer to the touch than is the skin of the corresponding part of the opposite side of the body. The term "lymphatic abscess" was employed because it was once thought that such abscesses arose only from lymphatic structures. Scrofulous abscess was the name given it when scrofula was supposed to be a definite disease, a common phase of which was this form of abscess. The term "chronic abscess" is employed because the condition usually develops slowly, and does not present the evidences of acute inflammation; an acute pyogenic abscess developing, as a rule, rapidly, and presenting positive signs of inflammation. I agree with the late Professor Ashhurst that the term "chronic," in this connection, is improper, as it tends to give a wrong idea. It refers merely to time; and we know that a genuine pyogenic abscess that is deep seated may be rather slow in developing, and that a tuberculous abscess that is superficial may develop with considerable rapidity. When used properly, the term "chronic abscess" means that real pus exists, this pus having arisen from the pyogenic infection of the granulation tissue of a lesion of syphilis, tuberculosis, or actinomycosis. In other words, a genuine chronic abscess is secondary pyogenic infection of an infective granuloma. The terms "wandering," "migrating," "gravitating," and "congestive" have been used because the fluid products of a tuberculous inflammation are liable to wander a considerable distance away from the primary focus of disease. For instance, a tuberculous abscess that is discovered in the groin may have arisen from tuberculous caries of the vertebræ. This tendency to wander is not due to gravity, as one of the names of the condition would suggest; but the wandering always takes place in the line of least resistance.

It will be seen from the foregoing that a true tuberculous abscess is not an abscess at all, because it does not contain genuine pus. It is a collection of the degenerated products of tuberculous inflammation; and a tuberculous abscess may be defined as a circumscribed cavity of new formation, containing the degenerated products of a tuberculous inflammation. These products may have been formed in that region or may have passed to that point from some adjacent or distant focus of tuberculous disease. If a supposed tuberculous abscess is found to contain genuine pus, there must have been mixed infection with pyogenic bacteria; and such mixed infection either causes violent and dangerous inflammation or leads to the formation of a true chronic abscess, in which there is no sign of acute inflammation. The tubercle bacillus is not

pyogenic. It can produce inflammation, but not pus, and pus can be formed in a tuberculous focus only by secondary infection with pus bacteria.

Situations of Tuberculous Abscesses.—These abscesses are particularly apt to form as the result of tuberculous disease of bones, joints, lymph-glands, and subcutaneous connective tissue, but the brain, any viscus, or any tissue in the body may present the condition.

Age.—No age is exempt, but children are most prone to the trouble; and the period of greatest liability is before the age of twenty years.

Contents.—The usual terms for the contents are scrofulous, curdy, or caseous pus. As previously stated, it is not true pus, but it resembles pus when viewed by the naked eye. Examination of this fluid by staining methods, by cultures, and by inoculations shows that it contains no pyogenic bacteria. It consists of liquefied and caseated tubercle, masses of coagulated fibrin, and bits of necrotic tissue. The tuberculous material is whitish, yellowish, or yellowish green, thick, and without odor. Floating in this pus are portions of caseous matter, which, as the elder Gross said, resemble bits of soft-boiled rice. Occasionally the tuberculous material, especially if it comes from disease of a lymph-gland or of a bone, is almost watery and nearly colorless, and contains curd-like masses, consisting of tuberculous granulations, coagulated fibrin, and necrotic tissue. It was previously stated that tuberculous pus is free from odor. This is not true of tuberculous pus from the ischiorectal fossa, which is highly putrid; but in ischiorectal tuberculosis, as a matter of fact, there is usually mixed infection with pyogenic organisms, as well as with the organisms of putrefaction. If tuberculous pus is permitted to stand, the curdy mass settles to the bottom, and a thin serous fluid remains above.

Formation of Tuberculous Abscess.—The growth of tubercle bacilli in the tissues causes chronic inflammation. The cells of the tissues, especially the fixed cells, proliferate and form granulation tissue. This granulation tissue consists of multitudes of cell clusters, and each cluster is called a primitive tubercle (see page 146). Each individual tubercle enlarges; myriads of new ones form, and many of the old ones fuse. These new cells, however, do not become vascularized. In the earliest stage of their formation there are blood-channels, but these become closed through endothelial proliferation and through the pressure of cells external to them. The tuberculous area then becomes absolutely avascular. This avascular mass of cells is composed of what are known as epithelioid cells, and the cells obtain nourishment by imbibition. The nourishment is very incomplete. As the nodule enlarges the nourishment grows more and more insufficient. Finally, the adjacent blood-vessels that furnished the fluid for imbibition become occluded, and nourishment is no longer possible. The toxins of the tubercle bacilli, acting upon this area of greatly lowered nutritional activity, produce coagulation necrosis, and caseation follows this. The caseation begins at many points near the middle of the tuberculous nodule. Each area of caseation enlarges. Several of them fuse, and eventually many caseated areas coalesce. The tuberculous lesion may be spreading at the periphery at the same time that it is undergoing caseation at the center. The bacilli in the caseated material soon die for want of nourishment. When an area of caseated tubercle is liquefied by the addition of serum, what we call caseous or curdy pus is produced, and the lesion is then known as a tuberculous abscess.

The **wall of the abscess** is formed by compressed or solidified tissues. In a very recent case the wall is soft and will readily collapse. In an old case it is dense or actually fibrous and will not collapse. This wall of compressed tissue is not, as used to be thought, a pyogenic membrane which secretes the tuberculous material, but it actually surrounds the tuberculous material and hinders its diffusion. As Roswell Park says, it is not a pyogenic membrane, but it is a prophylactic membrane. The inner surface of the wall of the compressed tissue is lined with tuberculous granulations, which at different points show different stages of the tuberculous lesion. This layer of tuberculous granulations is known as *Volkmann's membrane.* The fluid in the abscess may contain a few living bacteria, but often none can be found; and certainly the bacteria are not multiplying in this fluid, but they exist in numbers and multiply in Volkmann's membrane. When tuberculous matter has been long retained and is thoroughly encapsuled the bacilli soon die for want of nourishment, and because a culture from a supposed tuberculous area fails to show the bacilli of tuberculosis we have not obtained conclusive evidence that the area is not tuberculous. We know this same fact to be true of the fluid of tuberculous empyema.

From the abscess wall there may be one, two, several, or many sinuses tracking

out. These sinuses are lined with granulation tissue exactly like the Volkmann membrane in the main abscess; and they may spread by a sort of crawling progression for long distances, perhaps passing through dense fascia, and at their terminations may form secondary tuberculous abscesses. The wall of an abscess may contain expansions or loculi. If an abscess spreads to some distant place, the tuberculous infection, of course, goes with it, and it is the tuberculous infection that causes the spread. Injury, breaking, or contusion of this granulation tissue, if unaccompanied with the removal of all the tissue or the killing of all the germs it contains, may diffuse the infective matter and actually cause disseminated tuberculosis. We sometimes see such dissemination after spontaneous opening, non-aseptic operation, or forcible squeezing; and particularly after an imperfect operation that removes only a part of the tuberculous area.

Terminations of Tuberculous Abscess.—The abscess may slowly and gradually enlarge, and finally open of itself, either on the skin or on the mucuous surface, or into some viscus or joint. It may become encapsulated by fibrous tissue, there being absorption of the fluid and shrinking of the entire focus, the caseous part perhaps remaining or becoming calcified. The tuberculous abscess may actually be replaced by fibrous tissue, and this constitutes a permanent cure. When the tuberculous area is merely encapsuled by fibrous tissue, some living bacilli may remain latent in the wall; and long afterward, as the result of injury or of some other damage, an abscess may reform at the old site of disease. Sir James Paget called this condition *residual abscess*. As a rule the abscess, as it shrinks, tends toward cure. The bacilli usually die for want of material to nourish them, but occasionally they remain latent for a long period of time. When they do die the tuberculous granulation tissue may become healthy tissue, be vascularized through the entrance of blood-vessels, and be converted into scar tissue. Tuberculous abscess may also be cured by a surgical operation.

Secondary Infection of a Tuberculous Area by the Bacteria of Suppuration.—This is liable to occur when the abscess undergoes spontaneous evacuation, and may occur when it has been opened by the surgeon. It occasionally occurs when the abscess has neither undergone spontaneous evacuation nor has been opened by the surgeon, having been infected apparently as a point of least resistance. When such infection does occur there is, in all probability, some area of ordinary suppuration elsewhere in the person's body, and the bacteria of suppuration have entered the body fluids. Pyogenic infection is apt to produce violent inflammation and profuse suppuration—a condition that is extremely dangerous because septicemia is very liable to develop. In some very rare cases suppuration destroys the tuberculous area and cures the tuberculous disease. More commonly, however, it produces illness, and in large abscesses it may cause death. Because of this liability to secondary infection surgeons were long opposed to operating on tuberculous abscess unless it was evidently going to evacuate itself. In some cases secondary infection produces a true chronic abscess (see page 167). Infection by streptococci is much more dangerous than is infection by staphylococci. Acute inflammation with dangerous constitutional symptoms is particularly apt to arise if the walls of the abscess contain very little tuberculous tissue, if they have been bruised or damaged by powerful chemicals, if there is poor drainage (and there is certain to be poor drainage if loculi exist, or if the incision is small and blocked with plugs of fibrin or necrotic tissue), if a partial or imperfect operation has been performed, if a number of virulent bacteria have been introduced, or if the vital resistance is at a low ebb.

Secondary Infection by the Bacteria of Putrefaction.—This complication is extremely grave and may produce death. It is commonly associated with pyogenic infection. The wound fluid becomes intensely putrid, violent acute inflammation arises, and the absorption of materials from the wound induces the systemic condition known as sapremia or putrid intoxication.

Signs and Symptoms of Tuberculous Abscess.—A purely tuberculous abscess presents no evidence of inflammation except swelling; and, owing to the absence of heat, it has received its name of cold abscess. The cutaneous surface looks and feels normal or is paler than normal until the structures just beneath the skin or the skin itself becomes involved. When this happens, livid discoloration appears, but the lividity presents a very different appearance from the dusky discoloration of an acute abscess. Neither is the skin edematous or glossy as it is in acute abscess.

There is rarely tenderness in the region of the abscess, and still more rarely spontaneous pain. Pain and tenderness, although frequently absent in the area of a tuberculous abscess, may be complained of at the primary focus of disease. Tenderness is especially likely to be noted at the primary focus; and in cases of joint tuberculosis

and of bone tuberculosis it is nearly always present. There may or may not be pain at the primary focus, but referred pain is frequently complained of. For instance, in tuberculous disease of the hip-joint the pain may be referred to the inner side of the knee; and severe bellyache is frequently observed in Pott's disease of the spine. At the point to which pain is referred, however, there is seldom tenderness. For instance, in the bellyache, particularly of Pott's disease of the spine, the belly is not tender, although the spine may be. In sacro-iliac tuberculosis the pain is often referred to the distribution of the sciatic nerve, but the nerve is seldom tender on pressure. In a psoas abscess we find that pain in the spine can be induced by pressing on the spinous process of the diseased vertebra, by concussion to the heels or the head when the spine is held stiff, and especially by flexion of the spine; but the spinal pain is lessened or completely abolished by extension, fixation, and rest. The primary focus of disease, if spinal or articular, produces rigidity in the adjacent muscles, and rigidity secures rest by inhibiting movement, but it also impairs the function of the part. In an intra-abdominal tuberculous abscess there is rigidity of the abdominal muscles.

In a tuberculous abscess fluctuation is usually obtained readily, because the fluid is not surrounded by a thick mass of granulation tissue and also because a considerable amount of fluid is usually present. A notable characteristic of a tuberculous abscess is the tendency to wander, and it may appear with suddenness at some distant point. Abscesses of the spine wander long distances, but the wandering is not the effect of gravity, and is due to the disposition of the tuberculous matter to travel in the line of least resistance. The temperature of the body may be entirely normal if the infection is purely tuberculous. As a rule, however, there is a slight evening elevation; and the patient is weak and pale, grows tired readily, sleeps poorly, and has a wretched appetite and impaired digestion. The blood examination sometimes shows a notable diminution in the number of red blood-cells, and the hemoglobin is usually lowered to 60 or 70 per cent. There is no leukocytosis. In multiple tuberculous foci, and particularly in tuberculosis in children, there is a marked decrease in the red blood-cells. If secondary infection occurs, there is a rapid and progressive diminution in the number of red cells and usually a trivial increase in polynuclear leukocytes.

A tuberculous abscess underneath the deeper fascia may break through the fascia by making a small opening, and a large secondary abscess may arise in the subcutaneous tissue. The entire abscess is thus shaped like an hour-glass, the opening through the fascia being the narrowest point. Such an abscess is called a *shirt-stud abscess*. A tuberculous abscess is liable to form one, several, or many sinuses, and the end of each sinus may expand into a secondary abscess. The surgeon must always make a careful examination to try to determine whether the abscess is the primary disease focus or whether the tuberculous matter has wandered from a distant point. He must also make a thorough examination to see whether anywhere in the body there are other regions of disease. He will often find such a region of disease; for instance, in the lungs. In many cases, however, there is no clinical evidence that other areas of tuberculous disease exist.

A tuberculous abscess arising deep in the tissues usually requires weeks or months to reach the overlying skin or mucous membrane and undergo spontaneous evacuation. That spontaneous evacuation is imminent is shown by livid discoloration and thinning of the skin. Finally, at the area in which the skin is thinnest a little tit is elevated. This condition is known as pointing, and a rupture occurs at this point, tuberculous pus running out. Spontaneous evacuation is a peril because it is liable to be followed by secondary pyogenic or putrefactive infection. After spontaneous evacuation has occurred a true chronic abscess may form; but, instead, there may be violent acute inflammation, manifested locally by pain, heat, and dusky discoloration. If acute inflammation does arise there develops a fever, which presents evening exacerbations and morning remissions, and is accompanied by exhausting sweats during the night or early morning. Fatal septicemia or sapremia may follow spontaneous evacuation.

Results of a Tuberculous Abscess.—It may undergo spontaneous cure, and the cure may be lasting, but long after an apparent cure a new abscess may form (the residual abscess of Sir James Paget). A tuberculous abscess may remain stationary for a very long time, and then perhaps diminish in size and be cured, or extend in size and rupture. After spontaneous rupture suppuration may cure the tuberculous area by annihilating the tuberculous tissue; but, as a rule, after spontaneous rupture there is either an acute septic process or a chronic suppuration, constituting a genuine *chronic* abscess.

Amyloid Disease.—The pyogenic infection of an area of chronic tuberculosis, especially of a bony area, if it induces long-lasting suppuration, may lead to the development of *albuminoid*, *amyloid*, *waxy*, or *lardaceous disease*. Pyogenic infection of a tuberculous area, though by far the commonest, is not the only cause of amyloid disease. It may arise when there has been no pyogenic infection of the tuberculous area. It may arise after prolonged ordinary suppuration. It may follow bone syphilis, and may be due to cancer, Bright's disease, malaria, chronic dysentery, or prolonged lactation. In this condition a peculiar material is deposited in the middle coats of the smaller arteries and later the inner coats are involved. The albuminoid substance resembles fibrin and there has been much dispute as to its nature. One theory is that this deposit takes place from blood-serum which has been dealkalinized because the flow of pus has removed potash salts from the blood. Krakow seems to have demonstrated that the albuminoid material is a combination of chondroitin-sulphuric acid and histon. This acid, carried by the blood or lymph, "combines with a protein of the fixed tissues" (W. Taylor Cummins, "Proceedings of Patholog. Soc. of Philadelphia," Dec., 1910).

In rare cases this deposit is only a local mass. The corpora amylacea of the prostate and nervous structure are due to albuminoid deposit. Such a deposit may take place directly in a tuberculous focus or a syphilitic lesion.

In the vast majority of instances the disease is general, involving blood-vessels, the membrana propria of mucous membranes, the liver, the kidneys, and especially the spleen. The lymph-glands, tonsils, stomach, intestines, heart, and connective tissues are less often involved. The amyloid material is deposited between the cells and not in them. The tissues of a subject of amyloid disease are very prone to suppurate from even slight infection.

In all or nearly all cases the spleen is involved. The victim of general albuminoid disease is pale, greatly exhausted, emaciated, and very anemic; suffers from diarrhea and usually develops capillary hemorrhages beneath the skin and mucous membranes. The albuminoid material can be detected chemically in the urine if the kidneys are involved. Albuminoid degeneration is incurable and is usually fatal; but if the patient is subjected to proper treatment soon after it begins it may be arrested and never progress.

Diagnosis of Tuberculous Abscess.—The fluctuation, the absence of evidences of acute inflammation, the tendency to wander, and, in some cases, the sudden appearance, mark the diagnosis. The surgeon always examines with care to see whether there is some distant tuberculous focus from which the abscess may have wandered, or whether the abscess itself is at the primary seat of disease. The advancing impairment of the general health, the diminution of red corpuscles, the lessened amount of hemoglobin, the normal or almost normal temperature, and the absence of leukocytosis are points in the diagnosis of the condition. In a doubtful case the aseptic use of the tubular exploring needle is important, the fluid that emerges being studied by the microscope after staining, by cultures, and perhaps by inoculating it into guinea-pigs. The fluid that is withdrawn may contain no bacteria that can be demonstrated; but if it is sterile, one should strongly suspect tuberculosis. Various diagnostic tests for tuberculosis will be found on pages 160–162.

Prognosis.—Advanced albuminoid degeneration makes the prognosis of tuberculous abscess hopeless and any extent of albuminoid degeneration is ominous. Secondary pyogenic infection, as already stated, may produce death or a lingering suppuration. The prognosis is worse in very young children than in adults, but in older children is better than in adults; and in any case it is unfavorable if the victim cannot or will not follow rigidly a proper plan of open-air treatment, if the exhaustion deepens, if the anemia is marked, if there are tuberculous lesions in distant parts or in important organs or structures, if the patient is unable to take enough food or if he cannot digest what he does take, and if the regions of tuberculosis cannot be extirpated or sterilized. Under other circumstances the prognosis is favorable.

Tuberculous Abscesses in Various Regions.—Tuberculous abscess of the head of a bone (see also Brodie's Abscess, page 455) arises in the cancellous structure of a long bone, most often in the head of the tibia, and is frequently noted as having been preceded by a trivial traumatism. The focus of tuberculosis seldom induces severe symptoms unless secondary pyogenic infection occurs. A tuberculous nodule forms as a result of tuberculous osteomyelitis. The bone about the nodule is hyperemic, the bony trabeculæ are thickened, and the cancellous spaces "are devoid of fat cells, and they contain a swollen semifibrous material" (Warren's "Surg. Pathol."). The

center of the nodule becomes cheesy, the bone trabeculæ are absorbed, and the bone becomes cheesy and broken up, the cheesy mass containing bone fragments. Finally the area becomes filled with tuberculous pus, the cavity which contains it being lined with tuberculous granulations. Distinct sequestra may form and the bone about the diseased focus may undergo sclerosis. In tuberculous abscess of bone pain is continuous, but is not usually very severe, is of a boring character, and is worse when the patient is in bed. Attacks of synovitis arise from time to time in the adjacent joint. The bacteria of tuberculosis obtain access to the bone by means of the blood, and find in the bone a point of least resistance. There is no such thing as an acute abscess of bone. A pyogenic inflammation, of such severity as to cause an acute abscess in soft parts, in bone causes acute osteomyelitis. A less violent pyogenic infection causes a very chronic suppuration.

Retropharyngeal or **postpharyngeal abscess** is often tuberculous. Such an abscess is usually due to caries of the cervical vertebræ, but can arise in the connective tissue of the parts or as tuberculous adenitis. An abrasion of the mucous membrane may admit the bacilli to the connective tissue or the glands. A swelling projects from the posterior pharyngeal wall, and there is great interference with respiration and deglutition. Caseous matter from caries of the cervical vertebræ may reach the posterior mediastinum by following the esophagus, or may appear in front of or behind the sternomastoid muscle in the neck (Edmund Owen). A tuberculous abscess back of the pharynx is apt to undergo pyogenic infection in which case the patient develops fever, sweats, pain, and prostration.

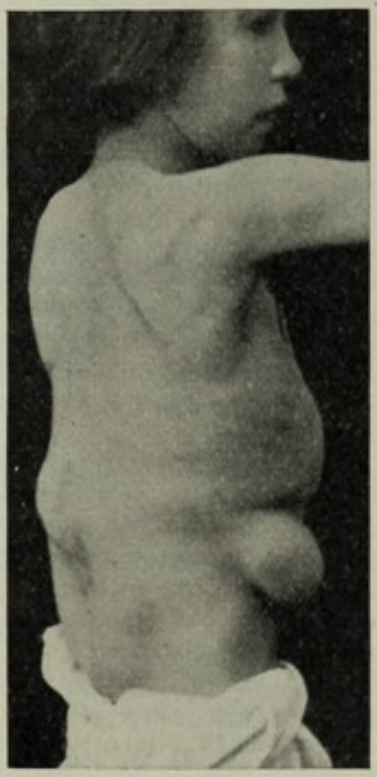


FIG. 66.—Dr. Arthur J. Davidson's case of psoas abscess.

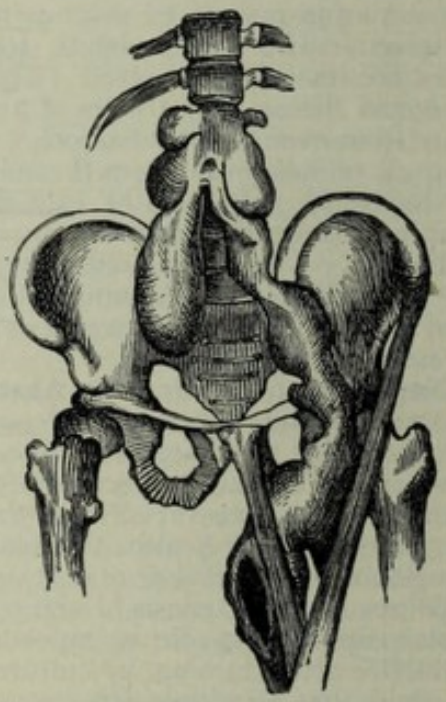


FIG. 67.—Psoas abscess (Albert).

Dorsal Abscess.—The tuberculous matter in dorsal abscess arises from dorsal caries, flows into the posterior mediastinum, and reaches the surface by passing between the transverse processes. The tuberculous matter from dorsal caries may run forward between the intercostal muscles or between these muscles and the pleura, pointing in an intercostal space, at the side of the sternum, or by the rectus muscle. It may burst into the gullet, windpipe, bronchus, pleural sac, or pericardium. It may descend to the diaphragm and travel under the inner arcuate ligament to form a psoas abscess, or under the outer arcuate ligament to form a lumbar abscess. A psoas abscess may point above Poupart's ligament or in the lumbar region. If it extends below Poupart's ligament it usually points external to the femoral vessels (a characteristic which is said to distinguish it at once from an ordinary femoral hernia), but may burrow in any direction.

Iliac abscess arises from lumbar caries, the swelling lying in the iliac fossa and pointing above Poupart's ligament.

Psoas abscess (Fig. 66) is usually due to lumbar caries, but may arise from dorsal caries. The fluid usually points in Scarpa's triangle external to the femoral vessels, but may descend much lower (Fig. 67). A psoas or iliac abscess, by following the lumbosacral cord and great sciatic nerve, forms a gluteal abscess. Psoas abscesses may open into the bowel, bladder, ureter, or peritoneal cavity. A hernia is almost never mistaken for a psoas abscess, but a psoas abscess is sometimes mistaken for a hernia (Fig. 68). J. Torrance Rugh points out that without a search for spinal kyphosis or muscular rigidity the mistake may be made, but that the presence of a mass in the iliac fossa continuous with the external lump eliminates the possibility of the condition being hernia.

Lumbar Abscess.—In a lumbar abscess the fluid produced by dorsal caries descends beneath the outer arcuate ligament, or the fluid from lumbar caries which collected anterior to or in the quadratus lumborum muscle passes between the last rib and iliac crest in the triangle of Petit, the small space bounded by the crest of the ilium, the posterior edge of the external oblique muscle, and the anterior edge of the latissimus dorsi muscle.[1]

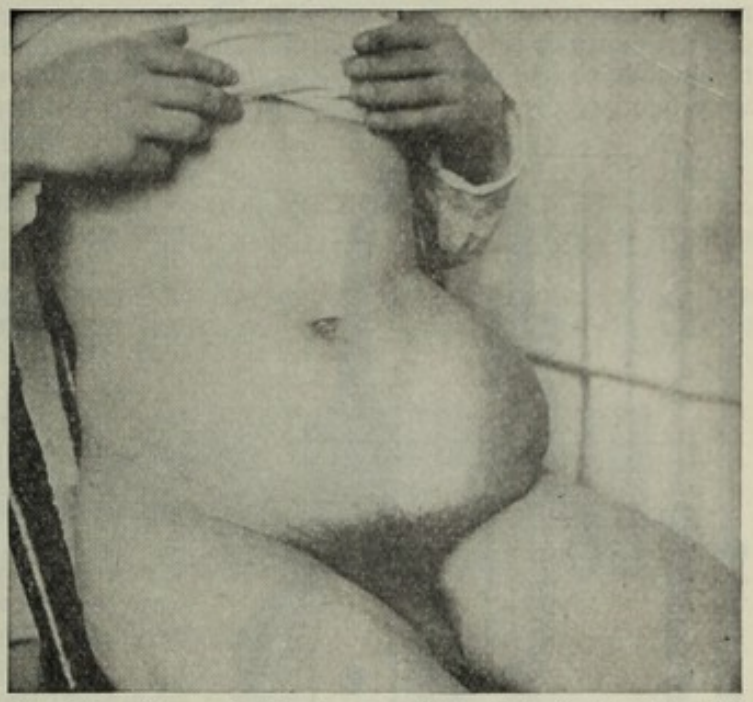


FIG. 68.—Case of cold abscess of the abdominal wall which had been treated as a hernia.

Tuberculous abscess of the neck results from tuberculosis of the cervical glands. It is not often that such an abscess attains any considerable size. It tends strongly to spontaneous rupture, and, if this is permitted to occur, a livid, corrugated scar results.

Tuberculous Abscesses of Joints.—(See page 585.)

Tuberculous Abscess of Rib.—It is not uncommon to find a tuberculous abscess of moderate size about a tuberculous rib. The pleura may become involved secondarily.

Tuberculous mediastinal abscess may result from the downward passage of a cervical abscess; from tuberculosis of the sternum, ribs, vertebræ or pleura, or from tuberculous mediastinal glands.

Tuberculous abscess of the breast (see page 1413) is a caseated and liquefied area of tuberculosis of the mammary gland. A lump is detected, which slowly enlarges and finally ruptures, sinuses being formed. The axillary glands are apt to be implicated. The patient may belong to a tuberculous stock, as a rule gives a history of previous tuberculous troubles of various sorts, and has usually borne children. Tuberculous abscess of the breast causes little or no pain.

Treatment of Tuberculous Abscess.—For many years the majority of surgeons would not open a tuberculous abscess unless it was on the point of rupturing. With the advent of antiseptic surgery it was assumed that aseptic incision and drainage would be the proper treatment for these cases; but the results, except in small superficial tuberculous abscesses, have been extremely disappointing. If a large abscess is so treated, pyogenic infection will, in all probability, sooner or later occur, with all its possibilities of disaster. Incision and drainage is the treatment for small and superficial abscesses.

Treatment of Small Superficial Tuberculous Abscesses.—The surgeon must remember that after one has opened an apparently superficial abscess it is his duty to make an examination to see that there is no channel connecting the abscess with a deep or

[1] For a lucid description of these abscesses see Owen's "Manual of Anatomy," from which much of the above is condensed.

a distant focus. If he finds such a channel, he may be disposed to follow one of the plans of treatment outlined below and on pages 174 and 175. It is also his duty to see whether there are sinuses tracking off from the abscess; and if these exist, he must slit them up. If there are loculi in the wall of the abscess, he must stretch their mouths. He must be particularly careful to see that he is not dealing with a *shirt-stud abscess*, in which there is a little opening through the deep fascia connecting the abscess above with the abscess below. In a shirt-stud abscess the deep fascia must be freely incised. After the abscess has emptied itself, its walls must be thoroughly scraped with a curet, and the cavity must be irrigated with warm salt solution and drained with a tube. If the skin above a superficial abscess is diseased and discolored, and the abscess is on the eve of spontaneous rupture or has ruptured, the discolored skin must be cut away with scissors. If the discolored skin is allowed to remain, a livid and jagged scar will inevitably result. If it is cut away a healthy scar which is not very deforming will result.

Treatment of Tuberculous Abscesses of Considerable Size.—*Method 1. Aspiration, Irrigation, and the Introduction of Iodoform.*—The operation is carried out with the most scrupulous aseptic care. The trocar is passed through the sound skin; is carried beneath the skin for an inch, as Senn suggests; and is then made to enter into the cavity of the abscess. The stylet is pulled out, and the flow of fluid is aided by very delicate pressure. Occasionally the tube will become blocked by necrosed tissue or plugs of fibrin. It is opened up again by pushing in a wire or forcing through it a stream of sterile fluid. When tuberculous matter ceases to run out of the trocar, a very warm solution of boric acid is thrown in in order to wash the abscess walls. This can be injected with a fountain syringe or with the special apparatus of Senn (Fig. 69). Enough of it is allowed to enter to overdistend the abscess cavity, as Mr. Callender long ago advised. The fluid is then allowed to pass out; fresh fluid is passed in; and this procedure is repeated, perhaps again and again, until entirely clear fluid flows out. When this takes place, an emulsion of iodoform is thrown in by Senn's syringe. A 10 per cent. emulsion in glycerin is as satisfactory as the more elaborate formulas. Verneuil used to employ iodoform and ether; but this is painful, is more liable to cause iodoform-poisoning, and sometimes induces gaseous distention and ruptures the wall of the abscess. In order to prevent the danger of iodoform-poisoning the surgeon should not introduce at one time more than 8 dr. of the emulsion, if dealing with an adult; or more than 4 dr. if dealing with a child. After the emulsion has been inserted into the abscess cavity the wound in the skin is sealed with a bit of gauze and iodoform collodion. Gauze is fluffed up and laid on the skin above the abscess, and the walls of the cavity are then forced toward each other by applying a roller bandage. The part is put at complete rest, and it is usually necessary to put the patient in bed. Sometimes, although very seldom, one injection will produce a cure; but usually, after one or two weeks, it will be observed that the cavity has to some extent filled again. A second operation is then performed; and, if improvement is really taking place, it will be found that the fluid is not nearly so thin as it was at the first operation. It is needless to persist in this method after six or seven attempts have failed to cure. If the abscess has thick and uncollapsed walls it is not fitted for treatment by aspiration and injection.

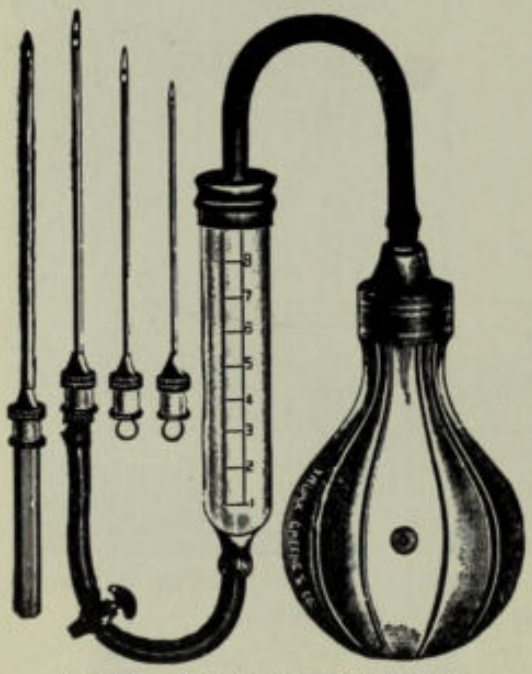


FIG. 69.—Senn's injection syringe.

Method 2. Incision, Cleansing, and Suture.—If, owing to the considerable size or the rather rigid walls of the abscess, one believes that the aspiration method would be useless; or if the aspiration method has been tried and has failed, one may adopt the following plan. It should not, however, be employed if the walls are *very* thick and rigid. An incision is made at the most dependent part of the abscess. The walls are scraped carefully with Barker's sharp-edged irrigating curet (Fig. 70), and are rubbed smooth with bits of gauze. The part is freely irrigated with hot boric acid solu-

tion, and pressure is applied to arrest bleeding. Iodoform emulsion is introduced; the skin is sutured; dressings, compresses, and bandages are applied, and complete rest is secured. This operation may cure an abscess, or it may be necessary to repeat the procedure two or three or many weeks afterward.

Method 3. Incision and Removal of the Primary Focus of Tuberculosis.—If the surgeon does not wish to use the iodoform treatment, or if it has failed, and if he finds that the primary seat of disease can be attacked and removed, an operation should be undertaken to get rid of Volkmann's membrane in the last-formed abscess and also to remove the primary tuberculous focus. An incision is made, when possible, that will lay open not only the last-formed abscess, but the primary lesion. Tuberculous tissue is thoroughly removed by Barker's spoon and by rubbing with gauze or, perhaps, by scissors and forceps. Any focus of bone disease is curetted and touched with pure carbolic acid, and loose fragments of bone are removed. The part is irrigated with a hot solution of boric acid; bleeding is arrested by pressure, and the wound is nearly but not quite closed, drainage being inserted at the most appropriate spot. Dressings, compresses, and bandages are then applied. By this operation the entire tuberculous area is removed, the raw surfaces are forced into contact, and there is scarcely more danger of secondary pyogenic infection than there is in any ordinary wound.

General Treatment.—It is never to be lost sight of that in every case of tuberculous abscess the general treatment of tuberculosis must be rigorously pursued (see page 162). In the treatment of a cold abscess give nutritious food, cod-liver oil, quinin, iron, and the mineral acids. Removal to the mountains or the seaside is often indicated, life in the open air is imperative, and mechanical appliances may be needed for diseases of the bones and joints.

Tuberculous Abscess of Bone.—Make an incision to bare the bone. Open the abscess with the trephine, the gouge, or the chisel; curet the interior of the wall of

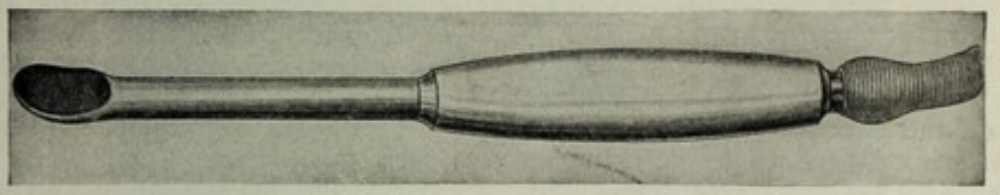


FIG. 70.—Barker's sharp-edged irrigating curet ("Keen's Surgery").

the cavity with a sharp spoon and rub it with bits of gauze; cut away the edges of the bone with rongeur forceps; irrigate the cavity with hot normal salt solution, dry its walls with gauze, and paint the cavity with pure carbolic acid; pack with iodoform gauze and apply antiseptic dressings. It is better not to employ an Esmarch apparatus. Bleeding will not be severe, and when no apparatus is used to prevent bleeding it is possible to see and thus be sure that all the diseased bone has been removed.

Tuberculous Abscess of Lymphatic Glands.—In non-exposed portions of the body the capsule of the gland should be incised, the gland should be dissected or scraped away and the cavity swabbed out with pure carbolic acid or iodin and packed with iodoform gauze, but drainage should not be prolonged. If the abscess is allowed to burst, it will cause an ugly scar; therefore, on exposed portions of the body, as the neck, special effort should be made to prevent a scar by incising early before the skin is involved. When only a little caseated matter exists and the skin is not discolored, prepare the parts antiseptically, incise, rub the interior with gauze, inject iodoform emulsion, and suture the wound. It used to be a custom in such cases to carry a silk thread by means of a needle through the skin, through the gland, and out at its lowest point, the part being then dressed with gauze. In three days the thread was removed and a firm compress was applied. The plan is not satisfactory and incision is to be preferred. When the gland is almost entirely broken down and the skin above it is becoming purple and thin, insert a hypodermic needle through sound skin into the abscess, draw off the fluid tuberculous matter, and inject iodoform emulsion. This procedure is to be repeated when the fluid again accumulates. By this means we can sometimes effect a cure in a week or so. When an abscess breaks or is on the point of breaking, cut away all purple skin, curet the abscess walls (the abscess having become a tuberculous ulcer), remove the remains of gland and capsule, swab the cavity with pure carbolic acid, and dress with iodoform and antiseptic gauze.

Tuberculous glands, if not cured by general treatment and the *x*-rays, ought in many cases to be extirpated. They should, as a rule, be extirpated before they caseate and form an abscess. If an abscess does form it is to be treated as directed above, and after healing takes place the diseased glands should be extirpated. If sinuses exist they are to be curetted and touched with iodin or carbolic acid. After healing, the glands should be extirpated. When sinuses exist there is always mixed infection.

Tuberculous Abscess of a Rib.—This lesion requires incision of the soft parts and resection of the diseased bone. The tuberculous area should be thoroughly curetted, rubbed with pure carbolic acid, and packed with iodoform gauze.

Tuberculous Mediastinal Abscess.—In tuberculous abscess of the mediastinum aspiration and injection of iodoform may prove efficient. In some cases it will be necessary to open and drain.

Tuberculous Abscess of the Mammary Gland.—Many operators simply incise, curet, pack with iodoform gauze, and dress antiseptically. It is wiser to remove the entire gland and to clear out the axilla, as in an operation for cancer, in order to prevent both recurrence and dissemination.

Large Tuberculous Abscesses.—In view of the facts that these abscesses may cause no trouble for years and that an operation may be fatal, some eminent surgeons have opposed an operation unless the abscess was moving toward inevitable rupture or was disturbing the function of organs by pressure. Most practitioners believe, however, and I agree with them, that this mass of tuberculous matter is a source of danger through being a depot of infective organisms which may overwhelm the system, and that death will seldom result from an operation performed by one who employs with intelligence strict antisepsis. In no other cases is attention to every detail more important, as a mixed infection may easily take place, and will probably mean death. As W. Watson Cheyne points out, over 70 per cent. of cases of spinal abscess treated by aseptic methods recover completely and without any real illness after such an operation. The recoveries from the old let-alone method must be infinitely less than this, and cases apparently cured by operation usually remain well. The surgeon must always remember that the wall of the abscess and not the fluid in the cavity is the real seat of disease, and this wall must be actually removed or completely sterilized if operation is to be safe and curative. To simply open, drain, and leave the wall to Nature to get rid of as she can is fraught with the gravest peril.

Psoas Abscess.—Some of these cases can be treated by aspiration and injection (see page 174), others by incision and subsequent suture (see page 174), others by the operation set forth on page 175.

Treves' operation for psoas abscess is described on page 653.

An operation occasionally performed for psoas abscess consists in an incision in the groin, an incision in the back, removal of carious vertebræ, thorough curetting and cleansing of the abscess wall, and through-and-through tubular drainage. It has been found, however, that this operation is uncertain and dangerous. It is not advisable to remove carious vertebræ unless the carious parts are loose, and through-and-through tubular drainage is rarely used unless mixed infection already exists. When a large abscess breaks spontaneously it should be widely opened at once, scraped and irrigated, rubbed with gauze, and packed with iodoform gauze. If secondary pyogenic infection of a large tuberculous abscess does occur the patient will develop septic fever and will probably die (*q. v.*).

Dorsal abscess and **lumbar abscess** are treated after the same plan as psoas abscess. One incision only is usually necessary unless the fluid has traveled to a distant point.

A **tuberculous postpharyngeal abscess** should not be opened through the mouth. To open it in this manner puts the patient in danger of suffocation by fluid running into the larynx during or after the operation. Further, mixed infection of the abscess area will be certain to ensue. Septic pneumonia will be apt to arise from inhaled infected particles, and profound gastro-intestinal disturbance will be liable to develop because of the inevitable swallowing of purulent, putrid, and tuberculous masses. Incise the neck and open into the abscess by Hilton's method, going through the sternocleidomastoid muscle or behind it. Rub the wall of the abscess with bits of gauze, remove any loose bone, irrigate with hot normal salt solution, inject iodoform emulsion, insert a tube, or pack with iodoform gauze.

Tuberculosis of the skin may arise from inoculation with material derived from a bovine or human source. It is frequently found that some other member of the family labors under tuberculous disease or that some family predecessor, direct or collateral, suffered or suffers from it. Stelwagon ("Diseases of the Skin") includes all

cases under five heads: (1) tuberculosis ulcerosa; (2) tuberculosis disseminata; (3) tuberculosis verrucosa; (4) scrofuloderma; (5) lupus vulgaris.

Tuberculosis Ulcerosa.—The disease arises at a mucous outlet and is usually secondary to internal tuberculous disease. Small miliary tubercles form which caseate and are converted into ulcers. An ulcer is shallow, round or oval in outline, with soft edges, the floor being composed of sluggish or edematous granulations covered with a crust. The discharge is scanty and seropurulent. In some cases there is but one ulcer; in others there are two or several, and the fusion of ulcers produces a serpiginous outline. The ulcers do not tend to heal, but gradually and steadily advance. Such ulcers are met with about the mouth, the genital organs, and the anus.

Tuberculosis Disseminata.—This occurs only in children; it is acute in onset and wide-spread. One type is polymorphic: spots, papules, pustules, and crusted ulcers existing, and lymphatic glands being enlarged. Another type arises after an attack of an exanthematous fever and presents "a rough resemblance to flat lupus tubercles, to sluggish acne papules, and to lichen scrofulosum" (Stelwagon, "Diseases of the Skin").

Tuberculosis Verrucosa.—*Anatomic tubercle*, the *verruca necrogenica* of Wilks, is due to local inoculation with tuberculous matter. It may be met with in surgeons,



FIG. 71.—Multiple tuberculous sinuses.

the makers of postmortems, leather workers, and butchers, usually upon the backs of the hand and fingers. It consists of a red mass of granulation tissue having the appearance of a group of inflamed warts. Pustules often form.

Scrofulodermata or Tuberculous Gummata.—By "scrofulodermata" we mean chronic inflammations of the skin, the granulation-tissue product of which caseates, mixed infection occurs, and small abscesses, sinuses, or ulcers form. A *tuberculous ulcer* has a floor of a pale color, and has no granulations at all, or is covered with large, pale, edematous granulations. The discharge is thin and scanty. The ulcer is surrounded by a considerable zone of purple, tender, and undermined skin, which is apt to slough. When healing occurs, the skin puckers and usually inverts.

Lupus begins usually before the age of twenty-five, but is met with often in individuals in middle life. It is most common upon the face, especially the nose. It is a very chronic and extremely destructive disease. Three forms are recognized: (1) *lupus vulgaris*, in which appear pink nodules that after a time ulcerate and then cicatrize partly or completely. These nodules resemble jelly in appearance; (2) *lupus exedens*, in which ulceration is very great, and (3) *lupus hypertrophicus*, in which large nodules or tubercles arise. Lupus may appear as a pimple, as a group of pimples, or

as nodules of a larger size. The ulcer arises from desquamation, and is surrounded by inflammatory products which, by progressively breaking down, add to the size of the raw surface. The ulcer is usually superficial, is irregular in outline, the edges are soft and neither sharp nor undermined, the sore gives origin to a small amount of thin discharge, the parts about are of a yellowish-red color, the edges are solid and puckered and scar-like and there is no pain. The sore is often crusted, the crusts being thin and of a brown or black color; it may be progressing at one point and healing at another; it is slow in advancing, but often proves hideously destructive. The scars left by healing are firm and corrugated, but are apt to break down. Clinically, it is separated from a rodent ulcer by several points. The rodent ulcer is deep, its edges are everted, and the parts about filled with visible vessels. It is not crusted, has not a puckered edge, its edges and base are hard, and it rarely shows any tendency to healing. Many victims of lupus live twenty or thirty years and die without the development of pulmonary tuberculosis. It is estimated that one-third of those who die show signs of pulmonary tuberculosis. Lupus patients exhibit a strong focal reaction to tuberculin and also show von Pirquet's reaction.

Lupus may be treated by the Finsen light, the *x*-rays, excision, electrothermic methods, curetment followed by cauterization with the Paquelin cautery, chlorid of zinc, pure carbolic acid, or pyrogallic acid. Tuberculin may be of service.

Tuberculosis of Subcutaneous Connective Tissue.—In this form of tuberculosis nodules form and break down (tuberculous abscesses). In the deeper tissues these abscesses are usually associated with bone, joint, or lymphatic gland disease (see Cold Abscess, page 167).

Tuberculosis of the Mammary Gland.—(See page 176.)

Tuberculosis of the Thyroid Gland.—It used to be thought that the thyroid was immune. Primary tuberculosis is very rare, but secondary tuberculosis is not nearly so unusual. It may exist with or without goiter. The condition may be miliary abscesses or tuberculoma or sclerosis. Mosiman reported on 9 cases from Prof. Crile's clinic ("Surgery, Gynecology, and Obstetrics," June, 1917).

Tuberculosis of Blood-vessels.—It is certain that bacilli in the blood or in tuberculous emboli may establish intravascular tuberculosis.

Tuberculous Meningitis.—(See page 760.)

Tuberculosis of nerves is excessively rare. Tuberculous neuritis may arise in the course of general tuberculosis. A nerve lying in a tuberculous area may itself become tuberculous. It rarely does so, however. In fact, nerves resist infections even though in the midst of it, and for this reason have been called the "aristocrats of the body."

Pulmonary Tuberculosis.—In adults the lungs are more commonly affected than any other structure. The lung affection may be primary or may be secondary to some adjacent or distant tuberculous process. Pulmonary tuberculosis belongs to the province of the physician and requires no description here.

Tuberculosis of the pleura is not uncommon. Tuberculous pleurisy may be acute or chronic. In some instances mixed infection takes place and suppuration occurs. The tuberculosis may be primary, but is usually secondary to pulmonary tuberculosis, and may be due to direct extension or to rupture of an area of pulmonary softening. A primary pleurisy not due to traumatism is very apt to be tuberculous. In many cases of tuberculous pleurisy there are tubercles present, but in some cases there are none.

Tuberculosis of the Alimentary Canal.—A tuberculous ulcer of the lip occasionally arises, and may be mistaken for a cancer or a chancre. A tuberculous ulcer of the tongue is commonly associated with other foci of disease, in fact, primary cases are extremely rare. J. R. Scott ("Jour. Amer. Med. Assoc.," 1916, clii) collected reports of 231 cases. It may occur at any age, but is most common between forty and fifty years of age. Scott found record of a case occurring in a child less than six years old. The disease is more common in males than in females. Such ulcers are separated from cancer by their soft bases and edges and by the rarity of glandular enlargements, and from syphilitic processes by the therapeutic test. Confirmation of the diagnosis is obtained by examination of an excised piece, cultivations, and inoculations. In cases secondary to laryngeal or pulmonary tuberculosis the sputum contains the bacilli of tubercle. Tubercle may affect the pharynx, palate, tonsils, and, very rarely, the stomach.

Gastric Tuberculosis.—It is thought that the acid gastric juice must protect the stomach from tuberculosis because tubercle bacilli are frequently introduced into the stomach, but the organisms very rarely lodge and multiply in the stomach wall. Fur-

thermore, bacilli when introduced into the stomach are retained but a short time and the stomach walls contain few lymph-follicles (Barchasch in "Beit. Z. klin. d. Tuberculose," vii, Part III, 1907). It may be assumed that gastric catarrh and motor impairment are predisposing causes. Gastric tuberculosis may be primary, but is usually secondary to pulmonary tuberculosis, infected sputum having been repeatedly swallowed ("Jour. Amer. Med. Assoc.," Dec. 28, 1907). Gastric tuberculosis may cause cicatricial stenosis of the pylorus, ulcer (of which I reported an instance), a tumor-like thickening, solitary tubercle, and miliary tuberculosis (Barchasch, Loc. cit.).

Broders ("Surgery, Gynecology, and Obstetrics," Nov., 1917) out of all cases in literature accepts 49 as certainly cases of gastric tuberculosis.

Intestinal tuberculosis may follow pulmonary tuberculosis, but it may arise primarily in the mucous membrane of the bowel or result from tuberculous peritonitis. Intestinal tuberculosis causes diarrhea and fever, may resemble appendicitis, and may cause abscess and perforation. True tuberculous disease of the appendix occasionally occurs. Scott ("Annals of Surgery," Dec., 1917) believes that tuberculous appendicitis is more common than is usually thought. He believes that 0.5 per cent. of all appendices removed by operation are tuberculous. Tuberculosis of the cecum is by no means as rare as we used to believe (see page 999). Fistula in ano is frequently tuberculous, and when it is, the lungs are very often involved, the pulmonary lesion being usually primary.

Tuberculosis of the Liver.—Tuberculous disease of the liver causes cold abscess or cirrhosis. Tuberculous abscess does not cause elevation of temperature and does not cause eosinophilia, which latter phenomenon we would expect a hydatid cyst to inaugurate. Typical cirrhosis without tubercles may arise, the bacilli being present in the tissues. Many cases of supposed alcoholic cirrhosis are probably tuberculous. The hepatic cirrhosis which may arise during peritoneal tuberculosis is tuberculous.

Peritoneal tuberculosis (see page 1012) may be primary, infection having taken place by way of the blood, may be part of a diffused process, or may follow intestinal tuberculosis, the serous and mucous coats of the bowel having been at some point in contact or a follicular ulcer having perforated (Abbe). The germ may have entered by the fallopian tube. Tuberculous peritonitis may be due to ovarian or fallopian tuberculosis, or to ulceration of a tuberculous appendix. In some cases a caseating tuberculous gland furnishes the causative bacilli. Peritoneal tuberculosis usually causes ascites, tympany, and tumor-like formations composed of adherent bunches of bowel or omentum or distended mesenteric glands (see page 1012).

Tuberculosis of the Pancreas.—Tuberculous sclerosis of this organ has been induced experimentally by Carnot.

Tuberculosis of the spleen may occur with tubercles or as a sclerosis.

The **heart muscle** is rarely attacked by tuberculosis. In fact, valvular lesions of the left side of the heart actually seem to protect the individual from pulmonary tuberculosis. Non-tuberculous endocarditis may arise in the course of a tuberculous process elsewhere. Tuberculous endocarditis does occur, but *very rarely*.

The **endocardium** may be inflamed and covered with fibrous exudate as a result of the toxins from some distant point of tuberculosis.

The **pericardium** may be attacked with primary tuberculosis, or the process may be secondary to pleural tuberculosis. There may or may not be pulmonary tuberculosis.

Tuberculosis of the brain induces meningitis and hydrocephalus (see page 760).

Tuberculosis of the membranes of the spinal cord is seen alone or in association with tuberculous inflammation of the brain.

Tuberculous disease of fascia is common; in fact, fascia is peculiarly prone to infection. Fascia may be attacked primarily, and when it is, the disease is apt to spread rapidly and widely and to produce most disastrous results. The elder Senn regarded tuberculosis of the intermuscular septa of the thigh as a very grave condition, which, if extensive, demands amputation of the limb. Secondary tuberculosis of fascia is far more common than the primary form, the original focus of disease being in bone, joint, tendon-sheath, or lymph-gland.

Tuberculosis of muscle is rare. Instances of primary tuberculosis have been reported. Secondary tuberculosis is more common, but even this condition is rare, muscle seeming to have a high degree of resistance.

Tuberculous disease of bone (see page 452) is very common in youth, and a sprain or a contusion, which is oftener slight than severe, may precede any signs of the disease. The injury establishes a point of least resistance, and in the damaged area

the bacilli are deposited and multiply, or a latent area of tuberculosis is roused into activity by the traumatism. The organisms may be deposited directly from the lymph or blood, or may arrive in an embolus from a distant tuberculous focus (lung or lymph-gland), and this embolus is caught in a terminal artery in the end of a long bone and causes a wedge-shaped infarction.

Tuberculous osteomyelitis, as a rule, begins just beneath the articular cartilage or in the epiphysis. There may be one focus, several foci, or many foci in the same bone. The products of the tuberculous inflammation constitute tuberculous nodules which destroy the medullary tissue and hence cut off the nutrition of adjacent bone. Bone trabeculæ are destroyed, and tuberculous granulations take their place, and here and there small dead portions of bone trabeculæ lie as sequestra among the granulations. In some bones, for instance, the vertebræ and the bones of the carpus and tarsus, the tuberculous process spreads widely; in some it tends to remain localized. Tuberculous granulations may be absorbed, may be encapsuled, may be replaced by fibrous tissue, or may caseate (see page 146). When an osseous tuberculous focus in the shaft of a long or short bone spreads the bone enlarges and becomes spindle shaped, as is seen in a phalanx the seat of tuberculous osteomyelitis, the condition known as *spina ventosa*.

Tuberculous disease of the joints (see page 582) is called *white swelling* and also *pulpy degeneration* of the synovial membrane. Joints are especially liable to tuberculosis in youth, although the wrist and shoulder not infrequently suffer in adult life. Joint tuberculosis is often preceded by an injury (page 452). The tuberculous process in rare cases begins in the synovial membrane. Nichols examined 120 tuberculous joints (some at autopsy, some after resection or amputation) and found one or more live foci in every case. Primary synovial tuberculosis is most often met with in the knee-joint, and next in the shoulder. Usually the disease begins in the end of a bone, dry caries resulting, necrosis ensuing, or an abscess forming, which may break into the joint.

Poncet's rheumatism, or tuberculous articular rheumatism, is a condition in which toxic joint inflammation is evidence of latent tuberculous infection perhaps at some distant point, it being often impossible to demonstrate the bacillus in the joint fluid or tubercles at the autopsy (see page 581).

Tuberculosis of lymphatic glands is known as *tuberculous adenitis*. It is the most typical lesion of scrofula. Tuberculous adenitis is most frequent between the third and fifteenth years. A person not of the tuberculous type may acquire tuberculosis of the glands, but the disease is unquestionably of much greater frequency in those who are recognized as predisposed to tuberculosis. Tuberculous glands may get well, may even calcify, but usually caseate if let alone. Long after healing they may break down and soften (*residual abscess of Paget*). They very frequently suppurate because of mixed infection. Though at first a local disease, tuberculous adenitis may prove to be a dangerous focus of infection, furnishing bacteria which are carried by blood or lymph to distant regions or throughout the entire system. Glandular enlargement is in rare instances widely diffused, but it is far more commonly localized. Enlargement of the cervical glands is most common. Tuberculous disease of the mesenteric glands is known as *tabes mesenterica*. Tuberculosis of lymph-glands may be due either to bovine bacilli or to human bacilli.

Tuberculosis of the cervical lymph-glands is a very common condition. It is most common in children over two years of age and is often seen in young adults. It is rare in children under two and in persons of middle age. In the majority of cases infection takes place from the tonsils, pharynx, or posterior part of the oral cavity, and in these cases the first glands to enlarge are those just below the parotid salivary glands. In a number of cases enlargement begins in the submaxillary or submental glands, and in these cases infection originates from the teeth, mouth, or face (Dowd in "Surgery, Gynecology, and Obstetrics," March, 1909). A tuberculous lesion of the scalp may be followed by tuberculosis of the parotid lymph-glands. Cervical adenitis may be unilateral or bilateral and is a very chronic condition. It is predisposed to by enlargement of the tonsils, adenoids, and nasopharyngeal catarrh. In young children three-fourths of all cases are due to bovine bacilli (page 149). The enlargements usually arise insidiously, but sometimes, especially after whooping-cough, measles, or scarlet fever, they come on more rapidly. When first observed the enlargements are small, round, firm, isolated, painless, and somewhat movable. As they enlarge they fuse into an irregular swelling which may be quite tender and is always anchored to surrounding parts. As the glands caseate the mass softens, the

skin over it becomes adherent and red, and finally breaks open. Cold abscess may form or mixed infection with pus cocci may take place.

Cervical lymphadenitis may be confused with lymphadenoma. The former, as a rule, first appears in the submaxillary, submental, or parotid lymph glands, the latter, in the subclavian or sternomastoid glands. The mass in the former is more tender, softer, and less movable than in the latter. Tuberculous glands weld together, they are apt to remain localized for a considerable time, and they tend to soften. The younger the patient, the greater the probability of softening. In adults there is comparatively slight tendency to softening. Tuberculous adenitis may be accompanied by other tuberculous manifestations. Lymphadenoma from the start affects many glands; it may arise simultaneously in several regions, although in some cases there is a distinct beginning in one region. Lymphadenoma shows very little tendency to suppurate, and does not break down except late in the course of the disease, and is accompanied by great debility and anemia. Tuberculin tests may aid in the diagnosis, but a difficulty is that Hodgkin's disease and tuberculosis may coexist. Malignant gland tumors infiltrate adjacent glands and other structures, binding skin, muscles, and glands into one hard, firm mass.

Tuberculous cervical adenitis is in most instances a reasonably curable condition. In children under two or three years of age, however, it is a dangerous condition and one apt to be associated with severe pulmonary, osseous, or other complications. Some cases of adenitis can be cured by open-air treatment, heliotherapy, food, medicine, tuberculin, the *x*-rays, and hygienic care. In many, however, operation is indicated in addition to such treatment, and these operations are usually successful if thoroughly performed when the disease is localized and softening has not occurred. When possible operation should be performed when the patient is at the seaside, or, at least, the patient should convalesce there if circumstances permit. Thorough extirpation is the proper operative treatment and any diseased condition of scalp, face, mouth, tonsil, teeth, or nasopharynx is to be corrected. My belief is that about 75 per cent. of cases are permanently cured by thorough operation. If a patient is well five years after operation the cure may be regarded as permanent. Cured cases seldom die subsequently of any tuberculous lesion. The second Mr. T. Pridgin Teale, of Leeds, was the pioneer in the performance of complete operations for the removal of tuberculous glands.



FIG. 72.—Multiple tuberculous sinuses.

It is not uncommon after removal of infected glands and healing of the wound to have several or numerous small, hard nodules form beneath the skin in the area operated upon. Dowd extirpated some of these nodules and found they were not tuberculous, but were fibrous. I have been able to confirm Dowd's statement in several of my own patients.

Extensive plastic operations are necessary in some cases to get rid of ugly, corrugated, and contracted scars.

Medical treatment is not nearly so valuable as surgical treatment in this form of tuberculosis. If medical treatment alone is relied on, many of these cases develop pulmonary tuberculosis. Attridge, quoting Demme and Dowd ("Surgery, Gynecology, and Obstetrics," Dec., 1908), sets the number which develop it when medical treatment is relied on at 21 per cent., and the number developing other distant tuberculous lesions at 8.2 per cent.—a total of 29.2 per cent., and these figures do not include bone infections and late infections of the lymph-nodes. Even in cases supposed to have been cured by medical means it will be found that most of them react to tuberculin, showing that lesions are latent rather than cured. Wohlgemuth shows that complete removal cures 75 per cent. of cases; curetting and drainage cures 63 per cent.; general treatment, 24 per cent. (Attridge, Ibid.). In a series of 100 cases operated upon by Dowd pulmonary tuberculosis arose in but 1 case and bone tuberculosis in 3 cases. If miliary tuberculosis exists, if the patient is much exhausted, if the infection is not definitely

localized, or if an internal organ is the seat of active tuberculosis, operation is not indicated.

Death seldom follows operation. The records of the Victoria Hospital, Chelsea, show 4 deaths in 533 operations, a mortality of 0.75 per cent. (Geoffrey Jefferson in "Lancet," May 9, 1914). The mortality without operation is probably 10 per cent. Complete extirpation of the involved group of glands is practised when the disease is well localized. If it is not well localized I follow Attridge's plan (Ibid.) and wait until it becomes so, treating the patient in the interval by open-air life, heliotherapy, nourishing food, medicine, tuberculin, and the *x*-rays. If softening occurs, the area should be incised and curetted and the exposed surface should be treated by repeated applications of tincture of iodin. When healing occurs extirpation is to be performed. If sinus formation exists, mixed infection has occurred or will occur and the sinuses must be curetted and treated with iodin until they heal, when the glands may be extirpated. I do not believe in a bilateral extirpation at one séance. The operation even on one side is prolonged and bloody and is all the patient is fit to stand. If both sides of the neck are involved, an interval of several weeks should be insisted on before the other side is attacked. Judd insists on the necessity of hunting up and removing all the little glands external to the sheath of the carotid, and in order to accomplish this makes his incision in the posterior triangle and begins his glandular removal there ("Collected Papers of Mayo Clinic," 1910–1911).

In chronic cases of cervical lymphadenitis it is invariably necessary to search for intra-oral and nasopharyngeal disease, and if such disease exists it must be treated before the glands are removed. After operation rigid open-air life is insisted on.

Tuberculosis of tendon-sheaths (*tuberculous tenosynovitis*) is discussed on page 678.

Tuberculosis of the Kidney.—(See page 1288.)

Tuberculosis of adrenals may cause sclerosis.

Tuberculosis may attack the **Fallopian tubes, ovaries,** or **uterus.**

Tuberculosis of the urethra, prostate gland, seminal vesicles, and **bladder** is considered in a section on Regional Surgery.

Tuberculosis of the Testicle (see page 1378).—This disease is not rare. It is sometimes primary, but is usually preceded by tuberculosis of the kidney, bladder, or prostate. But one testicle is affected in the beginning, but the other gland is apt to be attacked later. The tuberculous mass softens, becomes adherent to the scrotum, and breaks or bursts, exposing the damaged testicle (*fungus of the testicle*). The cord is apt to be involved in tuberculosis of the testicle.

Typhobacillosis.—This condition was described by Landouzy in 1883. It is a toxemia in which the localization of lesions is very much deferred and is preceded by a prolonged typhoid or septic stage (Matas, "Southern Med. Jour.," Oct., 1911). Bacilli of tubercle are widely distributed throughout the body, but for a long time there are no tubercles formed, and all of the symptoms are due to bacillary poison. Matas describes the condition as "a continued fever with remissions and enlargement of the spleen, without signs of visceral localization" (Ibid.). It strongly resembles typhoid, but the pulse is more frequent, the temperature is less regular, there are no spots, and no intestinal or bronchial symptoms pointing to typhoid. Few of these cases die early. Most of them make an incomplete recovery after several weeks, and in periods varying from weeks to months develop evident localized tuberculosis.

Acute Miliary Tuberculosis.—In this condition an organ, several organs, or the entire body is infected with tubercle bacilli which have caused the formation of multitudes of tubercles. The symptoms for a time resemble typhoid, but in a short time an organ or organs present evidences of disease. Death occurs in from three weeks to three months.

XII. RACHITIS, OR RICKETS

Rickets was known by the people and named by them long before any medical man had written of it. It first appeared in the London bills of mortality in 1634. Glisson, in 1650, wrote the first description of it and renamed it rachitis because of the commonly resulting spinal curvature. Rickets is a chronic disorder of nutrition arising during the early years of life (the first two or three) as a result of insufficient or of improper diet, aided and abetted in many cases by bad hygienic surroundings. It is at present frightfully common in central Europe. A deficiency of fat and protein and an excess of starch and sugar in the food or the use of a diet which, by inducing

gastro-intestinal catarrh lessens and perverts assimilation, are supposed to cause rickets. But there is, in all probability, something more. The food is deficient in the fat-soluble vitamin (Vitamin A). The disease is not common in nursing children unless breast feeding has been unduly prolonged, and children fed upon artificial foods are particularly apt to develop it. Holt says such diet is very deficient in fat and often in proteins, and contains an excess of carbohydrates ("Diseases of Infancy and Childhood"). Sir J. Bland-Sutton made some valuable experiments which indicate the injury done animals by denying them natural diet. He fed lion cubs in the London Zoological Gardens on raw horse meat only and the animals developed rickets. The London cab horses were not noted for fat and the young lions could not crush the bones and reach the marrow. The rickety animals rapidly recovered on feeding them with milk and powdered bones mixed with cod-liver oil. Some think that a deficiency of phosphates is causal. The disease is essentially a city malady, "being principally seen in children living in crowded tenements where the effects of improper food are most strikingly shown; yet even there the disease is rare in those who get a plentiful supply of good breast milk" (Holt, Ibid.). Rickets is characterized by incomplete osteogenesis and other nutritive failures, but it must not be regarded as a bone disease. It is true the bones are affected, but so are various other structures and organs, all of the disorders being due to an underlying nutritive defect. Some maintain that lactic acid or some other toxic material produced in the intestinal canal causes bone inflammation, but most observers do not believe the bone changes are inflammatory. Children are very seldom born with rickets, but develop it later, the period of greatest liability being between the seventh month and the fifteenth month. So-called congenital rickets is usually sporadic cretinism. A child with rickets may become scorbutic (*scurvy rickets*). Some regard rickets as the result of an infection. Glisson, in the seventeenth century, thought it was infectious. Some observers claim to have found bacteria in rickety bone and in the cerebrospinal fluid of rickety children (Mirculi, Sorgente). Findlay believes that infection plays a great part in rickets ("Brit. Med. Jour.," Nov. 4, 1922). Others think it results from thymus atrophy. Some blame syphilis, some malaria, some the thyroid gland, some the hypophysis cerebri, some the nervous system. Some believe that disease of the parathyroids alters calcium metabolism—perhaps too much calcium being cast out, perhaps too little being taken in or assimilated. It is well recognized that depriving a young child of sunlight and fresh air favors the development of rickets.

To sum up, we do not know the cause of rickets. Defective feeding and insufficient fresh air, sunlight, and exercise play a great part. The fat-soluble vitamin is not the whole thing in prevention, as a vitamin is in beriberi. Insufficiency of vitamin A, phosphorus, and calcium, and too little sunlight, fresh air, and exercise seem to constitute the causal compound.

Whatever may be the cause of rickets, the essential condition in the bones is an insufficient deposit of mineral matter in the new bone cells. The bone, cartilage, and periosteum become hyperemic, cartilage cells grow rapidly and fail to calcify properly. The new bone is soft and vascular and bone lamellæ toward the medullary canal are actually absorbed. There is excessive proliferation of cartilage which results in enlargement. The proliferating and imperfectly ossified cells cause enlargements at the ends of long bones and at the sternal ends of the ribs, and various bones bend and are distorted. The parietal bones bulge, the fontanels remain long open; there may be unossified gaps in the occipital bone, membrane only filling them (*craniotabes*). There may be pigeon-breast, bent long bones, curved spine, and distorted pelvis. The bones later may become firmly ossified in deformity. In rickets the spleen and liver are enlarged and the thymus is atrophied.

Evidences of Rickets.—Rickets is apt to arise in the spring, but may begin any time of the year. In some few cases it begins with fever. The condition is one of general ill-health; the child is ill-nourished, pallid, and flabby; it has a tumid belly and suffers from attacks of diarrhea and sick stomach; it is disinclined to exertion and has a capricious appetite; it is liable to sweating of the head when asleep; the sleep is restless and there may be night terrors; enlarged glands are often noted, the teeth appear behind time, and the fontanels close late. In health the posterior fontanel closes in the second month and the anterior fontanel in the eighteenth month. In rickets the anterior fontanel is often open when the child is three years of age. The sutures are often open at the end of the first year. In children under six months areas of softening may be felt in the cranial bones (*craniotabes*). This condition is most common if the child is syphilitic. The head is square in shape, the cranial bones

are thick, and areas of thickening known as bosses appear over the parietal bones. The head is large and the forehead bulges. The long bones become much curved, the upper part of the chest sinks in, curvature of the spine appears, and the pelvis is distorted. The ligaments are relaxed and lengthened and the joints are wobbly. The muscles are feeble and ill-developed. Infantile convulsions are common. The liver and spleen are enlarged. Nocturnal restlessness and night terrors are the rule. Laryngismus stridulus and tetany may occur. Rickety infants seldom cry (Dick). Swelling appears in the articular heads of long bones, by the side of the epiphyseal cartilages, and in the sternal ends of the ribs, forming in the latter case *rachitic beads* (the *rachitic rosary*). The lesions of rickets are due to imperfect ossification of the animal matter which is prepared for bone formation, and the soft bones gradually bend. The swellings at the articular heads are due to pressure forcing out the soft bone into rings. Rachitic children rarely grow to full size, and the disease is responsible for many dwarfs. Most cases recover without distinct deformity, but the time lost during the period when active development should have gone on cannot be made up, and some slight deficiency is sure to remain. Bow-legs, knock-knees, and spinal curvatures are usually rachitic in origin. The disease may be associated with scurvy, inherited syphilis, or tuberculosis. In appearance the rickety child is pot-bellied, pale and anemic, and usually fat and flabby, though occasionally thin. The spleen may be enlarged. There is great liability to enlargement of the tonsils, gastro-intestinal catarrh, and bronchial catarrh. The blood is deficient in red corpuscles and hemoglobin, and sometimes there is leukocytosis. The disease lasts for many months and is usually recovered from. It does not directly produce death, but is a powerful indirect cause of infant mortality because it lessens resistance and predisposes to many diseases. It is almost always afebrile, rarely congenital, and in unusual cases, known as late rickets, develops between the fifth and tenth year. The so-called acute rickets is practically always scurvy (Holt). The victims of rachitis begin to walk very late and are very liable to fracture the bones from slight force and greenstick fractures are particularly prone to occur (Fig. 73). After fracture of a rickety bone union is usually delayed. Rickety children do not play like other children, but are solitary and lack initiative.

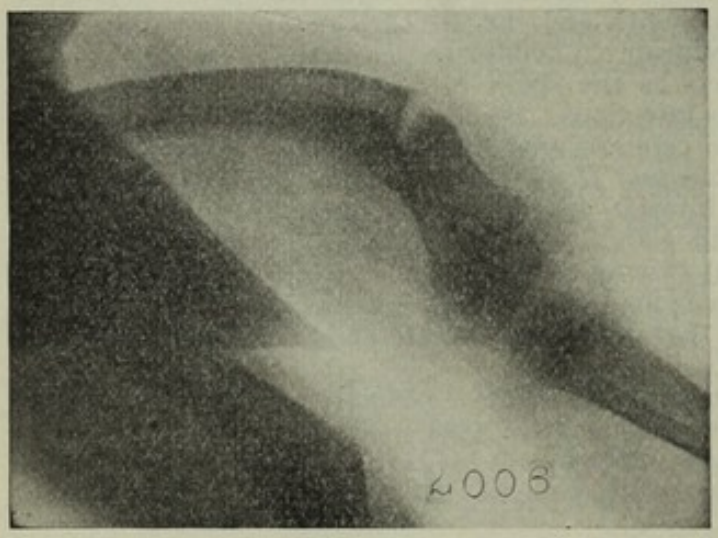


FIG. 73.—Fracture of femur in rickets.

Prevention of rickets is secured by seeing to it that the pregnant woman has a generous diet and that she should nurse her own child if it thrives on her breast milk (W. L. Rost in "N. Y. Med. Jour.," 1915, cii). Should artificial feeding become necessary, pure, raw milk should be used and elaborate formulæ are to be regarded as anathema.

The **treatment** consists in having the child live as much as possible in the open air and sunshine. The value of heliotherapy in rickets is well recognized, and it is known that light stimulates the formation of blood-platelets (Cramer and Drew in "Brit. Jour. Pathol.," Oct., 1923). The above named observers suggest that the platelets are part of the mechanism of defense against infections. Salt-water baths are useful. Sea air is very beneficial. Fresh food (milk, cream, and meat juice) should be ordered. Prune juice and orange juice are of service. As the child grows older it can be given eggs, and broths of vegetables and cereals (Rost, Ibid.). Cod-liver oil, syrup of the iodid of iron, arsenic, and some form of phosphorus are to be administered. Cod-liver oil furnishes vitamin. Some give thymus extract, others administer pituitrin. It is absolutely necessary to improve the primary assimilation. During the acute and progressive stage keep children off their feet in order to prevent deformities. Slight deformities of the extremities require no special treatment unless they increase. If the deformity is marked or is increasing, use braces; employ massage, manipulation, and faradism. By the time the child is three years of age the bones are usually so

firm that the pressure of a brace cannot cure the deformity, though the real test of brace efficiency is the degree of elasticity present in the bones, as determined by the surgeon's hands. After the age of three braces are commonly useless. Pronounced established deformities of the extremities are usually treated surgically. Kyphosis is treated by making the patient lie on his back upon a hard bed, without a pillow. The child sits up a few hours each day, the shoulders being held back and support applied to the body. In bad cases during the time the child is erect it should wear a brace or plaster-of-Paris jacket. Daily manipulation, the child lying prone, is helpful. Friction of and electricity to the spinal muscles do good.

Scorbutus (Scurvy).—Many ancient writers described symptoms which must have been due to scurvy. For instance, Pliny, speaking of the army of Germanicus when near the Rhine, describes a condition of illness characterized by sore gums, falling out of teeth, and weakness of the legs. Voyagers in the fifteenth century noted symptoms which we now know were caused by scurvy. In Vasco da Gama's voyage around the Cape of Good Hope more than half of his crew perished of what was certainly scurvy. It seems to have been first specifically described early in the sixteenth century. A most graphic picture of scurvy as it used to occur at sea will be found in "A Voyage Around the World in 1740 by Lord Anson," compiled by the Rev. R. Walter, chaplain of the "Centurion." Scurvy is rare today in adults, but was at one time very common among those who took long voyages, or who engaged in campaigns, or were the victims of sieges, and was quite common even in cities. Poupart describes it as he saw it in the St. Louis Hospital of Paris early in the eighteenth century. It was common during the siege of Paris. Of recent years it is very uncommon, and has occurred chiefly among voyagers in the Arctic and Antarctic regions or those who were beleaguered. Hopkins ("Jour. Amer. Med. Assoc.," 1917, lxix) saw 3000 cases of scurvy in the year 1915 in the Island of Aruba, a small island of the West Indies. In this island from April to November no fresh vegetables are obtainable and bad well water is used for drinking. It can occur in any part of the world, on land or sea. There was more or less scurvy among soldiers in the World War. It was noticed among those on short vegetable rations. Among the British troops in Mesopotamia scurvy was not common, but great numbers of Indian soldiers were attacked (Major Turner in "Brit. Med. Jour.," July 14, 1917). Many years ago I saw several cases in the Philadelphia almshouse. It is important to remember that though scurvy is rare in adults, it is by no means uncommon in ill-nourished infants.

Scurvy is a constitutional malady due to the consumption of improper diet, and especially to the employment of a diet characterized by the absence of vegetables. The essential element lacking is perhaps Vitamin C, the antiscorbutic vitamin (Hopkins in "Brit. Med. Jour.," Oct. 20, 1923).

The use of salt meat as a staple article seems to favor the production of the disease, but scurvy can occur when there was not a salty diet, and increase of sodium chlorid in the blood is not characteristic of scurvy, but occurs in various forms of anemia. Garrod considered absence of potassium salts to be the real cause. The diminution of potassium salts he supposed to be responsible for diminished alkalinity of the blood, but we know that diminished alkalinity is common in all forms of secondary anemia. Some consider absence of malates the cause. Absence of variety in diet, bad water, poorly ventilated quarters, insufficient exercise and sunlight favor the development of the disease. Some believe that an organic poison derived from tainted food is responsible (Torup). A bacterial origin has been suggested by Berthenson, Babés, and others. Certain studies made in the Transvaal suggest the bacterial origin of scurvy. Myer Coplans ("Lancet," June 18, 1904) states that it occurred in those getting excellent rations and began as inflammation of the gums, the constitutional symptoms following. If the gum condition was recognized early and cured simply by cleanliness and antiseptics, that is, by pure local treatment, constitutional trouble did not develop. Goadly ("Brit. Med. Jour.," 1910) showed that the mouth of a scurvy patient is acid to litmus, and even though there is no dental caries, in most cases there is early inflammation of the gums. Hewetson examined 400 South African males, varying in age from fifteen to thirty-five. He found 134 with scorbutic gums, although they seemed in good health ("Transvaal Medical Journal," April, 1911). Many think scurvy is due to the absence of a vitamin which is contained in fresh meat, milk, and certain vegetable juices. McCollum and Pitz ("Jour. Biological Chemistry," 1917, xxxi), after studying experimental scurvy on guinea-pigs point out that in guinea-pigs dead of scurvy the cecum is found distended with pasty feces and that scurvy can be

prevented if this cecal distention is prevented by mineral oil or other cathartics. The authors do not accept the vitamin theory of scurvy.

The effect of great depression of spirits in predisposing to scurvy and in aggravating cases of scurvy has often been commented on. During the siege of Breda in 1625 scurvy was rife. Bad news rapidly increased the number of cases. Good news checked it. Anson made a similar observation.

Scurvy begins with sore gums, weakness, drowsiness, muscular pains, and great susceptibility to cold. The skin is pallid or dirty white, and is occasionally mottled and often peels off. The patient is breathless on the slightest exertion. The pulse is excessively weak and slow. There is no fever unless a complication arises. The gums are often tender and inflamed from the start, but in some cases they are not. After two or three weeks in all cases usually the gums are found to be tender, painful and swollen, and bleeding at frequent intervals; the breath becomes offensive, the teeth loosen and even drop out; subcutaneous hemorrhages take place, giving rise to petechiæ or extensive extravasations; the vision becomes dim; the urine becomes scanty and of low specific gravity; cutaneous vesicles form, rupture, and give rise to bleeding ulcers, and ulcers likewise arise from breaking down of blood extravasation; hemorrhages take place into and between the muscles, and in severe cases beneath the periosteum and into joints, and blood may flow from the nose, lungs, kidneys, stomach, and intestines. Deep hemorrhages are palpable as hard lumps. Bleeding at an epiphyseal line may separate the epiphysis from the shaft. If an inflammation or ulceration arises at any point, fever is observed. In many cases blood-clotting is retarded. Wright maintains that there is diminished alkalinity of blood and that scurvy is really acid intoxication. Other observers dispute this. The examination of corpuscles and hemoglobin gives a picture identical with secondary anemia. As a rule the red cells number from 3,000,000 to 4,000,000 per c.mm., but may fall to 1,000,000 or even less. Hemoglobin loss is more marked than corpuscular diminution, hence the color-index is low. There is usually an increase in leukocytes. Major Turner in describing scurvy among the British troops in Mesopotamia says that it was sometimes made manifest by an otherwise inexplicable hemorrhage, by very slow healing of a wound or ulcer, and in some cases developed during an illness, the patient having been fed for a long time on sterilized food ("Brit. Med. Jour.," July 14, 1917). It was observed by DeHaven, who commanded the Grinnell expedition in search of Sir John Franklin, that scurvy causes old and soundly healed wounds to ulcerate. The same observation was made years before in Lord Anson's voyage. A sailor of the "Centurion" had been wounded fifty years before at the battle of the Boyne. He developed scurvy and the old wound opened. In another case an old and soundly united fracture gave way and felt like a fresh break. Most cases of scurvy get well under proper treatment, but complete recovery is not attained for a long time. Sudden death is liable to occur if any exertion is made. The lightest exercise may be fatal. Even moving a man while he is lying down may cause death. Many cases while quiet and recumbent feel well, eat well, sleep, make no complaint of pain, and yet even slight movement may cause death. Nansen is said to attribute the loss of the gallant Scott and his companions in the Antarctic to scurvy, the effort necessary to climb a glacier being, in his opinion, the cause of death.



FIG. 74.—The gums in scurvy.

Prevention and Treatment.—Captain Cook succeeded in preventing scurvy among

his sailors by providing plenty of fresh water; guarding them against fatigue, wet, and extremes of heat and cold; attending to cleanliness and ventilation, and stimulating cheerfulness. The great navigator lost no men from scurvy. In 1795, the British Admiralty, acting on the suggestions of James Lind (1757) and Sir Gilbert Blane (1785), provided ships with lime-juice or lemon-juice, with the most beneficial results in preventing the disease. As a matter of fact, lemon-juice was suggested by John Woodhall long before the time of Lind and Blane; Woodhall proposed it in 1636, Huxham, in 1747, recommended a vegetable diet. Until comparatively recent years sailors of the United States Navy were accustomed to refer to sailors of the British Navy as "lime-juicers." Scurvy is prevented at the present time by employing a proper diet and by maintaining cleanliness and hygienic conditions.

The following agents are believed to be especially useful as preventives: fresh meat, orange-juice, lemon-juice, cider, vinegar, milk, eggs, onions, cranberries, cabbages, pickles, potatoes, juice squeezed from a partly cooked beef steak, lime-juice, and citrate of sodium or potassium. When the disease develops, give vinegar, lemon-juice, onions, scraped apples, cider, salts of calcium, citric acid, arsenic or iron, whisky or brandy, and plenty of nourishing food. Lind used, with great success in many cases, 4½ oz. of lemon-juice or lime-juice and 2 oz. of sugar in a pint of Malaga wine. This was taken during each twenty-four hours. In twenty-four hours improvement was manifest. Antiseptic mouth-washes are necessary and strychnin is a valuable stimulant to the circulation. Sleep must be secured and ulcers are to be treated by antiseptic dressings and compression. Sunlight and fresh air are very useful. In a grave case transfusion of blood should be practised.

Infantile scurvy or **Barlow's disease** may exist alone or with rickets (*scurvy rickets*). It occurs most often in the children of the well-to-do, those who have been brought up on artificial foods, in fact, only children who are fed on artificial foods or on unsuitable breast milk get it. Sterilized milk, condensed milk, boiled milk, stale milk, or any artificial food may be responsible. It may occur in a breast-fed baby if the milk is insufficient or of poor quality, or if lactation has been inordinately prolonged. It occurs most frequently between the eighth and eighteenth months of life. It is noted that the child has lost its appetite, is losing weight, has perhaps lost the use of its legs, lies quiet with the thighs flexed and abducted, cries when touched and when it fears it is going to be touched (Grasty in "Amer. Jour. Obstet.," 1910). The child is anemic, suffers from gastro-intestinal disorders, spongy and bleeding gums if teeth have erupted, weakness of the legs, general muscular tenderness, night-sweats, and often febrile attacks (Rotch), bleeding from the nose, bleeding beneath the skin (blue spots), bloody urine and stools, bleeding beneath the periosteum, into joints, viscera, or muscles. In some cases hematuria is the first and perhaps the only symptom (J. Lovett Morse "Jour. Amer. Med. Assoc.," Dec. 17, 1904). A subperiosteal hemorrhage is very dense to palpation, is tender, is fusiform in outline, and does not fluctuate. It is sometimes mistaken for sarcoma. In 1 case seen by the author a hemorrhage beneath the periosteum of the femur was mistaken for a sarcoma. The limb attacked is flexed and the child will not move it. In another case hemorrhage into the knee-joint was thought to be inflammatory effusion from traumatism. Separation of an epiphysis may result from hemorrhage between it and the bone. Infantile scurvy is often unrecognized. If promptly treated, recovery is the rule, otherwise death may occur from exhaustion.

Treatment.—Keep the child quiet in bed and give liberal amounts of fresh and raw cow's milk and beef-juice squeezed from a partly cooked steak. Administer orange-juice, grape-juice, scraped apples, and tonics. To children over one year of age give potatoes. Antiseptic mouth-washes are necessary. See that the patient secures a maximum of fresh air and sunlight. In a very grave case transfusion is indicated.

XIII. CONTUSIONS AND WOUNDS

Contusions.—A contusion or bruise is a subcutaneous laceration due to the application of blunt force, the surrounding skin being uninjured or damaged without a surface breach and blood being effused. Punches, kicks, blows from a blackjack, falls, etc., cause contusions. In intra-abdominal contusions the skin of the abdomen is frequently not damaged. In contusions of structures overlying a bone the skin suffers with the deeper structures. If a large vessel is ruptured hemorrhage is profuse and much blood gathers in the tissue. If only small vessels suffer, hemorrhage is moderate.

An *ecchymosis* is diffuse hemorrhage over a large area, the blood lying in the spaces of the subcutaneous or submucous areolar tissue. A very small ecchymosis is known as a *petechia;* a very large ecchymosis is called a *suffusion* or *extravasation.* A *hematoma* is a blood-tumor or a circumscribed hemorrhage, the blood lying in a distinct cavity in the tissue. In extremely severe contusions tissue vitality may be destroyed or so seriously impaired that gangrene follows. Suppuration rarely occurs, but occasionally does so, and is most apt to in a drunkard or a person of debilitated constitution. A contusion may lead to thrombosis and embolism. When hemorrhage arises in the tissues after a contusing force it soon ceases unless a very considerable vessel is ruptured. The arrest of hemorrhage is brought about by the resistance of the tissues, the contraction and retraction of the vessels, coagulation of blood, and in some cases of severe injury coagulation is favored by syncope. Blood in the tissues, as a rule, soon coagulates, the fluid elements being absorbed and the red corpuscles breaking up and setting free pigment, which may be carried away from the seat of injury or may crystallize and remain there as hematoidin. In some cases inflammation occurs about the extravasated blood, a capsule of fibrous tissue being formed, and the blood being slowly absorbed or the fluid elements remaining unabsorbed (*blood-cyst*), or the blood becoming thicker and thicker, and finally calcifying. Blood in serous sacs (joints, pleura, pericardium) coagulates very slowly. As blood is being absorbed it undergoes chemical changes and color changes ensue, the part being at first red and then becoming purple, black, green, lemon, and citron. The stain following a contusion is most marked in the most dependent area. After a bruise of the periosteum a blood-clot forms, much tissue induration occurs, and a hard edge can be detected by palpation at the margin of the clot. Drunkards, the obese, opium habitués, tea inebriates, anemic persons, and many neurotic individuals may develop extensive bruising from slight force.

Symptoms.—The symptoms are tenderness, swelling, and numbness, followed by some aching pain or a feeling of soreness. The pain rarely persists beyond the first twenty-four hours. Cutaneous discoloration appears quickly in superficial contusions, but only after days in deep ones. In some regions—the scalp, for instance—it can scarcely be detected; in others, as in the eyelid and vulva, discoloration is early, wide-spread, and marked. Discoloration and swelling are very marked in regions where loose cellular tissue abounds (eyelids, prepuce, scrotum). The swelling is primarily due to blood, and is added to by inflammatory exudation. In a more severe contusion a hematoma may form. A recent hematoma fluctuates, but gradually, because of cell proliferation, the edge becomes hard, but the center continues to fluctuate. The mass gradually grows smaller and finally disappears. A subperiosteal hematoma of the scalp may be mistaken for depressed fracture of the skull. Any form of hematoma of the scalp may be mistaken for an abscess, but differs from it in the absence of inflammatory signs. It occasionally, though rarely, suppurates. In a case in which suppuration occurs an abrasion, which may be very minute, often exists on the skin. In any severe contusion there is considerable and possibly grave, or even fatal, shock.

Treatment.—In a severe injury bring about reaction from the shock. Local treatment consists in rest, elevation, and compression to arrest bleeding, antagonize inflammation, and control swelling. Cold is useful early in most cases, but it is not suited to very severe contusions nor to contusions in the debilitated or aged, as in such cases it might cause gangrene. In very severe contusions employ heat and stimulation. When inflammation is subsiding after a contusion, compression and inunctions of ichthyol should be employed. If the amount of blood is very large, massage must not be used because it may cause embolism or fat-embolism. If a distinct cavity exists, aspiration or incision lessens the danger of fat-embolism. A contusion should never be incised unless the amount of blood is large and a distinct cavity exists, or hemorrhage continues, or infection takes place, or a lump remains for some weeks, or gangrene is threatened. For persistent bleeding freely lay upon the contused area, turn out the clots, ligate vessels, insert drainage-strands or a tube, and close the wound. If gangrene is feared, make incisions and apply heat to the part. If a slough forms, employ antiseptic fomentations. The constitutional treatment for contusion, after the patient has reacted from shock, is the same as that for inflammation. (See Abdomen, etc.) Massage and passive motion are imperatively needed after contusion of a joint.

Hematoma auris is a collection of blood between the perichondrium and the auricle. It is usually limited to the concave surface. The blood is absorbed very slowly and as a result of fibrous degeneration and softening of the cartilage the auricle

becomes twisted and shrunken. The condition is usually unilateral, is far more common in men than in women, is most common among the chronic insane, but does occur in the sane. In the sane it is due always and in the insane usually to traumatism. In the sane it results only from violent force. In certain types of the insane it may result from trivial force or may arise spontaneously. It is particularly apt to arise in certain forms of lunacy, viz., chronic lunacy with episodes of excitement (chronic mania, epileptic insanity, dementia with violent outbreaks, and especially paresis).

As blood gathers between the cartilage and perichondrium a lump is noticed, which gradually increases in size, fluctuates, and which is purple in color. After a few days of increase it becomes stationary, develops a hard edge, and then begins to shrink; deformity results. Such a deformed ear among the sane is known as a cauliflower ear, a boxer's ear, or a prize-fighter's ear.

During the early hours of the case use cold. Later cover with cotton wool and bandage. When the lump becomes stationary aspirate and make pressure by contractile collodion. Two or three aspirations may be required and they will lessen deformity. Aspiration does as much good as incision. After deformity has occurred nothing can be done.



FIG. 75.—Hematoma auris of the insane (Dr. E. A. Schumann).

Hematoma of scalp (page 734), if subcutaneous, is small, hard, and moves with the scalp. If subaponeurotic, is extensive, fluctuates, and develops a hard edge because of blood coagulation and thickened tissues. Blood under the pericranium cannot extend beyond the area of the bone (see Cephalhematoma, page 728). Hemorrhage under the pericranium is most common in children, for in them the vascular connections between bone and periosteum are numerous and free. Subcutaneous hematoma occurs particularly from a force applied vertically. Subaponeurotic hematoma results from a glancing blow. Hematoma of the scalp may accompany and may be confused with fracture of the skull (page 734).

Hematoma of the dura mater is discussed under Extradural Hemorrhage (page 741).

Traumatic arterial hematoma is considered under Gunshot Wounds in War and Wounds of Vessels (pages 220, 377).

For **perirenal hematoma** see page 1286.

Wounds.—A wound is a breach of surface continuity effected by a sudden mechanical force. Wounds are divided into open and subcutaneous, septic and aseptic, incised, contused, lacerated, punctured, gunshot, stab, and poisoned wounds.

The **local phenomena of wounds** are pain, hemorrhage, loss of function, and gaping or retraction of edges.

Pain is due to the injury of nerves, and it varies according to the situation and the nature of the injury. It is influenced by temperament, excitement, and preoccupation. It may not be felt at all at the time of injury. Early it is usually acute, becoming later dull and aching. In an aseptic wound the pain usually remains slight, but in an infected wound it always becomes severe.

The nature and amount of *hemorrhage* vary with the state of the system, the vascularity of the part, and the variety of injury.

Loss of function depends on the situation and extent of the injury.

Gaping or *retraction of edges* is due to tissue elasticity, and varies according to the tissues injured and the direction, nature, and extent of the wound.

The **constitutional condition** arising after a severe injury is a state known as *shock*.

Traumatic Shock.—The condition was known to the ancients. The name is comparatively modern. The term "shock" was introduced in 1795 by James Latta to designate the condition ensuing upon severe injury. (See G. C. Kinnaman in "Annals of Surg.," Dec., 1903.) Shock is a general depression of the vital powers arising from

a traumatism. As the elder Gross said: "Shock is a rude unhinging of the entire machinery of life." Collapse is a condition symptomatically identical with shock, but arising at once or almost immediately after an injury (especially a blow upon the epigastrium or testicle) or sudden and violent emotion (fear or the reception of bad news). Such a victim may or may not faint. In collapse there is anemia of the nerve-cells. There is great loss of vascular tone. It may be inhibition of the heart, reflex paralysis of vessels, or, as Crile teaches, inhibition of the vasomotor center. It is either rapidly fatal or soon passes away. Violent emotion may not cause real shock, but can certainly cause collapse, which is symptomatically identical with shock. Depressing emotions predispose to and aggravate shock (fear, worry, anxiety, etc.). A frightened patient is a worse risk than a calm one. There are many theories as to the cause and essential nature of shock.[1] Certain it is that there is no responsible defect in cardiac muscle or nerve control to account for the great fall in blood-pressure which is the most obvious phenomenon of shock. Some attribute shock to failure on the part of the adrenals to furnish sufficient adrenalin to sustain vascular tone (J. E. Sweet, Collective Review in "International Abstract of Surgery," June, 1916). Crile regards adrenal exhaustion as an essential element of shock. There is no real proof that adrenal activity is necessary to maintain blood-pressure. Henderson thinks that shock is due to a deficiency of carbon dioxid in the blood (acapnia). He maintains that injuries causing shock may reduce the return of venous blood to the heart to 60 per cent. of normal, that fear, pain, and general anesthesia, by excessive respiratory movements, reduce the amount of CO_2 in the blood (acapnia), and that prolonged acapnia lowers venous tone and so leads to gathering of blood in the veins. He now believes that hyperpnea leads to acapnia, that the failure of the venopressor mechanism results in venous anoxemia (deficiency in oxygen). Boise claims that shock is due to cardiac spasm followed by exhaustion. Meltzer looks upon shock as inhibition of the bodily functions in general. Some regard fat-embolism as the cause of shock. If fat-embolism in the lungs were the cause of shock we should always have in shock distended veins, cyanosis, and pulmonary congestion leading to edema. As a matter of fact shock does not present these conditions. In it the veins are shrunken. If cerebral emboli are thought to be causal, we must find a reason why the emboli seek the vasomotor center instead of the respiratory and other medullary centers. The shock caused by burns and by head and chest injuries finds no reasonable explanation in fat-embolism. Crile, considering wounds of the abdomen, points out that shock is always severe when hollow viscera are penetrated, and usually slight when they are not penetrated, yet in both the damage to fatty tissue is about the same. Again, in fat-embolism the symptoms are deferred and there may be high temperature. The acidosis theory (Gaskill, Bayliss) finds advocates. It is true that reduction of blood alkali follows reduction of blood-pressure, but lowering of pressure diminishes the alkali reserve and increases the H-ion concentration of blood. Acidosis means insufficient oxidation and may develop after hemorrhage or shock. It would seem that the advocates of the acidosis theory confuse a result with a cause. Starling, Malcolm, and others assert that shock is due to constriction of the arterioles resulting from paralysis of the vasodilator nerves. As a consequence of the capillary congestion there is reduction in the volume of the blood and secondary nutritive impairment. The theory that shock is the result of vasomotor failure was advocated by Keen and Mitchell over fifty years ago. The great modern advocate of this view is Crile. Certain it is that loss of blood-pressure is the most obvious phenomenon of shock. The vasomotor theory maintains that there is exhaustion or inhibition of the vasomotor mechanism. Exhaustion is gradually induced; inhibition is suddenly produced. It is supposed that by overstimulation of sensory nerves violent impressions are conveyed to the nerve-centers, the vasomotor center is exhausted or inhibited, vasoconstrictor power is lost, the peripheral arteries and capillaries are palsied and are depleted or nearly emptied of blood, and the blood is largely transferred to the veins. The blood-pressure is lowered, the cardiac action is impaired, the respiratory action is impeded, and quantities of dark colored blood gather in the somatic veins, but especially in the veins of the splanchnic area. (See the very able study of "Surgical Shock," by Crile.) Although this theory finds wide acceptance, some able investigators do not accept it. The term *collapse* is used by some to designate a severe condition of shock, and is employed by others as a name for a condition produced by functional depression of the vasomotor center the result

[1] See the very able review in "The Nature of Shock," by Major G. Seelig, in "Internat. Abstract of Surg.," Feb., 1914, and the masterly treatise on "Traumatic Shock," by Walter B. Cannon (Appleton's Surgical Monographs).

of mental disturbance, cardiac failure, respiratory failure, or vasomotor insufficiency, rather than of physical injury. Crile regards collapse as inhibition of the vasomotor center, in contrast to shock, which is exhaustion of the center. As a matter of fact, shock and collapse are often both present. Crile says that the bombardment of the nerve-centers by a tumult of peripheral impressions causing shock is shown by the fact that if the nerves from a part are thoroughly cocainized so that they will not transmit sensory impressions, operation upon the part will produce practically no shock. Crile calls such cocainization the introduction of a *physiologic block*. Again, Crile insists that in shock there are demonstrable changes in the brain cells. The changes consist in shrinking of nuclei and dissipation of the granular matter of the protoplasm. Such changes mean that the cells involuntarily discharged nerve force many times, were caused to discharge by impressions brought to them, and by the discharges were exhausted of certain necessary chemical materials. Peripheral impressions act by suggesting painful or harmful things to the nerve-cells, that is, by causing subconscious fear. Crile calls such automatic association *philogenetic association*. He aims at a shockless surgical operation. To accomplish this he combats fear and worry before operation, avoids ether (which he does not believe protects from shock), gives nitrous oxid and oxygen and blocks the sensory nerve-fibers coming from the part. Crile's thesis is that overstimulation of the mechanism which protects the organism from harmful stimuli is followed by reaction and exhaustion and that failure of blood-pressure due to exhaustion of the vasomotor center is the cause of shock. He further believes that shock may be caused not only by physical injury, but by worry, fear, mental turmoil, and infection. Cannon insists that the vasomotor center is not primarily exhausted in shock. If it were it could not be stimulated, and we know that often it can be. The same observer regards the nerve-cell changes observed by Crile as secondary results of low blood-pressure. Crile now maintains that man is an electrochemical mechanism and that exhaustion results from difference in potential between the poles of the organism (Crile, Hosmer, and Rowland on "Thermo-Electric Studies of Temperature Variations in Animal Tissues," "Amer. Jour. Phys.," 1922, lx and lxii).

Traumatic toxemia is regarded by Quénu, Cannon, Sir Cuthbert Wallace, and others as the cause of shock. Many facts render it probable. Shock is seldom seen at once after an injury, rather a little time after, yet it occurs before evidences of bacterial infection could be manifested. Shock is most profound when there has been great damage to muscle and when several or many areas have been damaged. Damaged tissue means broken-down proteins, hence the toxin. The excess of nitrogen in the blood and urine noted in shock is thus explained. When a limb has been damaged the prompt application of a tourniquet retards shock. Even if there is little tendency to hemorrhage the removal of the tourniquet may be followed by the rapid development of shock. If the external wound is small and the deep damage is grave, shock is severe, probably because of the absorption of toxins. If a large mass of tissue with the skin is carried away shock is not so profound as when the skin remains. Thorough drainage seems to antagonize it. Cannon and others state that early excision of a damaged area causes shock to disappear. Whatever theory we elect to hold as to the cause of shock, the underlying conditions are well known. The most obvious elements are great fall in blood-pressure and the notable diminution in the amount of circulating blood (60 per cent.). Too little blood returns to the heart and as a consequence the heart, getting too little blood to stir normal contractions, becomes rapid and weak. Lessening of the blood volume in the absence of hemorrhage can only be due to imprisonment somewhere of a quantity of the fluid. It was long thought that the missing blood was held in the splanchnic area, and it was said that a man in shock was bleeding to death in the splanchnic area. Surgical operations done during shock have demonstrated that the splanchnic vessels are not distended, in fact, they are actually shrunken. In all probability the blood is held in the capillaries, especially the superficial capillaries, and those of the bowel. If blood is drawn from the capillaries it is found to contain from 5,000,000 to 7,000,000 red cells. This concentration is brought about by transudation of plasma and by increased viscosity of the blood. If a vein is tapped the blood count of the venous blood is practically normal. This condition of capillary stagnation is probably brought about by toxemia which damages the capillary endothelium. (See the monograph on Traumatic Shock by Walter B. Cannon, D. Appleton & Co.) As a result of the lowered blood-pressure there is lack of oxidation which may cause acidosis. Shock may, but seldom does, arise at once or nearly at once after an injury (*initial shock*). If it does do so it is nearly always associated with serious hemorrhage or is a collapse due to emotional turmoil. As a rule shock

arises an hour or more after the injury (*primary shock*). It may arise suddenly, but usually comes on gradually, and it may even produce almost instant death. I agree with Bloodgood that even a violent injury does not of necessity at once produce it. We often see a man with a crushed limb who does not exhibit shock, the condition gradually coming on, preceded and accompanied for a time by pain, terror, etc., and being aggravated perhaps by hemorrhage. The onset of shock may be delayed for an hour or several hours. If the victim of a railroad accident is greatly excited he may actually move about for quite a time before passing into shock. A soldier seriously wounded in battle seldom shows signs of shock at once. If shock appears after many hours the surgeon should always suspect and examine for concealed hemorrhage. What surgeons used to call *secondary shock*, that is, deep shock arising twenty-four hours or more after an operation or injury, is probably due either to acute sepsis or to hemorrhage. Fat-embolism may be mistaken for shock. During an operation if shock arises it is apt to do so gradually, but this is not always the case, for sometimes it comes on with great suddenness, as when the bone of the thigh is sawed through, or when there is a burst of blood from a large vessel. Sudden death from what is usually called shock is probably due to reflex stimulation of the pneumogastric nuclei and arrest of cardiac action. It is known as *death by inhibition*. A blow over the solar plexus, upon the point of the chin, upon the testicle, on the larynx, or over the heart may cause death from inhibition. It may also occur during intralaryngeal operations or manipulations, and during general anesthesia. Sudden death from terror or from the reception of ill news is probably caused in the same way. Shock is more severe in women than in men, in the nervous and sanguine than in the lymphatic, in those weakened by suffering than in those who are strangers to illness. Disease of the kidneys, diabetes, chronic cardiac disease, and alcoholism predispose to it. Fear is probably a factor. Injuries of nerves, of the intra-abdominal viscera, of the urethra, or of the testicle produce extreme shock; so do crushes and compound fractures of the extremities, and the nearer to the body the injury is, the greater is the shock. Archibald and McLean in "Annals of Surgery," 1917, lxvi, state that on the battle front it has been found that chest wounds and head wounds seldom produce severe shock, an observation not in accord with older writings on injuries in civil life. Anything which extracts the body heat favors the development of shock (exposure to cold air, insufficient covering, chilling the body by solutions or wet towels). Those who are cold, wet, fatigued, and hungry are predisposed. Prolonged and rough transportation adds to the gravity of shock (Archibald and McLean, Ibid.). If a man with a broken thigh is transported without first splinting the limb shock will be much more grave than if the limb has been splinted temporarily. Pain adds to shock. In cerebral concussion there is shock plus other conditions. Sudden and profuse hemorrhage greatly aggravates, and prolonged anesthetization causes shock. Great shock may occur after the removal of a large tumor or a quantity of fluid from the abdomen. Exposure of tissue and vital parts, like the intestines, to air aggravates shock, and traction on intra-abdominal contents adds to it. Manipulation of the intestine is a powerful cause of shock. Acute intestinal obstruction causes shock. Crile thinks that fear (conscious, or unconscious) is an ever-existing factor in shock causation. W. T. Porter ("Boston Med. and Surg. Jour.," 1916, clxxv), in a very valuable study of shock as seen in the trenches, makes the interesting statement that during an ordinary bombardment, even if prolonged, the soldiers exhibited no fall of blood-pressure. Under a very violent bombardment with 8-inch shells the blood-pressure actually rose. The severe shock noted in most of those wounded in battle is due largely to rough and prolonged transportation and delayed treatment. A general anesthetic may cause or add to shock. Chloroform does so more than ether. Nitrous oxid and oxygen does so least.

Crile maintains that an individual may be anesthetized by ether or chloroform and feel no pain, and yet noci-influences may cause shock. The influences then act by suggesting painful or harmful things to the nerve-cells, that is, by causing subconscious fear.

The **symptoms** of well-developed ordinary shock (*torpid* or *apathetic shock*) are subnormal temperature; weakness of heart action; irregular, small, weak, rapid, and compressible pulse (very soon after the beginning of shock the pulse may be slow and remain so for a brief time, but it soon becomes frequent). The mucous membranes wherever visible are blanched. The lips, lobes of the ears, nails, and tips of the fingers and toes may be bluish. The eyes are sunken and fix on some object with a purposeless stare. The face is expressionless and exhibits neither pain nor anxiety. The skin is cold,

of marble pallor or of ashy whiteness, bloodless, and often clammy or profusely perspiring. Sweating about the head is particularly noticeable. The respirations are shallow, frequent, feeble, irregular, and perhaps sighing or gasping. The extremities are cold. The reflexes are diminished in activity. A sphygmomanometer will indicate a notable fall in blood-pressure. The victim may not move at all, or may now and then make a movement of arm, leg, or body. If an extremity is lifted and suddenly dropped it falls like a palsied part. There is little or no appreciation of pain, although when he moves or is moved he may groan. The expired breath feels cold to the surgeon's hand. The voice is low and harsh and sounds sepulchral and far away. Consciousness is usually maintained, but there is an absence of mental originating power, the injured person answering when spoken to, but volunteering no statements and lying with partly closed lids and expressionless countenance in any position in which he may be placed. The answers to questions though apparently intelligent may be utterly unreliable. If asked how he feels he will say he is weak and that his limbs are dead. Before death stupor may creep upon the patient. There is great motor weakness and muscular relaxation. The pupils are dilated and react but slowly to light. The sphincters are relaxed. Nausea is absent and vomiting may, as in concussion, presage reaction. Gastric regurgitation, after a considerable duration of shock, is not unusual, and is a bad omen. It must impress students of physiology that certain of the well-known signs of shock do not seem to indicate that there are paralysis and dilatation of the peripheral vessels, as the popular theory of shock supposes. The signs which do not co-ordinate with the theory are anemia of the surface, lowered temperature of the surface, and small pulse (Seelig and Lyon in "Surgery, Gynecology, and Obstetrics," Aug., 1910). Shock is not rarely followed by acidosis and by suppression of urine. Whereas the victim of shock is usually stupid and indifferent, he may become delirious. If delirium arises, the condition is very grave. Travers called shock with delirium *erethistic* or *delirious shock*. As a matter of fact, such a state is not genuine shock, but is either a traumatic or a toxic delirium added to or following upon shock. It is usually due to uremia or sepsis. Delirious shock may arise after a person has been bitten by a poisonous snake. Many years ago Travers described a *delayed form* of shock, which comes on twenty-four hours or more after an injury. It may be a sign of hemorrhage or an evidence of acute sepsis, and is sometimes met with after the administration of ether or chloroform. Fat-embolism may be mistaken for it. The statements made by a person who has recovered from a severe shock are always unreliable as to events which occurred while shock existed, and are often doubtful as to the details of the accident. Not unusually the memory of the accident is perverted or even destroyed.

Diagnosis.—Concealed hemorrhage is difficult to differentiate from shock. The former produces impairment of vision (retinal anemia), great restlessness, frequent yawning, extreme thirst, nausea, and sometimes convulsions. In shock the hemoglobin is unaltered in the blood obtained from a venous tap; in hemorrhage it is greatly reduced (Hare and Martin). In shock the blood of a capillary tap shows increase of red corpuscles, in hemorrhage it does not. In hemorrhage recurrent attacks of syncope are met with. In pure shock such attacks do not occur. In abdominal hemorrhage the abdomen may exhibit physical signs of a rapidly increasing collection of fluid. Shock and hemorrhage are often associated. A usual characteristic of shock is rapid onset, which separates it distinctly from exhaustion. It arises usually at an earlier period after an injury than does fat-embolism, in fat-embolism there are pulmonary or cerebral signs which are absent in shock, and in embolism the temperature sooner or later becomes elevated.

The Prevention of Shock in Operations.—When possible examine the patient with care before operating, giving special attention to the condition of the kidneys and know if there is acidosis. The amount of urine passed and the amount of urea it contains should always be determined when possible. The amount of urea should be estimated from the twenty-four-hour urine. The normal amount of urine in the twenty-four hours is about 50 ounces and the normal amount of urea 2 per cent. Less urea is significant of danger from shock and subsequent kidney complications. If blood examination shows lessening in the alkali reserve and it is not possible to postpone operation, precede operation by the intravenous injection of 1 pint of a warm 2 per cent. solution of sodium bicarbonate and an enema of glucose, and follow operation by glucose enemas. If the condition of the patient leads us to fear that there may be dangerous shock, do not purge him at all before operation, and just previous to operation give a rectal injection of hot saline fluid and a hypodermic injection of 1/100 gr. of atropin. It is also a good plan in some cases to give a hypodermic injection of 1/8 gr. of mor-

phin twenty minutes before operation. It tranquilizes the patient and less ether will be needed to anesthetize him. Examine the patient thoroughly and prepare him carefully beforehand and decide if he should take a general anesthetic at all, and if so, which one. Nitrous oxid does not seem to cause shock, Crile says, because cell activity is lessened by deficiency of oxygen.

Many operators believe that ether and chloroform lessen shock. Crile disputes this. He holds that they merely inhibit conscious fear and muscular response to peripheral impressions, but do not save the brain-cells from noci impressions, and hence do not save the cells from exhausting discharges.

It would seem probable that a drugged brain-cell could not receive influences as acutely and strongly as one untouched by ether or chloroform. I believe that a general anesthetic given properly and in proper amount does, to some extent at least, lessen the shock of an operation.

In some cases (as in typhoid perforation or strangulated hernia) a local anesthetic may be used. The nerves well above the area of operation should be infiltrated with novocain, even if a general anesthetic has been given. This prevents the ascent of peripheral impressions, makes what Crile calls a "physiological block," and so antagonizes shock. After infiltration of the nerves with novocain, even if a general anesthetic has not been given, a limb can be amputated below the infiltrated area without pain and without great depression of the vital powers. I have performed a number of amputations most satisfactorily relying for anesthesia purely upon anesthetization of the nerves. In these cases there was very little shock. This is a valuable procedure even when ether is given. In some few cases in which we fear shock spinal anesthesia is used; in others, scopolamin and morphin is given. If a general anesthetic is used it must be skilfully administered and not a drop should be given beyond the amount necessary to maintain thorough anesthesia. Cover every part but the field of operation with hot blankets and put cans of hot water about the patient, or put him on a bed composed of hot-water pipes covered with blankets. Prevent bleeding with the greatest possible care. Operate as rapidly as is consistent with safety and thoroughness. The blood-pressure is of great importance in estimating the degree of shock, and any sudden fall of blood-pressure is ominous. It is a custom with many operators to fix a sphygmomanometer to the arm and have an assistant watch the scale constantly during an operation. If shock develops during an operation, hasten on the work, lessen the amount of ether, and apply active treatment. Return the patient to bed as soon as possible and without exposure in cold halls or a windy elevator shaft. Occasionally it becomes necessary to suspend an operation in order to prevent death on the table.

Crile's **anoci association operation** is founded on the prevention of shock by the exclusion as far as possible of all painful, terrifying, and depressing influences from a patient before, during, and after operation. The patient is not kept for days or even for hours waiting in fear. He is to be reassured, made confident, is to be dominated by his surgeon. He is anesthetized by means of nitrous oxid and oxygen, ether being added only if necessary. The tissues and sometimes the nerve trunks are infiltrated with a local anesthetic. During the operation all noci impressions are carefully excluded. This method, in the hands of Crile, Bloodgood, and others, has given highly satisfactory results.

Treatment.—In treating shock with hemorrhage first, and as soon as possible, arrest hemorrhage (page 197). In treating ordinary apathetic shock raise the feet and lower the head, unless this position causes cyanosis. At least place the head flat and the body recumbent. Wrap the patient in hot blankets. Have several blankets under him and surround him with hot bottles, hot bricks, hot-water bags, or cans of hot water. Always wrap a can, a bottle, or a bag in flannel or some other material to avoid burning the patient. If the patient does not vomit, and if we are sure there is no perforation of an abdominal viscus give hot coffee by the mouth. Hot coffee is a useful enema in shock. Ordinary stimulants seem of little or no value and drugs given by the stomach are not absorbed. Salt solution should be thrown into a vein if blood-pressure is below 80 (*intravenous infusion*). If blood-pressure is higher, it may be given by the rectum (*proctoclysis*) or subcutaneously (*hypodermoclysis*). Intravenous infusion does some good, but, unfortunately, the benefit is very temporary. The best solution to use is a pint of salt solution (0.9 per cent.) containing 6 per cent. of gum acacia. This fluid does not leave the vessels nearly as soon as pure normal salt, and hence its value in adding to the amount of the circulating blood is much prolonged. Blood transfusion is very valuable in hemorrhage cases, but is seldom demanded in pure shock. Salt solution containing adrenalin is of notable

service in hemorrhage cases (each liter of salt solution contains 1 teaspoonful of a 1:1000 solution of adrenalin chlorid). The operation of intravenous infusion is described on page 421. The custom of giving salt solution in a vein has become so common that resident physicians are apt to resort to it as a routine. It is to be remembered that if given rapidly or in too great quantity it may gather in the chambers of a dilated right heart and arrest a heart so weakened that it has almost reached its limit of function. I am satisfied that the rapid administration of salt solution intravenously is responsible for some deaths. Crile maintains that the only way "to increase and sustain the blood-pressure when the vasomotor center is exhausted" is to "create a peripheral resistance either by a drug acting on the blood-vessels themselves or by mechanical pressure."[1] In order to accomplish this he used adrenalin chlorid. Because of the rapidity with which this drug is oxidized he gives it intravenously, slowly and continuously from a buret, using a solution of a strength of from 1 : 50,000 to 1 : 100,000 in salt solution. The rate of flow should be "controlled by a screw-cock attached to the rubber tube." Crile also places the patient in a rubber suit and distends the suit by means of an air pump and thus obtains equable resistance. The difficulty with giving the solution in a vein is that the drug first comes in contact with "the vessels having the least power of influencing blood-pressure," and before a notable rise can be affected by arterial action "it is necessary that the solution should pass through the right heart, the lungs on its way to the aorta, then finally affecting the coronary arteries" (Crile in "Amer. Jour. Med. Sciences," Jan., 1909). The best way to use adrenalin solution in very dangerously severe shock is to introduce it as Crile now advises, that is, into the arterial system and toward the heart. Occasionally, by this means, resuscitation from apparent death may be accomplished. Crile calls this method *centripetal arterial transfusion*. It is applied as follows ("Amer. Jour. Med. Sciences," April, 1909):

"In human resuscitation the technic is as follows: The patient in the prone posture is subjected at once to rapid rhythmic pressure upon the chest, with one hand on each side of the sternum. This pressure produces artificial respiration and a moderate artificial circulation. A cannula is inserted toward the heart into an artery. Normal saline, Ringer's, or Locke's solution, or, in their absence, sterile water, or, in extremity, even tap water, is infused by means of a funnel and rubber tubing. But as soon as the flow has begun the rubber tubing near the cannula is pierced with the needle of a hypodermic syringe loaded with 1 : 1000 adrenalin chlorid, and 15 to 30 min. are at once injected. Repeat the injection in a minute if needed. Synchronously with the injection of the adrenalin the rhythmic pressure upon the thorax is brought to a maximum. The resulting artificial circulation distributes the adrenalin that spreads its stimulating contact with the arteries, bringing a wave of powerful contractions and producing a rising arterial, hence coronary, pressure. When the coronary pressure rises to, say, 40 mm. or more, the heart is likely to spring into action. The first result of such action is to spread still further the blood-pressure-raising adrenalin, causing a further and vigorous rise in blood-pressure, possibly even doubling the normal. The excessively high pressure is most favorable to the resuscitation of tissue, especially of the central nervous system (Stewart). Just as soon as the heart-beat is established the cannula should be withdrawn, first, because it is no longer needed, and second, because the rising blood-pressure will drive a torrent of blood into the tube and funnel. Unless there has been hemorrhage, the only object in the use of saline infusion is to serve as a means of introducing the adrenalin into the arterial circulation toward the heart. Bandaging the extremities and abdomen tightly over masses of cotton is very useful." Direct injection of the heart with adrenalin is described on page 1208.

In prolonged shock and in shock with persisting hemorrhage direct transfusion of blood is indicated (see page 410). The use of hot and stimulating rectal enemata is important. The rectum may absorb fluids when the stomach refuses to do so. An enema of hot coffee is decidedly stimulating. Enemata of hot normal salt solution are beneficial (*proctoclysis*). The tube is carried as high as possible and the injection is introduced so as to distend the colon. *Hypodermoclysis* is given as follows: Insert an aspirator tube into the cellular tissue of the loin, scapular region, or under the mamma, first disinfecting the part with tincture of iodin. The tube is attached to a fountain syringe, which is filled with warm normal salt solution, and is hung at a height of 2 or 3 feet above the bed (Fig. 76). In an hour's time a pint or more of fluid will enter the tissue and be absorbed. It is the custom to give hypodermic injections of ether, brandy, strychnin, digitalis, or atropin. Crile has demonstrated experimentally

[1] George Crile in "Boston Med. and Surg. Jour.," March 5, 1903.

that strychnin is perfectly futile in pure shock and may actually aggravate the condition. In collapse it is of some value. We believe this statement is true clinically. Strychnin goads a heart to increased action when that organ has not sufficient blood passing into it to enable it to contract firmly and strongly. The use of strychnin in shock has been compared by Hare to beating a dying horse to make it pull. I believe that atropin is of definite but temporary benefit in shock, especially if the skin is very moist. This drug, according to my colleague, Prof. Hobart A. Hare, is a sedative to the vagus; but what makes it particularly valuable is that it acts upon the vasomotor system, combats the dilatation of the blood-vessels, maintains vascular tone, opposes stagnation of blood in any vessels, and increases the amount of moving blood. If the skin is very moist, atropin is particularly indicated. Senn recommends the hypodermic injection of sterile camphorated oil, a hypodermic syringeful every fifteen minutes, until reaction begins. Inhalation of oxygen is often of much service, and artificial respiration may be necessary. Mustard plasters should be placed over the heart, spine, and shins. A turpentine enema is useful. Pituitrin is a remedy to restore blood-pressure. The dose for intramuscular injection is from 10 to 30 min. It is usually given intravenously in saline fluid. The duration of its action is brief. In severe cases of shock bandage the extremities. Bandaging for the relief of shock is called *autotransfusion*. This procedure increases peripheral resistance and enables the body to utilize to the best advantage the small amount of circulating blood, and sends most of it to the brain, where it will maintain the activity of the vital centers and keep up circulation and respiration. For this purpose ordinary muslin bandages may be used, or gauze bandages, or the bandages of Esmarch. Crile's rubber suit accomplishes the object more satisfactorily than does bandaging the extremities. The victim of shock must rest, and the best rest is during sleep as a rule. If pain does not develop and if restlessness does not arise sleep will come. If there is pain and restlessness, give $\frac{1}{4}$ or $\frac{1}{2}$ grain of morphin. Crile believes in morphin, and gives it in sufficient amount to lower the respirations to 12 per minute, but, as John Fraser says, reduced respiration means increased risk of acidosis. In serious cases artificial respiration and stimulation of the diaphragm with a galvanic current may be used. At the military front the elements of treatment were regarded by many as gravity, injection of normal salt solution, and adrenalin (W. T. Porter, Ibid.). The head is placed 30 cm. lower than the feet and the position is maintained until blood-pressure becomes nearly normal. Saline fluid is thrown into the veins if the blood-pressure is below 80 and the administration is stopped when the pressure reaches 80. Should it fall again, adrenalin is injected into an ankle vein. When very low blood-pressure is associated with continued bleeding immediate transfusion of blood is indicated. In Depage's hospital at La Panne and in Carrel's hospital at Compiègne a special table was used to obtain the lowered position of the head and the table was heated by electricity. Porter is disposed to believe that respiratory reaction may be of service, the thoracic pump driving blood to heart and lungs. Should we operate during shock? We should certainly do so when death without prompt operation is inevitable. We must operate, if it is necessary to do so, to arrest hemorrhage, to relieve strangulated hernia,

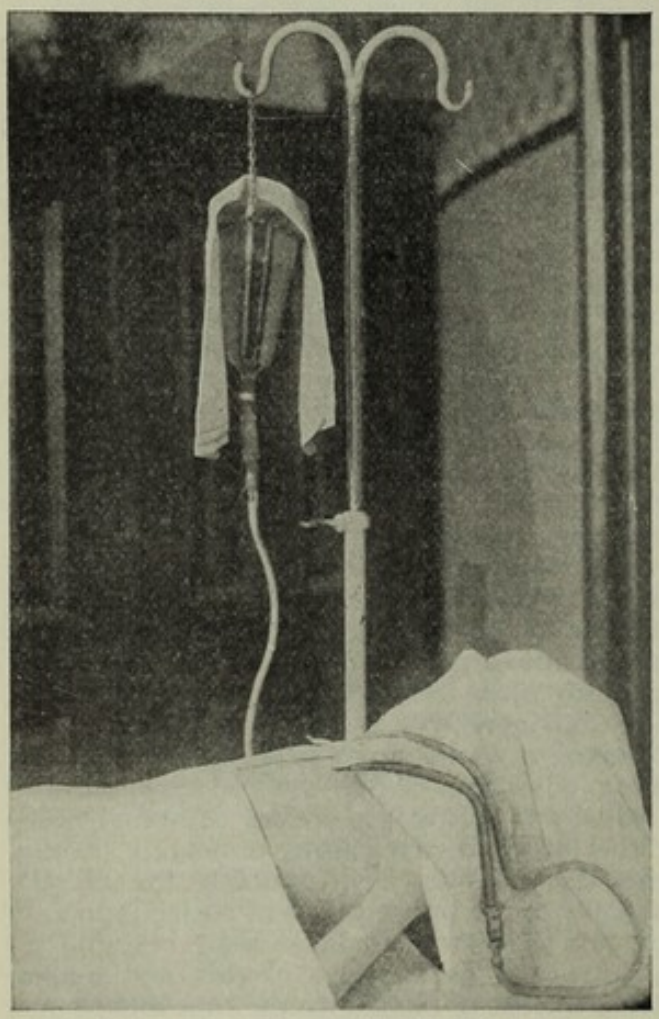


FIG. 76.—Subcutaneous saline infusion (Senn).

intestinal obstruction, obstruction of the air-passages, compound fractures of the skull, extravasated urine, or intraperitoneal extravasations from ruptured viscera. If hemorrhage can be temporarily controlled by pressure or a clamp, so much the better, and the permanent arrest can be effected after the reaction from shock. It is not judicious, in the author's opinion, to amputate during shock if hemorrhage is controlled. The band which controls the bleeding also prevents the absorption of toxic products from the region of tissue damage, and so tends to prevent aggravation of shock. A tourniquet or Esmarch bandage should be applied, and attempts be made to bring about reaction, and when reaction is obtained the amputation should be performed. If the patient does not show promptly evidences of reaction, and particularly if the trend is toward a worse condition, do not delay, but operate. It is only just to say that some eminent surgeons oppose this rule. Roswell Park says that "shock is often alleviated by the prompt removal of mutilated limbs which, when still adherent to the trunk, seem to perpetuate the condition." The same teacher believes in operating at once upon severe compound fractures.[1] After every operation keep careful watch upon the amount of urine passed, see to it that the patient takes sufficient fluid, and if the urine becomes scanty put a hot-water bag to each loin, give diuretics by the mouth, secure cutaneous activity, give saline purgatives, and administer hot saline enemata. If the condition is not soon benefited, the custom is to infuse hot saline fluid into a vein. I am doubtful if intravenous infusion of saline fluid is beneficial in suppression, and I even fear it may do harm (see the studies of Widal, Marie and Crouzon, Merklen, and others). Rössle ("Centralbl. f. Chir.," 1907, xxxiv) says that in certain cardiac and renal conditions salt solution damages the capillaries and does actual harm. In urinary suppression following accident or surgical operation (*postoperative suppression, postoperative anuria*) the condition is so dreadfully grave that it is justifiable to expose each kidney and split the capsule in order to relieve tension and in the hope of thus abating congestion. In fact, I believe this should always be done. In a case in which there had been total suppression for three days I did this operation. During the next thirty-six hours the patient passed 12 oz. of urine, but died of complications. *Postoperative suppression of urine* is almost invariably fatal. Acidosis must be watched for, and if it arises is to be fought actively (page 107). So-called delayed shock is treated in the same manner as apathetic shock if hemorrhage, sepsis, and fat-embolism can be excluded. If hemorrhage is the cause, the bleeding must be arrested, and blood be transfused, or saline fluid be infused into a vein. If delirious shock is due to sepsis, the treatment is that of sepsis. If it is nervous delirium, give morphin and other sedatives. If due to uremia, the treatment is obvious.

Fat-embolism.—(See page 122.)

Fever.—(See Fevers, page 58.)

Treatment of Wounds.—All wounds other than those made by the surgeon are regarded as infected. The rules for treating such wounds are: (1) arrest hemorrhage; (2) bring about reaction; (3) remove foreign bodies; (4) antisepticize; (5) drain, coaptate the edges, and dress; (6) secure rest to the part and combat overaction of the tissues. Constitutionally, allay pain, secure sleep, maintain the nutrition, and treat inflammatory conditions. In many cases give prophylactic doses of antitetanic serum.

Arrest of Hemorrhage.—To arrest hemorrhage the bleeding must be controlled by an Esmarch band or digital pressure until the bleeding point can be grasped with forceps; it is then caught up and tied with catgut or aseptic silk. Slight hemorrhage ceases spontaneously on exposure of the bleeding point to air, and moderate hemorrhage ceases permanently after the temporary application of a clamp. An injured vessel when not of the smallest size must be ligated, even if it has ceased to bleed. Capillary oozing is checked by hot water (120° F.) and compression. If a large artery is divided in a limb, apply a tourniquet before ligating. (See Wounds of Vessels.)

Bringing About of Reaction.—(See Shock.)

Removal of Foreign Bodies.—Remove all foreign bodies visible to the eye (splinters, bits of glass, portions of clothing, gun-wadding, grains of dirt, etc.) by forceps and a stream of corrosive sublimate solution, sterile water, or normal salt solution. In a lacerated or contused wound portions of tissue injured beyond repair should be regarded as foreign bodies and be removed with scissors.

Cleaning the Wound.—To clean the wound shave the surrounding area if it is hairy. If we intend to disinfect with iodin the shaving must be done dry. Rub the adjacent skin with alcohol and paint the wound and the skin with a 2 to 5 per cent. iodin solution. Or, the skin may be scrubbed with castile soap, green soap or with

[1] Park's "Surgery by American Authors."

ethereal soap and water, shaved with the aid of lather, and the skin and wound disinfected by a mixture of alcohol, phenoco, and acetone (A P A mixture). A 0.5 per cent. solution of hypochlorous acid is valuable for wound disinfection. Disinfection is only relative. Complete primary disinfection is not possible if infection exists. It is more nearly possible when there is only contamination. In *contamination* microbes are free in the wound. In *infection* they have entered into the tissues which surround the wound. Complete disinfection of an infected area can be accomplished by extirpating the wound. In every wound in which we have reason to suspect tetanus infection a preventive dose of antitoxin should be given. We have particular occasion to apprehend tetanus if the wound is contaminated with feces, street dirt, stable dust, or stable refuse, or if it were caused by a toy pistol such as boys use to celebrate the Fourth of July. Lacerated wounds and punctured wounds are particularly apt to be followed by tetanus. A clean wound made by the surgeon need not be irrigated or treated with antiseptics; in fact, an antiseptic leads to necrosis of tissue, causes a profuse flow of serum, and necessitates drainage. If clots have gathered in a wound they must be removed, as their presence will prevent accurate coaptation of the edges. In an infected wound they are washed out by a stream of corrosive sublimate solution or, better, by a 0.5 per cent. solution of hypochlorous acid. In a clean wound they are washed out by hot salt solution. If dirt is ground into a wound, as is often seen in crushes, excision is desirable. If this is not or cannot be done, pour sweet oil or gasoline into the wound, rub it into the tissues, and scrub the wound with ethereal soap. The oil or gasoline entangles the dirt, and the soap and water remove both oil and dirt. After the rough cleansing irrigate with hypochlorous acid (0.5 per cent.). In some cases, especially in bone injuries, it is necessary to scrape the wound with a curet. If a fissure of the skull is infected, enlarge the fissure with a chisel in order to clean it. In a badly infected wound one of the popular agents for use in producing disinfection is pure carbolic acid. After cleaning the wound, it is necessary in certain regions to examine in order to determine if tendons or important nerves have been cut. If such structures have been divided, they must be sutured with fine silk, chromic gut, or kangaroo-tendon.

Drainage, Closure, and Dressing.—Superficial wounds require no special drainage, as some wound fluid will find exit between the stitches and the rest will be absorbed. A large or deep wound requires free drainage for at least twenty-four hours by means of a tube, strands of horsehair, silk or catgut, or bits of iodoform gauze. An infected wound must be drained invariably. Good drainage may, to a considerable extent, compensate for imperfect antisepsis. Some wounds are allowed to remain wide open. This is usually the best plan in infected wounds of the hand. Violent suppuration may impair the usefulness of the hand and so destroy a man's ability to earn a living. Spreading suppuration seldom occurs when the wound is kept open. If capillary drains are employed, apply a moist dressing. Otherwise the strands dry and fail to act as drains. Approximate the wound edges with interrupted sutures of silk or silkworm-gut if the wound is deep and considerable tension is inevitable. Catgut is used for superficial wounds and for those where tension is slight. If there is decided tension, silver wire may be used. In very deep wounds buried sutures must be used. These sutures may consist of absorbable material (kangaroo-tendon or catgut) or unabsorbable material (silver wire or very fine silk). Of late I have been following the Johns Hopkins custom and have closed all clean wounds with sutures of very fine iron dyed silk passed by small and very sharp sewing needles. By the use of these fine sutures a minimum amount of tissue necrosis occurs, the risk of infection is greatly lessened, and the resulting scar is the smallest that can be obtained. As is well known, tight sutures cause tissue necrosis and hence predispose to infection. It is impossible to tie the fine black silk tightly, because if we try to do so it breaks. It requires considerable practice to learn to tie the sutures without breaking. This fine silk can be buried without fear, as it never causes a sinus, and it is used for layer sutures with perfect confidence. I learned this plan from Dr. Harvey Cushing, and am much pleased with it. If the wound is infected, it has been the custom to dress with warm, moist antiseptic gauze covered with dry gauze. If it is not infected, dress with dry sterile gauze. The custom once was to cover even dry gauze with a rubber-dam to diffuse the fluids, but we now prefer to omit the rubber-dam and use plentiful dressings. A dry dressing absorbs wound fluids quickly and is less likely to become infected. Change the dressings in twenty-four hours or sooner if they become soaked with discharge. Dressings are changed for cause, but not according to scheduled time. They must, of course, be changed when they become soaked with wound fluid, and

soaking may occur in a few hours, but may not occur for days. As long as the temperature remains normal and the wound free from pain, if the dressing is not wet with discharge, it can be left in place unless removal is necessary to take out a drainage-tube. If pus forms, open the wound at once. Many surgeons sprinkle wounds before approximation and wound surfaces after approximation with a drying powder. These powders are of great use in infected wounds, but are not necessary in clean wounds. Among the substances employed are salicylic acid, boric acid, calomel, acetanilid, aristol, iodoform, subiodid of bismuth, and glutol. In large wounds which cannot be approximated it is occasionally advisable to skin-graft by Thiersch's method. A small wound which cannot be sutured is dusted with an antiseptic powder and dressed. A granulating wound is dressed as is a healing ulcer. In recent infected wounds, disinfection, drainage, Dakin's fluid or dichloramin-T and rest, associated with Bier's treatment, comprise the means of local treatment. Incision is usually required. In later infections or severe infections the wounds must be opened widely and treated with Dakin's fluid or dichloramin-T. A sloughing wound is opened, is dusted with iodoform or acetanilid, and is dressed with hot antiseptic fomentations.

Many of the above rules have been set aside by the introduction of the Carrel-Dakin fluid or dichloramin-T. One of these is now generally used in infected wounds. It gradually makes the wound fluid practically sterile, at which time secondary suturing can be performed (page 231).

Rest.—Severe wounds require the confinement of the patient to bed. Bandages, splints, etc., are used to secure rest. In a closed wound rest need not be protracted, in fact, our former custom was to insist upon it for too long a period. The slight irritation of moderate motion stimulates repair. We no longer feel it necessary to keep laparotomy cases in bed for three full weeks, but we get them up in from ten to twelve days. By doing this we secure just as firm a cicatrix, greatly lessen the annoyance from constipation and flatulence, and diminish notably the number of cases of postoperative pneumonia and phlebitis. I do not, however, advocate getting such patients up in twenty-four to thirty-six hours, as is advised by some surgeons. A patient with an infected wound or an open or draining wound should be confined to bed. The methods of combating inflammation have previously been set forth. In wounds of the hand rigid immobilization must not be persisted in too long. To do so will mean adhesion of tendons and impairment or destruction of the usefulness of the hand. If spreading infection arises motion is not permissible until infection ceases to spread and granulations begin to form. If there is no infection, passive motion of wrist and fingers should be begun the day after the injury and each day the hand should be dressed in a different position.

Constitutional Treatment.—Bring about reaction from depression, but prevent undue reaction. Feed the patient well, stimulate him if necessary, attend to the bowels and bladder, secure sleep and allay pain. Watch for complications, namely, inflammation, suppuration, gangrene, tetanus, erysipelas, suppression of urine, and pneumonia. Observe the temperature closely; it may be a danger-signal of urgent importance.

Incised Wounds.—An incised wound is a clean *cut* inflicted by an edged instrument. Only a thin film of tissue is so devitalized that it must die. Such wounds have the best possible chance of union by first intention.

The pain may be very severe; but if the instrument, weapon, or tool was sharp and used quickly pain may be trivial. The pain is less severe than that caused by some other varieties of wounds. The acute pain does not last long, and is followed by smarting. The hemorrhage is profuse, varying, of course, with the region cut. Bleeding from the scalp is violent, because there are numerous vessels which lie in fibrous tissue and they can neither retract nor contract. The edges of an incised wound retract because of tissue elasticity, and the wound "gapes." If the skin or fascia is divided at a right angle to the muscle beneath, there is wide gaping. If the cut is parallel to the muscle-fibers, the gaping is slight.

When the skin is violently pulled upon, it tends to split in a certain line. Langer and Kocher speak of this as the line of cleavage, and point out the direction of these lines in various situations. A cut across the line of cleavage is followed by wide gaping. A cut in the direction of the line of cleavage produces slight gaping, and is followed by a trivial scar.

When a muscle is cut across the wound edges separate widely. When a tendon is completely cut across extensive separation occurs.

An incised wound can be thoroughly inspected, all divided structures can be iden-

tified, foreign bodies can be easily removed, and disinfection can be carried out satisfactorily.

Treatment.—According to general principles. Arrest hemorrhage, asepticize, etc.

Examine the wound carefully to see if a nerve, a tendon, or a muscle is divided, and if such injury is discovered, insert sutures at once (Figs. 77 and 78). If the wound is extensive or deep, it may be necessary to use buried sutures in order to keep the sides of the wound in contact. If the surface of a wound is approximated, but the depths are not, the dead space or cavity becomes filled with wound fluid, and infection almost certainly occurs. If buried sutures have not been used, such a cavity must be obliterated by the judicious application of pressure upon the surface. This is secured by the adaptation of a mass of loose or fluffed-up gauze, and the firm application of a bandage or binder. If a dead space cannot be obliterated by pressure, it should be drained. An incised wound is usually closed with interrupted sutures (Figs. 79 and 80). In adjusting the sutures, see that the edges of the wound

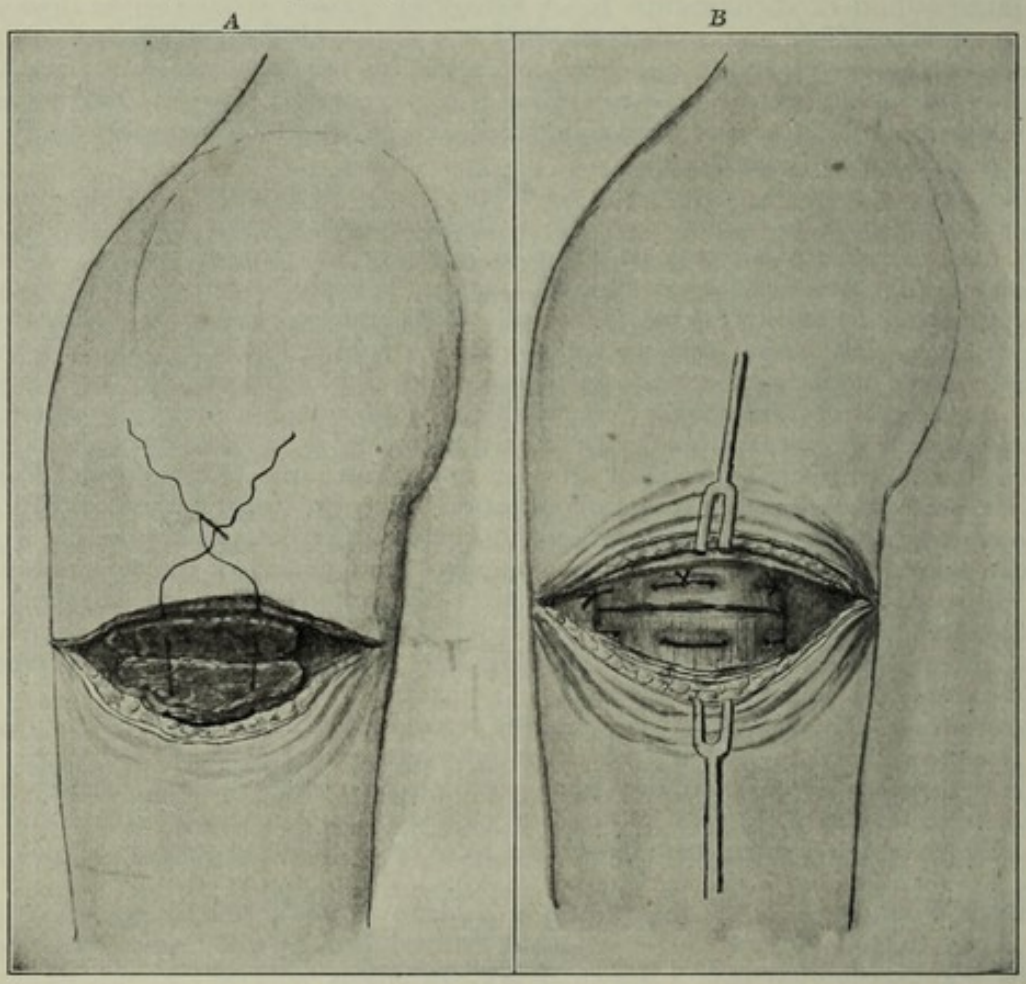


FIG. 77.—Muscle suture: *A*, Transverse wound of biceps muscle, showing marked retraction of muscle-ends and mattress-suture in place; *B*, muscle suture completed (Senn).

are not inverted, but are neatly approximated with raw edge to raw edge. Tie the stitches firmly, but not tightly. If a stitch is tied too tightly it will make a ridge, as shown in Fig. 79, and undue tightness is sure to cause necrosis, and is often productive of a stitch-abscess. As previously stated, I usually close wounds with sutures of very fine black silk. This will break if we try to tie it tightly, and as it never causes a sinus when retained in the tissues it can be used for buried sutures as well as for the skin. A silk suture and a catgut suture should be tied with the reef knot; a suture of silkworm-gut may be tied with either a surgeon's knot or a reef knot. If a wound is on the face, particular care must be employed in closing it, in order to limit the amount of disfigurement. Fine sutures of silk or horsehair are passed with a fine sharp needle or a subcuticular stitch is used. In a clean wound stitches may, as a rule, be removed in from six to eight days. In a large wound one-half the stitches are removed at one sitting, and in a day or two the rest are removed. Stitches are removed promptly if they begin to cut out or if infection occurs.

The old continued suture is rarely used for skin wounds at the present time. This suture is employed to suture the dura after division, to suture the two layers of pleura together before an abscess of the lung is opened, to suture the peritoneum after laparotomy, and to suture the mucous membrane after certain operations upon the stomach. The continuous suture is shown in Fig. 81. A continuous suture knotted after each

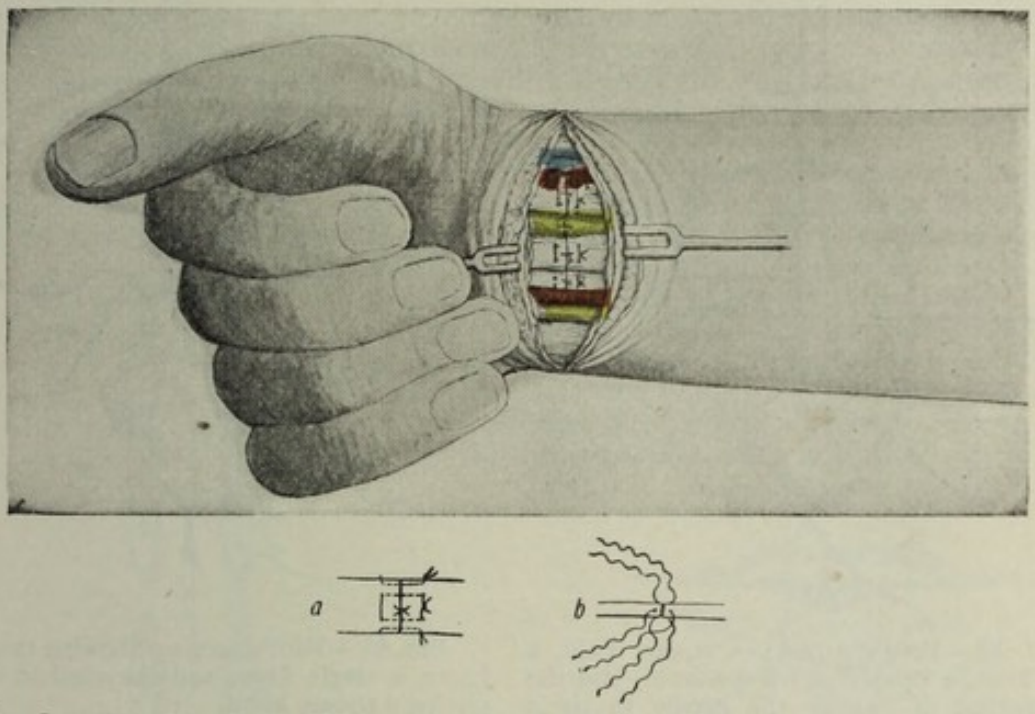


FIG. 78.—Suturing of tendons and nerves in incised wounds: *a*, Primary tendon suture; *b*, primary nerve suture (Senn).

emergence was devised by Ford. It is very useful in suturing the parietal peritoneum (Figs. 82 and 83).

Chassaignac in 1851 devised a method of intradermic suture which Kendal Franks revived some twenty-five years ago.

Halsted's subcuticular stitch (Fig. 84) makes a most perfect closure of the skin wound, and is followed by the smallest possible scar. In closing a deep wound the

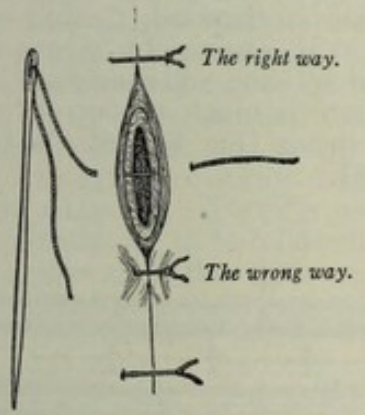


FIG. 79.—The interrupted suture (after Bryant).

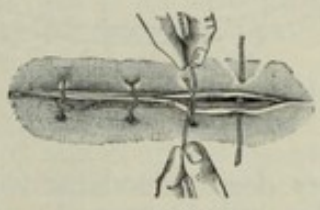


FIG. 80.—Tying an interrupted suture. The knot is placed to the *side* of the wound as shown in Fig. 79.

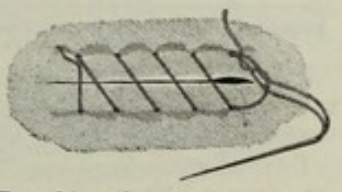


FIG. 81.—Continuous suture.

muscles, fasciæ, and subcutaneous structures are sutured in layers by buried sutures before the subcuticular stitch is inserted. It is only used in wounds which are almost certainly clean (as those made by the surgeon), and in wounds which do not require drainage. The suture material should be of fine silver wire or horsehair caught upon a curved Hagedorn needle or silkworm-gut carried by a long, straight, round needle. The suture is passed through the corium on each side of the wound, as shown in Fig. 84. The curved needle must be held in the bite of a needle-holder. When the suture

has been passed the ends are pulled upon, and the skin wound closes neatly. This method secures a linear cicatrix (see Arana on "The Intradermic Suture" in Semaine méd., 1916, xxiii).

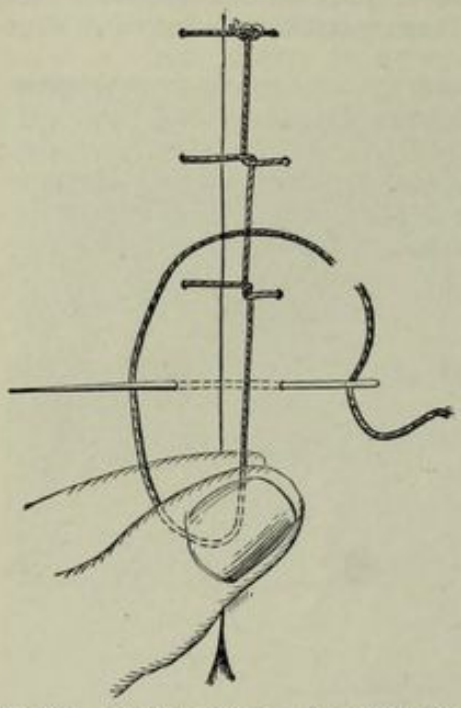


FIG. 82.—Ford's suture: A square knot, a single knot, a double or friction knot, and the first method of passing the needle to tie a single knot immediately.

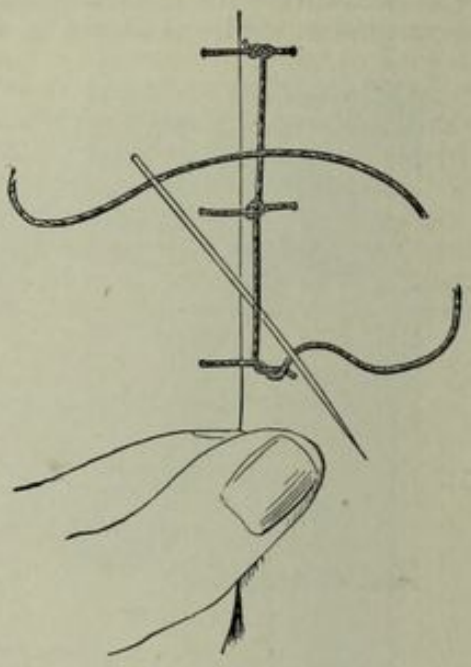


FIG. 83.—Ford's suture: Showing two square knots, a single knot, and the method of completing a square knot.

Halsted's suture does not penetrate the cuticle; hence, in passing it the white staphylococcus is not carried through stitch-holes and into the wound, an accident which might be followed by infection of a stitch hole or even of the wound. When it is desired to withdraw this stuure, take one end in the bite of the forceps, cut it off short with scissors, catch the free long end with forceps, and pull steadily upon it. During withdrawal the wound is supported by light pressure on a superimposed piece of gauze. A wound of a knuckle is cleansed, treated with 3 per cent. iodin, drained by means of a piece of rubber tissue, and should not be sutured.

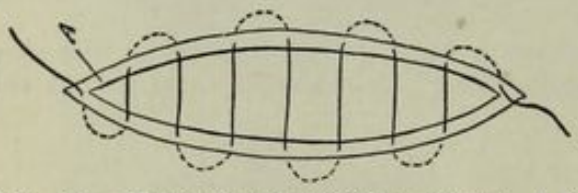


FIG. 84.—Halsted's subcuticular suture: *A* is the true skin.

In very deep wounds or wounds in which there is much tension after approximation the quilled suture (Fig. 85) or the button suture (Fig. 86) may be used. The twisted suture or hare-lip suture is shown in Fig. 87.

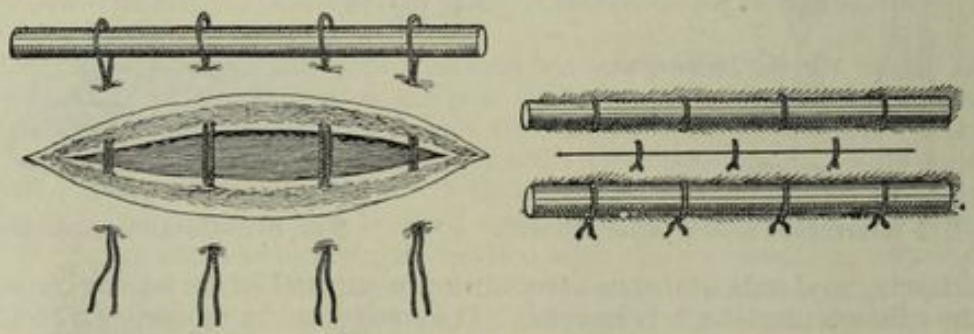


FIG. 85.—The quilled suture.

If infection occurs, the wound becomes swollen, tender, painful and discolored, and the temperature of the patient soon becomes elevated. In such a condition cut the stitches, disinfect, and drain.

Wounds of Mucous Membranes.—If the surgeon intends to inflict a wound upon a mucuous surface, he should see to it that the patient's general condition is good. Thorough asepsis is impossible, and a good result depends largely upon the vital resistance of the tissues. Before operating, irrigate the part frequently with boric acid, peroxid of hydrogen, or normal salt solution. When ready to sew up the wound be sure that all irritant fluids are sponged away (saliva in the mouth, etc.). Cleanse the wound with hot normal salt solution. The stitches must include submucous tissue as well as the mucous membrane, and consist of silver wire, catgut, silk, chromic catgut, or silkworm-gut. After sewing up a wound in the mouth wash the oral cavity at frequent intervals with salt solution or dilute alcohol and follow each washing with an insufflation of iodoform.

In accidental wounds irrigate with salt solution, dust with iodoform, and close as directed above. Corrosive sublimate is so irritant that it does harm when applied to a mucous membrane. In some wounds of the lip and tongue the sutured wound is covered with *Whitehead's varnish*, a material which adheres tenaciously. It is a modification of the compound tincture of benzoin, a saturated solution of iodoform in ether being substituted for the alcohol and one volume of turpentine to 10 of the mixture being added.

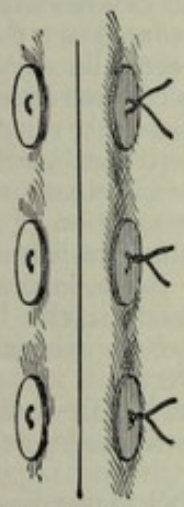


FIG. 86.—Button suture.

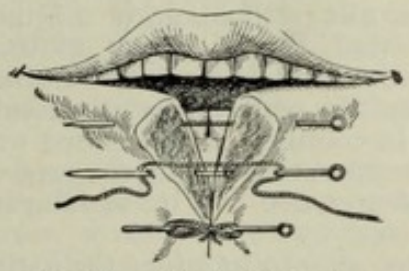


FIG. 87.—The twisted suture.

Contused and Lacerated Wounds.—A contused wound results from a blow or a squeeze which bruises and crushes the tissues and splits or ruptures the skin. It is a common injury when force is applied to tissues over a bone. The blow of a blackjack upon the scalp may cause either a contusion or a contused wound. A contused wound is irregular in outline, has jagged edges, and is surrounded by a broad zone of contusion. The worst form of contused wound is a crush of an extremity produced by being run over. The skin is often widely separated from the tissues beneath. A crush is liable to be followed by gangrene, embolism, or fat-embolism.

A lacerated wound results from tearing apart of the tissues. It, too, is irregular and jagged, and is accompanied by more or less contusion. A *brush-burn* is a contused-lacerated wound due to friction. Both lacerated and contused wounds contain masses of partly detached and damaged tissue, the vitality of which is endangered. Nerve-trunks, muscles, and great vessels may be torn across. Hence, such wounds are apt to slough, frequently suppurate, and are occasionally followed by cellulitis or even by gangrene. There is more danger of tetanus than in incised wounds. A wound especially apt to be followed by tetanus is made by the toy pistol. In contused and lacerated wounds the edges are discolored and cold to the touch, and there is little primary hemorrhage unless a great vessel has been torn. There is considerable danger of secondary hemorrhage if large vessels have been injured. In wounds of this nature the pain is often slight, but it may be violent. Shock may become severe.

Avulsion of a limb is a dreadful form of lacerated wound. The thumb or a finger may be torn off or the arm may be wrenched from the body with or without the scapula. In such cases the wound is large, jagged, and irregular, long strings of muscle or tendon hang from the gap, the wound edges are cold, but the bleeding is trivial. The shock may become profound.

Avulsion of the scalp may be produced when the hair is caught in machinery. The American Indian inflicts this injury when he scalps a conquered foe. In some cases of avulsion of the scalp the periosteum is removed with the flap; in most it is not. The flap usually consists of skin and aponeurosis. In this form of laceration there is severe bleeding.

Treatment.—The surgeon brings about reaction and endeavors to asepticize the wound and skin about it (see page 197), arrests hemorrhages, and ligates any visible damaged vessel whether it bleeds or not. Foreign bodies are to be removed. Hopelessly damaged tissue should be cut away. In a shell wound doubtful tissue must not be retained. In some cases amputation is necessary. Give an injection of antitetanic serum as a preventive. Repeat the dose twice at intervals of eight days. Secure thorough drainage, in some situations making counteropenings if necessary. In many cases leave the wound open. In some cases excise the wound. Tube drainage may be necessary or iodoform gauze in strands may be used. In the past contused wounds and lacerated wounds, except when on the face, were seldom closed by sutures. They were rarely closed, because the great damage to tissue and serious interference with the blood-supply strongly militate against primary union. In the face the blood-supply is so good that primary union may be obtained in part or entirely and surgeons thought it worth while to try to obtain it. A method of treatment popularized by surgeons active in the World War is to excise the wound. If this can be done soon after the injury (within a few hours) close without drainage. Otherwise, leave the wound open, employ the Carrel-Dakin treatment, and when bacteria practically disappear, perform secondary suturing. Cold must not be applied to a region of lowered vitality because it may cause gangrene. Heat is useful. Hence, it is a custom, even from the start, in cases in which excision has not been practised, to dress with hot antiseptic fomentations, and this mode of dressing is regarded as imperative if sloughing begins. An excellent fomentation is made by soaking the gauze in a hot solution of acetate of aluminum, using 1 fluidram of a 7½ per cent. solution to an ounce of water (Waterhouse, "Brit. Med. Jour.," July 9, 1910). The best treatment for a lacerated wound, if extirpation and immediate suturing has not been practised, is the use of Dakin's fluid and the performance of secondary suturing. Of course, the part must be kept at rest. In contused and lacerated wounds give antitetanic serum.

If suppuration occurs, the surgeon sees to it that the pus has free exit, and if necessary secures free exit by making incisions. Bier's treatment and rest are useful for infections.

After *avulsion of a limb* the patient is brought out of shock, large vessels are sought for and tied, damaged tissue is cut away, the wound is drained freely, and is *partly* approximated by sutures. After *avulsion of the scalp* bleeding vessels are carefully closed by sutures or suture-ligatures. A portion of the scalp may be torn away, but a pedicle may connect it with the balance of this structure. In such a case cleanse the parts thoroughly and suture the flap loosely in place (W. T. Bivings, "Phila. Med. Jour.," June 7, 1902) using only a few sutures. If the portion of scalp is entirely separated, adopt Gussenbauer's suggestion when possible and graft pieces of the avulsed scalp on the wound. If an ulcer results from avulsion it must be repeatedly grafted. Abbe obtained healing in a case after four years by the use of 12,000 grafts. If dead bone forms it must be chiseled away.

Punctured wounds are made by pointed objects, as needles, splinters, etc. The depth of a punctured wound greatly exceeds its surface area. After the withdrawal of the instrument inflicting the injury the wound closes partly at points, blood and wound fluid cannot find exit, and if, as is probably the case, bacteria were deposited in the tissues, infection by pus organisms is very likely to occur, and if it does occur suppuration spreads widely. There is also danger of infection by tetanus bacilli. Such a wound may involve an important blood-vessel, and in such a case profuse hemorrhage may occur; otherwise hemorrhage is slight. A great cavity of the body may be penetrated or an important organ may be wounded. Large-sized foreign bodies may be driven into the tissues or a portion of the instrument may break off and lodge. Pain is rarely severe unless a considerable nerve has been damaged. If both a large vein and artery are punctured a varicose-aneurysm or an aneurysmal-varix may form.

Treatment.—When possible, inspect the object which did the damage to see if a piece has been broken off. If there is severe hemorrhage, enlarge the wound and tie the bleeding vessels. In a puncture not made by the surgeon the wound must be regarded as infected. If a trivial wound is made by a dirty instrument through skin known to be unclean, it is proper that the skin about the puncture be sterilized, that the wound be enlarged by a crucial incision, that foreign bodies be removed, that a 3 per cent. solution of iodin be caused to diffuse itself into the wound from an ampule, and that a bit of rubber tissue be inserted as a drain. Such treatment, though painful, and appearing unnecessarily severe or even cruel to the sufferer from a trivial puncture, is necessary, and may save the patient from serious illness or from death. Every

deep puncture inflicted by an instrument not surgically clean, and every puncture inflicted by a nail, a splinter, a meat-hook, a rusty pin, a tooth of a cat or dog, etc., must be regarded as grossly infected and must be treated by free incision, iodin, and drainage. If the puncture is superficial and is made with a smooth-pointed instrument like a needle, when the instrument was not grossly infected the parts may be dressed with hot antiseptic fomentations, but they should be inspected daily for evidence of infection, and at the first sign of trouble an incision must be made. If a foreign body is retained in the tissue it must be removed.

If an important cavity of the body has been invaded by a puncture exploratory incision is necessary (see Brain, Thorax, Abdomen). A puncture made by a contaminated body requires that a large dose of antitetanic serum should be given, or, at an interval of eight days after a moderate dose, another dose, and after eight days more another dose should be administered (page 142).

Stab wounds were formerly considered with punctured wounds, but Senn wisely placed them in a class by themselves. Stab wounds are inflicted by the penetration of the tissues by a pointed or narrow instrument—for instance, a dagger, a knife, the blades of scissors, a bayonet, or a sword. Such wounds are narrow and very deep. A stab wound may cause rapid death by penetration of a large blood-vessel. Some great cavity of the body may be penetrated and internal hemorrhage will then occur. The body may be transfixed by a sword or bayonet. Bone is rarely injured unless the skull is penetrated or the chest entered. In stab wounds there is usually great hemorrhage and shock.

Treatment.—Whenever possible, look at the object which did the damage and see if a piece is broken off. If no great cavity is entered, treat by general rules: arrest bleeding, react from shock, disinfect, etc. The treatment of penetrating wounds of the abdomen, thorax, and cranium is discussed in the special sections. Stab wounds call for preventive doses of antitetanic serum.

Arrow wounds might be considered under the head of punctured wounds or stab wounds. When hostilities with the red men were frequent and before mercenary traders had fitted out the savages with rifles, arrow wounds were common among the men of the frontier. They are now very rare. Military surgeons still encounter them, especially in some parts of Africa and in the Philippine Islands. An arrow wound may be a trivial puncture of the skin, a deep wound of the soft parts with or without bone injury, a penetration of a joint, or of one of the body cavities. The skull cavity may be entered by an arrow. In some of these cases there is a puncture of the bone without the formation of fissures, but usually when bone is punctured there is fissure formation, splintering, or depression. A large blood-vessel may be divided by an arrow and violent bleeding result or fatal concealed hemorrhage may take place from a wounded viscus. Some tribes poison arrows. It is said that the Piutes were the only tribe of North American Indians which did this.

Some tribes in South America use curare, others use snake-venom, others use decomposed meat. Certain tribes in Africa employ the venom of the puff adder. In Northern Nigeria some form of strophanthus plays a part in nearly all the poisons used (Allan C. Parsons in "Brit. Med. Jour.," Jan. 23, 1909). The same author points out that the poison used is generally complex and contains also various animal and vegetable ingredients, particularly decomposed organic matter, plant juice containing strychnin, and soil contaminated with tetanus organisms.

Treatment.—An arrow is always septic and should be extracted. Sometimes when it has been buried deeply in a part it should be pushed across and extracted through a counteropening after the protruding shaft has been cut off. An arrow-head cannot be pulled out by the shaft. The barbs on the head catch and prevent extraction and the neck of the shaft is apt to break. The tissues should be freely divided down to the head of the arrow and on each side of it, when it can usually be withdrawn by forceps. If embedded in bone, the head must be gently rocked from side to side to loosen it, every care being taken to avoid breaking a stone or bending an iron arrow head. If an arrow has penetrated the abdomen, laparotomy should be performed. If it has entered a joint, the joint should be freely opened. If it has entered the chest, one or more ribs will require resection. If it has entered the skull, trephining is indicated. Any bleeding vessels are to be caught and tied. The track of the arrow should be carefully disinfected and drainage should be secured. It is particularly important to remove a poisoned arrow at once. After removing a poisoned arrow, if the nature of the poison is known, proper treatment should be applied to antidote the poison. The French Colonial surgeons fill wounds inflicted by poisoned arrows with tannic

acid. The same custom is followed by English surgeons in West Africa (Allan C. Parsons in "Brit. Med. Jour.," Jan. 23, 1909). Antitetanic serum should be given.

Gunshot wounds are contused or contused-lacerated wounds inflicted by materials projected by explosives. A bit of rock or a crowbar hurled by dynamite inflicts a gunshot wound, as does a shell-fragment, a pistol-ball, small birdshot, a rifle bullet, pieces of a hand grenade, a flying cap, a piece of wadding, grains of powder, a buckshot, a fragment of metal broken off a shell, grapeshot, canister and shrapnel, or a cannon-ball. Injuries by portions of a bursted boiler, pieces of masonry or wood, are either lacerated or punctured wounds, and need no special consideration here. In this article we treat of injuries caused by bullets, shot, shell, etc., that is, by missiles propelled from firearms.

Firearms are instruments by means of which missiles are projected to a distance by the expanding gases of burning gunpowder. There are many different sorts of firearms. Artillery includes various sizes of guns upon supports, from the great howitzers, of a caliber of 420 mm., and which fire huge shells, to machine-guns, which fire ordinary rifle bullets. Field artillery frequently uses shrapnel-shells. Such a shell is a case of steel, cylindroconoidal in shape, containing a number of bullets and a charge of explosive, the shell exploding by means of a time-fuse. Canister is an iron casing containing bullets unassociated with an explosive discharge within the casing. The canister breaks when fired, and the balls separate over a large area. It is used only at close range—that is, 300 or 400 yards.



FIG. 88.—Lodged shot.

Among small arms may be mentioned muskets, revolvers, shotguns, and rifles. Wounds from the old-time musket ball are now never met with except in warfare against barbarous tribes. The musket has a smooth bore and fires round bullets of soft lead. This round, soft bullet, being large, moving with comparative slowness, and flattening easily, is very liable to glance, to deform, and to lodge. Fragments of clothing are apt to be carried in with the bullet. When a musket is fired at close range and the bullet strikes the tissue at a right angle, it produces a punched-out entrance wound. If the velocity is low or the impact is not at a right angle to the tissues, the entrance wound may "be formed of triangular flaps," the corners of which are inverted.[1] The entrance wound is surrounded by a bruised area. The track of the bullet is larger than the original diameter of the bullet, and is so badly contused and lacerated that some tissue is devitalized; and the shaft of a bone, if struck, is likely to be splintered. If the ball emerges, the wound of exit is larger than the original diameter of the bullet, and forms triangular and everted flaps. Healing by first intention seldom occurs in such wounds. The old smooth-bore musket, firing a round bullet, has been displaced by the rifle propelling a pointed or cylindro-ogival bullet.

In the firearms of civilians, as a rule, the bullets are made of lead, hardened and shaped by compression or hardened by an admixture with tin. The present-day rifle bullet (Fig. 95) has much greater velocity and penetrating power than the round bullet. Hence, it is more liable to penetrate and less likely to deflect and to lodge. Fragments of clothing are not so apt to be carried into the tissues as by the round ball. The tissues in the track of this bullet are less devitalized than in the track of the round bullet. The cutaneous surface is not so much contused. If the bullet strikes at a right angle to the surface the wound of entrance is about the size of the bullet, and is punched out or inverted; and the wound of exit is larger than that of entrance and is often everted. The bones are more seriously comminuted than by the round bullet, and osseous fragments may be driven widely into the tissues. In fact, "an explosive

[1] "Wounds in War," by Surgeon Col. W. F. Stevenson.

effect" may occur at close range. Delorme laid it down as a rule that comminution of bone makes the wound of exit larger; and he asserts that a wound of exit larger in diameter than the thumb means comminution of bone (Fig. 103). He was not speaking of the pointed bullet. If the pointed bullet does not strike at right angles it will be deflected, and, going through the tissues side on instead of point ahead, will leave a frightful gap.

Gunshot Wounds Seen in Civil Life.—Wounds are occasionally inflicted by the sporting rifle or shotgun, and frequently by blank cartridges; but the vast majority of such wounds seen by the civilian surgeon are inflicted by revolver or automatic pistol.

Wounds from the Sporting Rifle.—In the sporting rifle a large charge of powder is employed. Some sporting rifle bullets have no hard jackets. Others have an incomplete hard jacket. In a bullet with a partial hard jacket the "nose" of the bullet is exposed and soft. The bullets are usually larger than those used in the military rifle. Such bullets deform in the tissues, and inflict dreadful, tearing wounds. If a bullet of a sporting rifle strikes a limb, amputation may be required. If it strikes the head or trunk, it will almost certainly produce a fatal wound.

Wounds from the Shotgun.—The degree of injury is in direct relation to the adjacency of the wounded individual to the gun, when the discharge took place, to the size and number of the shot, and to the charge of powder. Single shot may bruise the surface and fail to enter the tissues or may enter the tissues. When many shot enter together they strike as a solid body. Single shot are usually deflected from vessels and nerves, and seldom lodge in bone, but, rather, flatten on the bone surface. Even a single shot lodged in the eyeball is apt to produce violent inflammation which may destroy the eye. Numerous shot entering together at close range produce extensive contusions of the surface and fearful lacerations of the tissues, and often inflict irreparable damage. Bone may be fractured and bits of clothing or other foreign bodies may be carried into the wound with the shot. At close range toes or fingers may be blown off, an eye may be blown out, or portions of tendon or muscle may be shot away. At close range dreadful subcutaneous lacerations are caused by the gases. Primary hemorrhage is seldom severe because the wound is lacerated; but secondary hemorrhage is to be feared, and serious infection usually follows such injuries. Buckshot at close range inflict grave or dreadful wounds. The United States Army is supplied with a cartridge for use in riots. This cartridge contains two shot, each about the size of a buckshot.

The Treatment of Shotgun Wounds.—If the shot be scattered and lodged it is seldom necessary to remove them. As a rule, such cases require only cleansing of the skin and aseptic dressings. If shot lodge in a joint, they impair function; if in the face, they produce deformity. In both of these cases removal is necessary. When a shot lodges in the eye it usually, but not always, causes blindness. If the eye is gravely damaged it must be enucleated. In serious lacerations produced by shot at close range the hopelessly damaged tissue must be cut away, hemorrhage must be arrested, foreign bodies must be removed (though no protracted search is either necessary or desirable to remove grains of shot), the wound must be disinfected as well as possible, free drainage must be employed or the Carrel-Dakin treatment should be used. It is wise to give prophylactic doses of antitetanic serum.

Blank-cartridge Injuries.—These injuries can occur only at close range. They consist of burns and lacerations, frequently a wad or a bit of clothing lodges in the tissues, and tetanus is a not unusual sequence. The explosive used in the toy pistol is a fulminate, and bits of the envelope of the explosive may be driven quite deeply into the tissues. There is considerable danger of tetanus after injuries inflicted by the toy pistol. What in the United States is called "Fourth of July tetanus" is tetanus following such an injury, the small boy being prone to employ a toy pistol to contribute noise to the celebration of the nation's birthday.

Blank-cartridge wounds and toy-pistol wounds are treated by cleansing the skin, enlarging the wound, removing foreign bodies, disinfecting, and draining. Prophylactic doses of antitetanus serum should always be given.

Wounds Inflicted by the Revolver Bullet.—The revolver varies in caliber from 0.22 to 0.45. Whereas it is true that certain military pistols of the automatic type fire a hard-jacketed rifle bullet, the revolvers of civil life propel cylindroconoidal unjacketed bullets at a velocity of about 700 feet a second. A revolver bullet of the civilian's weapon never produces an explosive effect except upon a very soft organ like the spleen. It is liable to deform in the tissues, is often deflected from bone or tendon, and is very apt to lodge. The shape of the bullet, the velocity with which it is

propelled and with which it rotates, and its hardness make it unlikely that at any near range the bullet will merely contuse, and not enter, the skin. Unless striking at a decided angle to the perpendicular, it will almost always enter. Sometimes it perforates, more often it lodges. In some cases, however, a revolver bullet, like a spent rifle bullet, may fail to enter the tissues. It then grazes the surface and inflicts a brush burn or simply contuses the part. Whereas it may be deflected, it comparatively seldom is; and it often deforms, though it does not do so to anything like the degree that the soft, round bullet does. If a bullet enters the tissues, a cavity, or an organ, and lodges there, it causes a *penetrating wound*. If it enters and emerges it causes a *perforating wound*. The bullet may not enter alone, but may carry with it bits of clothing or other foreign bodies, though this complication is much rarer in injury with the conical bullet than with the round ball. On one occasion I removed a piece of coat from the interior of the lung, to which it had been carried by a revolver bullet. In another instance I removed a piece of shirt from the interior of the abdomen, to which it had been carried by a similar bullet. A revolver bullet may break bone, though it is not nearly so liable to do so as a rifle bullet.

In studying a gunshot wound one must consider the *wound of entrance*, the *tissue track*, and, if the bullet has emerged, the *wound of exit*. It is usually stated that if a revolver bullet fired from a distance of 10 feet or more from the person struck hits the skin at a right angle, it makes a wound of entrance that is smaller than the bullet because the skin is elastic. It is a certain fact that one cannot assert from a mere inspection of the wound of entrance with what size bullet a man was struck. A 0.22 often leaves a most trivial opening. Careful separation of the margins enables us to measure a wound of entrance, and if this is done it will be found that a wound of entrance is never smaller than the bullet. (See Wm. S. Wadsworth in "International Clinics," vol. iv, Twentieth Series.) The shape of the wound is somewhat, but not regularly, circular, because a certain amount of tissue is destroyed. The margins are also somewhat depressed. It has a punched-out look, and the edges, as Draper tells us, are frayed in appearance ("Text-book of Legal Medicine"). The appearance of the wound of entrance will be very different if the bullet strikes the surface at an acute instead of a right angle. Then the wound will not be round, but oval, or, perhaps, linear. The edges of the wound look thickened and are contused, this discoloration being noted for a distance of 1 inch or even 2 inches from the margin of the wound. The skin surface may be blackened if the weapon were fired at very close range. This is due to staining with a mixture of burnt gunpowder and the grease of the outer surface of the bullet. When a bullet is fired very near to the surface of the body the clothing and skin will be burned, there will be some staining with burnt gunpowder around the wound, and unburnt powder-grains will be found lodged in the skin (*tattooing*). The burning is due to hot gases, and with the gases come powder-grains. Whether the weapon inflicting the wound was close or distant there is bruising of the skin, but when the powder is found in the tissues or on the surface and when the surface is scorched the weapon must have been close at the time of discharge. Hot gases singe hairs, clothing, or the skin itself. The nearer the skin the weapon was held, the more severe the burning. Wadsworth says, "all gas phenomena require very close range, usually within 18 inches." What is called the smudge is due to "the débris and smoke from the powder" and takes place at a range of less than 18 inches (Wadsworth in "International Clinics," vol. iv, Thirtieth Series). The absence of embedded powder, however, does not *prove* that the shot was not close, because the weapon employed might have been one using smokeless powder. When smokeless powder has been used the burn is the same as from black powder, the smudge is apt to be of an orange color, tattooing is rarer, and when it does occur shows fewer grains. If the smokeless powder contains graphite it produces a smudge. If the weapon were fired at close range the skin may have been burnt by burning gases or the clothing may have been burnt and the skin scorched by the burning clothing. Staining of the skin with powder can be washed off, but when the skin has been burnt it is dry like parchment. Powder-grains may cause severe wounds. It has been held by some that powder-grains are *never* found in the skin unless the bullet has been fired from a distance of less than 3 feet, but this is too arbitrary a statement to make in a court of law. In any medicolegal case experiments should be made with a weapon and ammunition of the same size and make as those used in inflicting the wound in order to determine the real facts of the case. Draper ("Text-book of Legal Medicine") makes the following important statement relating to burns of the skin: "If the weapon is held in the hand in the ordinary way, hammer and

sight on the barrel directed upward, the wound in the skin will show, immediately above its orifice, a brand or scorching caused by a slight recoil in the act of firing. The location of this brand will change as the position of the hammer is changed. If the weapon is held in a vise and fired this relation of the brand to the wound is obliterated. This observation, first made and published by Dr. D. B. N. Fish in 1883, supplies an accurate index of the position in which the pistol was held in firing." Wadsworth is of the opinion that the "flip" is usually but not always toward the hammer side. It is modified "by the grip on the handle at the instant of discharge." If the muzzle of a pistol is pressed lightly against the skin gases enter with the bullet and "burst the skin outward, giving a large ragged wound, which is not a wound of entrance, though always called so, but a wound of exit of the gas" (Wadsworth in "International Clinics," vol. iv, Thirtieth Series). If the muzzle is held firmly against the surface the gases cause a horrible wound under the skin. This condition is not the same thing as the explosive effect of a bullet. In passing through the tissues the revolver bullet makes a contused-lacerated wound, and we may find along this wound powder-grains (if the bullet has been fired at close range) and portions of clothing, pieces of the bullet itself, or perhaps of bone. A bullet may pass directly through both walls of the skull, traversing the brain in its passage. It may pass through a wall of the skull and lodge within the cavity of the cranium. In some cases it makes an opening of entrance that is smallest on the external surface of the bone and largest on the inner table. In other cases it makes extensive comminuted fractures. When a bullet tears its way through a muscle it makes a jagged, contused, lacerated wound. It does the same in the brain. In both cases the track of the bullet is larger than the bullet, and the tissue for a considerable distance wide of the track is contused or actually destroyed. In passing through an aponeurosis or a serous membrane the bullet may make a round orifice or a slit-like tear. Of course, the nature of the wound in the tissues will be greatly affected if the bullet is deformed by having struck bone, or if it carries bits of bone along with it. The deflection of a bullet from an aponeurosis, fascia, or bone so alters its course that the missile becomes very difficult to locate and remove without the aid of the *x*-rays. In some cases a bullet has entered near the front of the body and passed around the wall of the chest until it has almost reached its point of entrance, or else has lodged or emerged at some point of this course—in either case constituting what is known as a *contour wound*. Contour wounds are not infrequently seen upon the head. For instance, a bullet may strike the frontal region, pass around under the scalp, and lodge in or emerge from the occipital region.

When the bullet does not lodge, but emerges from the body, the wound of exit must be studied. If an undeformed bullet passes straight through the body it makes a wound of exit that is somewhat larger than the bullet. It has a torn-out appearance, but without distinct destruction of tissue, and exhibits an irregular outline and eversion of the edges. The margins of such a wound are bruised, but are never scorched and never show powder-grains. If a bullet has been deformed by hitting bone, or if it has driven bone before it, a very large lacerated wound of exit may be formed (Fig. 103). It is important to remember that the presence of a number of wounds on the surface of the body does not in itself prove that a number of different bullets have been fired, for in certain circumstances one bullet may make several wounds. A few years ago I saw a case in which a bullet had penetrated the right hand and the right thigh, and had lodged in the left thigh. There were three wounds of entrance and two wounds of exit. Many very extraordinary cases of this sort have been reported. Traumatic pulsating hematoma or arteriovenous aneurysm may form.

Symptoms of a Wound Caused by a Pistol Bullet.—Hemorrhage is often considerable, but ceases spontaneously unless a large vessel has been divided. If hemorrhage is profuse the constitutional symptoms of hemorrhage exist (see page 195). These symptoms are of great importance in abdominal wounds. A pistol ball seldom causes severe primary hemorrhage, because it will not often penetrate a large artery. It is apt to push aside a vessel and secondary hemorrhage is not unusual. Even if a large vessel is wounded and a succession of violent hemorrhages occur, a man may live for several days. Secondary hemorrhage may follow a gunshot wound because of contusion of vessels or of infection.

Pain is often not noticed at first. The injured individual, if greatly preoccupied or excited, may not know that he has been struck by a bullet. There may be only a feeling of numbness, but usually there is a dull or stinging pain. If a large nerve has been injured there may be violent pain. Even trivial gunshot wounds frequently produce profound shock, and yet it may happen that severe wounds may be accom-

panied by but slight shock. In most gunshot wounds of the brain, abdomen, and spinal cord the shock is very great.

General Considerations as to Treatment of Wounds Caused by Revolver Bullets.—The dangers are shock, hemorrhage, and infection. Bullets are not aseptic when they enter a part, but a bullet usually carries but few bacteria, and if bits of clothing are not carried in by the bullet and if infection is not inserted in the track of the ball the wound will in many instances heal kindly, the tissues taking care of the bacteria lodged in them. A stationary bullet, when there is no infection, is usually let alone. Careless examination of the wound will certainly cause infection. "The fate of a wounded man is in the hands of the surgeon who first attends him" (Nussbaum). If a bit of clothing or other foreign body is carried in by the bullet infection is inevitable. The



FIG. 89.—Fluhrer's aluminum gravitation probe (natural size except the length, which is 12 inches).

danger of a wound depends upon the size and velocity of the bullet, the part struck, the intensity of infection, "and the degree of asepsis observed during the first examination and dressing" (De Nancrede). The rules of treatment are: bring about reaction, arrest hemorrhage, disinfect, preserve asepsis, and, in many cases, remove the ball. Always notice if a wound of exit exists. It is a good plan, when endeavoring to determine the extent of injury, to put the parts in the position they were in when the injury was inflicted. We should try to ascertain the size and nature of the weapon, and the range at which it was fired. Examine the clothing to see if any fragments are missing and could have been carried in. Such fragments render sepsis inevitable. The surgeon must not feel it his duty to probe in all cases. In many cases it is better not to probe at all. Never probe when there is a wound of entrance and a wound of exit. Explore



FIG. 90.—Nélaton's bullet-probe.

for and remove the ball when there is infection or when sure that it has carried with it foreign bodies; or when its presence at the point of lodgment interferes with repair; or when it is in or near a vital region (as the brain) and in every case in which it can be reached with reasonable safety. In light of recent observations a rule should be to arrest serious hemorrhage, remove a bullet whenever possible and remove with it all bits of clothing carried in (treat separated fragments of bone and hopelessly damaged tissue as foreign bodies), arrest bleeding completely, disinfect the wound and either extirpate the wound and suture without drainage or leave the wound open and treat with Dakin's fluid or Dakin's oil and later perform secondary suturing (page 228). We must locate the ball when it is necessary to know its position in order to determine

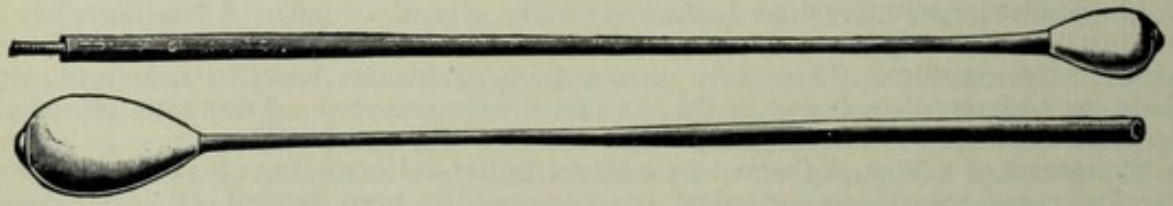


FIG. 91.—Senn's bullet-probe.

the question of amputation or resection. If the wound is large enough the finger is the best probe. The *x*-rays render the use of the probe seldom necessary.

Fluhrer's aluminum probe is a valuable instrument (Fig. 89). It is employed especially in brain wounds, and is allowed to sink into the track of the ball by the influence of gravity after the part has been placed in a proper position. If a lead bullet is deeply embedded it is possible to distinguish the hard projectile from a bone by inserting the asepticized stem of a clay pipe, a bit of pine wood, or *Nélaton's porcelain-headed probe* (Fig. 90). On any one of these appliances lead will make a black mark. No such test can be applied to a military bullet, for this has a hard metal jacket, and will not make a black mark on a white substance.

Though Nélaton's probe will not show the difference between a hard-jacketed projectile and bone, it is a valuable instrument to follow the track of any bullet wound. The porcelain head ought to be larger than it is usually made; in fact, it should be nearly the size of the bullet (Senn—Fig. 91).

In passing a probe use no more force than in passing a catheter.

The *induction balance* of Graham Bell has been employed to determine the situation of a bullet. The bullet may be located by *Girdner's telephonic probe.* In order to construct this instrument take a telephone receiver, fasten one of the wires to a metal plate and the other one to a metallic probe. Moisten a portion of the patient's body and place the metal plate in contact with it. The surgeon places the receiver to his ear and inserts the probe into the wound. If the probe strikes metal, a click is heard with distinctness. A bullet may be located by *Lilienthal's probe.* This apparatus consists of a mouth-piece, two insulated copper wires, and a probe. The mouth-piece is composed of two plates, one of copper and one of zinc, which are applied to the sides of the tongue. An insulated wire runs from each plate and into the metal probe. The tip of the probe is composed of two or four pieces of metal, is separated from the shank by a washer of rubber, and is attached to the wires. The operator closes the teeth upon the mouth-piece and inserts the probe into the wound. If the probe touches the bullet a distinct and continuous metallic taste will be appreciable.

The best means of discovering a bullet is to use the *fluoroscope* (see pp. 1454 to 1458) or to take a *skiagraph.* In order to locate it accurately view it through a series of squares, insert guide-pins, or, better than either of these plans, employ Sweet's apparatus.

In extracting the ball use very strong forceps (Fig. 92). The old American bullet-forceps is useless for the extraction of the hard-jacketed ball, as the points will not penetrate and the instrument will not hold.

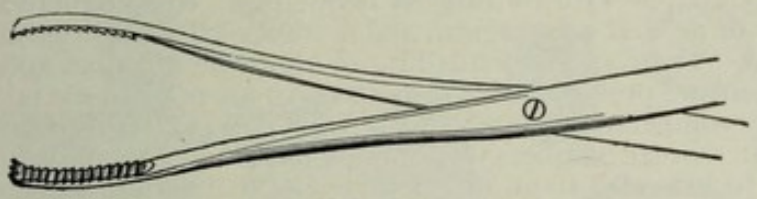


FIG. 92.—Bullet-forceps.

If hemorrhage is severe in a gunshot wound, enlarge the wound, find the bleeding vessel, and tie it. Before handling a gunshot wound asepticize the parts about it and irrigate the wound with hot sterile salt solution. In most situations sterilization with iodin and excision is proper. In some situations a wound should be drained with a short tube or a bit of iodoform gauze; in other regions this is unnecessary. The dressing should be antiseptic. Primary union rarely takes place after a wound inflicted by a pistol-ball or an ordinary rifle-ball (unless the wound were excised), because of the inevitable necrosis of damaged tissue in the track of the ball, but in some cases it can be obtained. Primary union is frequent after injury by the small hard-jacketed modern army projectile. Healing begins in the depths of the wound and extends toward the wound of entrance, or, if there be also a wound of exit, toward both. Radical operations may be demanded: laparotomy, trephining, rib-resection, joint-resection, or amputation.

Excision of a joint may be required when there is great comminution. *Amputation* is sometimes demanded because of severe injury to the soft parts, great splintering of a bone, grievous injury of a joint, damage to the chief vessels or nerves, or the destruction of a considerable part of a limb. Perform a primary amputation if possible, and make the flaps through tissue that will not slough. In civil practice, with careful antisepsis, more questionable tissue can be admitted into a flap than in military practice, where transportation will become necessary and antisepsis may be imperfect or wanting. It has been shown in recent years that even when a large joint has been perforated by a small hard-jacketed projectile, amputation or resection is rarely required if the wound has been treated aseptically from the beginning, but this is not true of the revolver bullet.

Surgery of War.—Military surgery (including in this term naval surgery) is a specialty. One who would practice it must have special training different from and beyond that given in the medical schools to civilians. He must be much more than a well-qualified physician and surgeon. Even the best qualified civilian surgeon is unfit

to pass into military service without special training, and no man is fit to come direct from civil life and take charge of a military or naval hospital.

The United States insists that every man appointed to the medical corps of the army or navy in days of peace and when time permits shall receive special instruction in the Army Medical School or the Naval Medical School before he goes to a regiment, a ship, or a hospital. In war days army men are specially trained in an army camp and naval men in a naval hospital.

The surgeons of the army and navy are protean specialists. They must be able to treat the sick and injured with the greatest skill and on the most modern principles. But they must know much more than this. They must understand bacteriology and be able to make various laboratory studies of blood, urine, feces, spinal fluid, wound fluid, etc. They must be masters of hygiene. They must possess executive ability. They must be able to discipline others and to command their respect, and must be willing to submit cheerfully to discipline. They must be forceful, self-reliant, and resourceful. They must be acquainted with the regulations and instructions of the military establishment. They must have a special knowledge of the wounds inflicted in war, of the transport of the sick and wounded, of the establishment of hospitals and of epidemic diseases that might gain a foothold on ship-board, in camp, or in barracks. The wounds received in war are peculiar. The treatment appropriate for a wound inflicted by a revolver bullet of lead might be entirely inappropriate for or totally impossible of application to a wound inflicted by the hard-jacketed projectile of a military rifle or by a shell fragment.

In civil life the patient has the best of surroundings. Every care can be given him. Numerous skilled assistants and nurses are at hand if needed. There is no hurry unless it is called for by his condition.

The problems presented to the surgeon are purely surgical and the case is dealt with in exact accordance with its surgical necessities. In war there are various problems other than those that are surgical, and non-surgical necessities may dominate the surgeon's actions. The war surgeon is first of all a military man and after that a humanitarian. There are problems of transport which are not present in civil life. Strategic necessity may compel hurried movement. There is inevitable delay in inaugurating radical treatment. Great numbers of wounded men may have to wait for long periods before they can be attended to at all. Time is insufficient and assistants are few.

Accommodations may be bad. Shelter may be imperfect. Climate and meteorologic conditions may be most trying. Food may be scanty and inappropriate. Medicines may be scarce. After some engagements in South Africa the British surgeons had to care for numbers of men under difficulties that were appalling, among which were fearful clouds of dust and swarms of flies. In the World War hospitals were again and again literally overwhelmed by the sudden arrival of immense numbers of men dreadfully wounded. In other words, the military surgeon, after a battle, is seldom able to treat his cases purely in accordance with surgical necessities, but his conduct must be influenced by other, often imperative, needs. If there are numerous wounded, he does not have time to do immediate laparotomies. He will lose some cases because he has not done laparotomy, but he would lose many other cases from delay in treating dangerous but remedial conditions were he to make many simpler cases wait until his laparotomies had been performed. He may be forced to make the abdominal wounds wait and after long delay there is seldom any use in opening the abdomen at all. The same is true of head injuries and chest injuries. The necessity for removal or the inability to treat properly at that time and place may lead a surgeon to amputate a limb which might be saved in a civil hospital. He strives with every pound of energy that is in him to save those who can be most certainly returned to the fighting line. After these have been cared for comes the problem of saving other cases and saving men from permanent crippling.

Wounds in War.—We will consider sword wounds, bayonet wounds, and wounds inflicted by rifle bullets and various forms of shells.

So many cases of bayonet wounds, and so many cranial, abdominal, and thoracic cases never live to reach the hospital but die in transit or on the field, that hospital returns in no sense show the relative frequency of such injuries. Again, returns from one region are not representative of another region. Trench warfare gives statistics which differ vastly from those which are obtained from fighting in the open, in besieged forts, or in beleaguered cities.

Marsiglio, from a study of near 6000 wounded, reached the following conclusions ("Riforma med.," 1916, xxxxv).

Nearly 58 per cent. of wounds are due to bullets. (It will be seen below that other observers claim that in trench fighting only 25 per cent. of wounds are due to bullets.)

The most common injuries are those of the limbs, over 65 per cent.

Next come cranial injuries, over 19 per cent.

Next come thoracic injuries, over 8 per cent.

Next come abdominal injuries, over 5 per cent.

Sword Wounds.—These wounds require no special description. They are of the same nature as slashes received in civil life. The dull European sword causes an incised wound with contused edges. The keen sword of India and the East causes an incised wound without contusion. Sword wounds were extremely rare in the World War, because infantry officers did not use them in an assault, and the part played by cavalry was small until long after the beginning of the strife.

Sword wounds are treated as are similar wounds in civil life.

Bayonet wounds are stab wounds, and their danger depends on the structures damaged and the degree of infection. There were many such wounds in the World War. A few years ago nations thought of discarding the bayonet on the ground that modern weapons of warfare rendered hand-to-hand fighting impossible. The Japanese in the war with Russia gave exhibitions of bayonet fighting, and in the World War there was bayonet fighting whenever a trench was taken. The treatment is on general principles (see Stab Wounds, page 205).



FIG. 93.—Showing secondary missile effect of a rifle ball striking binoculars, causing loss of right eye and multiple wounds of hand and face. The fragments shown were removed from eyeballs, face, and hand (Fauntleroy).

Wounds by Rifle Bullets.—Before the World War surgeons had reached the conclusion that over 90 per cent. of wounds in war were sure to be inflicted by rifle or machine-gun bullets. This estimate was wrong.

In trench fighting 25 per cent. of wounds are from rifle or machine-gun bullets and 75 per cent. from shells.

During the last few years frequent and notable improvements have been made in the military rifle. The range and rapidity of firing have been vastly increased, the velocity of the projectile and its penetrating power have been enormously added to, and the trajectory has been decidedly lowered. Hence, the zone dangerous to an enemy has been lengthened. In order to accomplish these things changes have been made in the gun, the explosive, and the projectile. It is a far cry from the old Brown Bess, of song and story, to the modern Lee-Enfield of the British Army, or the Springfield of the United States Army. All modern military rifles are of small caliber, that is, less than 0.35 inch. The Springfield rifles of the days of the war between the States had a caliber of 0.45 inch. The old Springfield projected a bullet at an initial or muzzle velocity of 1300 feet a second; whereas the modern rifle sends a projectile on its way with an initial velocity of 2700 feet a second, the bullet rotating on its long axis more than 2500 times during the first second of translation. At a range of 1000 yards it will penetrate nearly 13 inches of pine wood. At a range of 100 yards it "will penetrate a steel plate 0.3843 inch thick" (Borden in "Keen's Surgery," vol. vi). Up to 5000 yards a modern rifle can inflict a fatal wound, and it can be used point-blank at a range of from 500 to over 700 yards. With the Springfield of the United States Army the

point-blank zone of danger is about 718 yards. A bullet from a modern military rifle, even after having struck some solid, hard body, may grievously injure a man by ricochet. With a magazine rifle, at 2500 yards, from 5 to 10 per cent. of the balls will ricochet from turf. At 3000 yards they will bury in turf, but may ricochet from very hard ground. The United States Army magazine Springfield rifle weighs less than 9 pounds. The barrel is 24 inches in length and the diameter of the bore is 0.30 inch. The rifling makes one complete turn in every 10 inches. With this weapon, by magazine fire, 25 aimed shots may be fired in a minute; and when used as a single-loader, 23 aimed shots (Surgeon-General O'Reilly, U. S. A., in "Keen's Surgery," vol. iv). It should be noted that during the World War military necessity compelled the U. S. Army to adopt a modified Enfield. The Enfields could be made quickly because facilities existed in the United States for making them. Haste was imperative.

Old-fashioned Black Gunpowder as Compared with Smokeless Powder.—There are many different varieties of smokeless powder, but each is essentially a nitro-powder. Among these smokeless powders are melenite, used by the French; lyddite, employed by the British; and shimose, adopted by the Japanese. The United States forces use cellulose nitrate in perforated cylindrical, amber-colored grains. Nitro-powder is very nearly smokeless because all the products of its combustion are gases. Of the products of the combustion of black gunpowder, 57 per cent. by weight settle out from the atmosphere in solid form on cooling.



FIG. 94.—Showing the multiple wounds from secondary missile effects of bullet passing through binoculars and lodging in eyeball, face, and right hand. Photograph taken several weeks after operation (Fauntleroy).

There are great advantages in the use of smokeless powder. It is much more powerful than black gunpowder; hence, a smaller charge can be employed. The modern Springfield requires a charge of 47 gr.; and at the time of the discharge the pressure in the chamber is about 49,000 pounds to the square inch. Smokeless powder gives the bullet a greater velocity, causes less recoil, and fouls the barrel infinitely less than black powder; and the absence of smoke maintains a clearer atmosphere for observation, and also furnishes no sign of location which might prove of advantage to the enemy.

Projectiles.—The bullet of a modern rifle is either cylindro-ogival or pointed, has a lead core, and is hardened by being covered with a mantle or jacket of copper, steel, or nickel, or of alloys of copper and nickel, or of copper, nickel, and zinc. The English bullet has in its base a core of lead and in the point a core of aluminum. The jacket is of steel. The French bullet is composed of solid bronze and is without a steel jacket. The hard outer surface is absolutely essential, because the speed of the projectile is so great that no soft bullet would take the rifling. Fragments would be torn off from the bullet in the gun, and the grooves of the gun would soon be filled with metal, the gun becoming useless. The projectile of a modern Springfield rifle is elongated and pointed. The air-resistance is least in a bullet of this shape. The core is composed of lead hardened with tin, and its jacket is of nickel and copper.

The military surgeon deals with wounds inflicted by these small, dense, hard, cylindro-ogival, or pointed projectiles impelled with great velocity, and carried long distances. The old lead bullet was apt to carry in foreign bodies, was liable to lodge, was often deflected in the tissues, was flattened out on meeting with resistant structures, such as bone or cartilage, and, after flattening, became larger, tearing and lacerating the soft parts and comminuting the bone (Fig. 100). The modern hard projectile seldom carries in foreign bodies, is likely to perforate, is rarely deflected, and is so

hard that its shape is often but little altered on meeting with resistant structures. Hence, it was thought that the new bullet would prove more humane than the old projectile and inflict wounds that would be more easily treated, because the bullet would be unapt to lodge and extensive damage would seldom be inflicted. This view has proved in many respects correct.

With the modern rifle of small caliber and the hard projectile propelled by smokeless powder the range has been notably increased, the trajectory of the bullet's flight has been greatly lowered, and the danger-zone to an enemy has been correspondingly lengthened.

Mechanics of Projectiles.—If a moving bullet were acted upon by no force but propulsion, it would continue to move in the direction that it was pursuing when it left the muzzle of the gun and its course would be a straight line, but it is acted upon by other forces. Even in a vacuum its course would not be a straight, but a curved line, because gravitation would draw it toward the earth. Under ordinary circumstances the air also resists its forward progress.

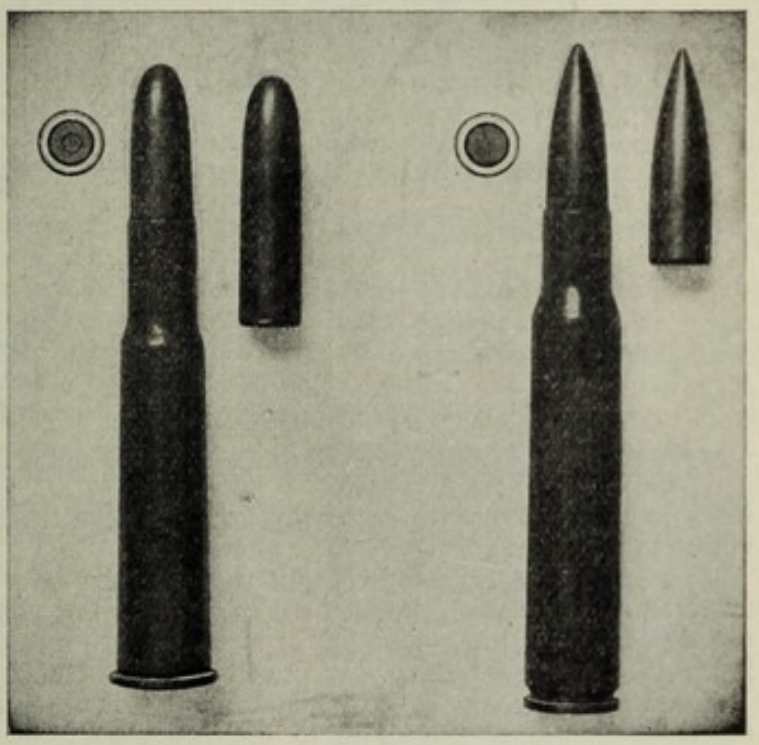


FIG. 95.—1, Krag-Jorgensen bullet; 2, new Springfield bullet (pointed).

A moving bullet is urged onward by the force of the exploding powder. This onward movement is called the *motion of translation*. The rate of forward movement is the *velocity*, and this is expressed in feet per second. Air resistance causes the velocity to lessen rapidly, and the farther away from the gun the projectile is, the greater is its loss of velocity. For instance, on leaving the muzzle of the Lee-Enfield rifle a bullet has a velocity of 2060 feet a second (*muzzle velocity* or *initial velocity*); at 700 yards it has a velocity of 1039 feet a second; at 2000 yards, 571 feet a second; at 3000 yards, 369 feet a second ("Gunshot Wounds," by Major C. G. Spencer). The muzzle velocity of the bullet of the United States Army Springfield is 2700 feet a second. The velocity of a bullet at any particular portion of its flight is called *remaining velocity*.

A bullet fired from a rifle rotates on its long axis. This rotation is called *spin* or the *movement* of *rotation*, and is in the direction of the groove of the rifling. It is this motion that keeps the point of the bullet toward the front and prevents rotation on its short axis, which would be responsible for increased air resistance, diminished striking force, and lessened range. If a cylindroconoidal bullet were fired from a smooth bore, it would rotate on its short axis at even as short a range as 9 yards, and would strike a target in its length (Stevenson's "Wounds in War").

The diminution in the transverse diameter of bullets has necessitated an increase in length in order to maintain their weight and sectional density. (*Sectional density* is the weight divided by the area of the cross-section.) The increase in length makes an increased rapidity of rotation indispensable. The higher the pitch of the rifling, the more rapid the rate of rotation imparted to the bullet. The Minié rifle had a complete turn in 78 inches. The United States Army Springfield has a complete turn in 10 inches. The velocity of spin as the bullet leaves the barrel of a Springfield is about 2500 times a second. The velocity of rotation changes as the velocity of translation changes; and when translation ceases, because the energy of propulsion has expended itself, rotation also ceases. "But when the motion of translation is suddenly and completely arrested by contact with an obstacle, then, if the bullet is not broken up, the motion of rotation continues until its energy is expended" ("Wounds in War,"

by Surgeon-General W. F. Stevenson, C. B., A. M. S.). A rifle-bullet in its flight deviates a little laterally, and in the direction of the groove of the rifling. In the United States Army rifle the groove of the rifling is toward the right when the gun is held with the butt toward the shoulder; hence, the deviation of the bullet is toward the right. This lateral deviation is called *drift*.

Influence of Gravity and Air Resistance.—We have previously stated that, even if moving in a vacuum, the line of flight of a bullet (the *trajectory*) would be a curved and not a straight line because of the influence of gravity, which pulls the bullet toward the earth. The bullet would fall 16 feet the first second, 64 feet in two seconds, 144 feet in three seconds, and so on. A bullet moving forward in a vacuum would advance through equal distances in equal periods of time, and, as gravity would draw

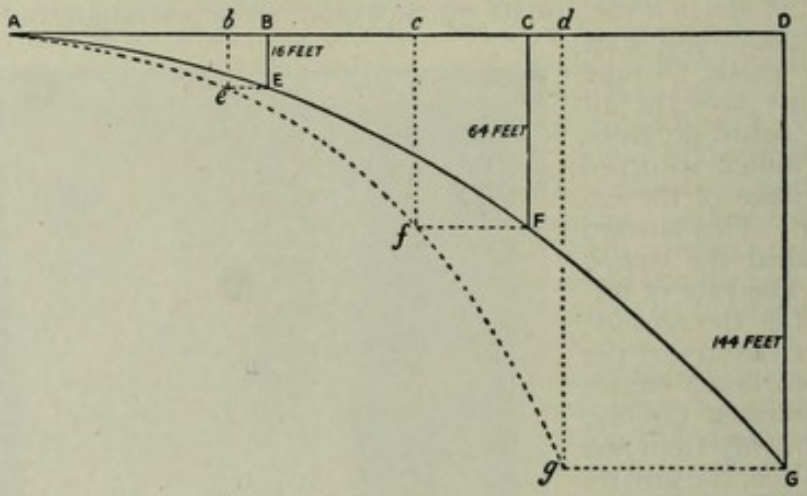


FIG. 96.—Trajectories in vacuo and in air (Stevenson).

it toward the earth with increasing rapidity, the trajectory would be a parabola (Fig. 96, line A–E–F–G).

Air resistance retards strongly the advance of a bullet and causes it to lose its velocity rapidly, and a bullet fired in air does not advance through equal distances in equal periods of time. Because of air resistance a bullet falls to the earth sooner than it would under the influence of gravity alone. Hence, the trajectory of a bullet in air is not a true parabola, but the line of descent is much nearer to the vertical than would be the case in a vacuum (Fig. 96, line A–*e*–*f*–*g*).

Air resistance depends upon the velocity of the bullet, the cross-section area of the bullet, the shape of the head of the bullet, the atmospheric density, and the steadiness of flight ("Gunshot Wounds," by Major C. G. Spencer). Air resistance is least in the

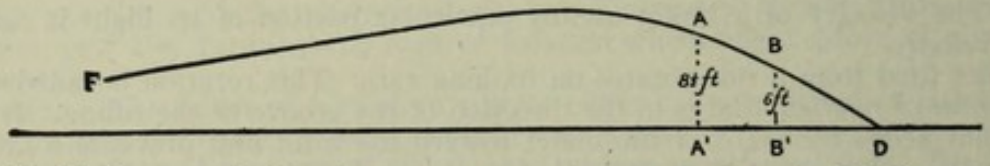


FIG. 97.—Trajectory, showing dangerous zones: A–B–D, Trajectory of bullet; D, point of termination of the bullet's flight; A–B, point of first catch for cavalry; B, point of first catch for infantry; A^1–D, dangerous zone for cavalry; B^1–D, dangerous zone for infantry (Spencer).

bullet that tapers rapidly. A bullet begins to lose its steadiness of flight about 1000 yards from the muzzle of the rifle.

The Danger Zone.—Owing to the fact that the trajectory is a curved line elevation must be given to rifles except at point-blank range, and the degree of elevation must be increased according to the range. Point-blank range for a Springfield is up to 718 yards. By this term is meant that when a gun is aimed horizontally the entire course of the bullet up to 718 yards is dangerous for infantry. For longer ranges the rifle must be elevated and the bullet "shot into the air." Sighted at 2000 yards the Snider sent a bullet 866 feet above the line of sight; the Martini-Henry sighted at the same range, 357 feet; the Lee-Enfield at the same range, 194 feet. It becomes evident that when a rifle is elevated the bullet rises far above a man's head, and continues to rise to what is known as the *culminating point*, when it begins to descend. It does not be-

come dangerous to men until it gets near to the earth. The point at which it becomes dangerous to cavalry is called *the point of first catch for cavalry* (Fig. 97). The point at which it becomes dangerous for infantry is called *the point of first catch for infantry* (Fig. 97). The *dangerous zone* (Fig. 97) is from the point of first catch to the termination of the bullet's flight, because anywhere in this zone men may be struck, but between the point of first catch and the man firing the gun soldiers are perfectly safe.

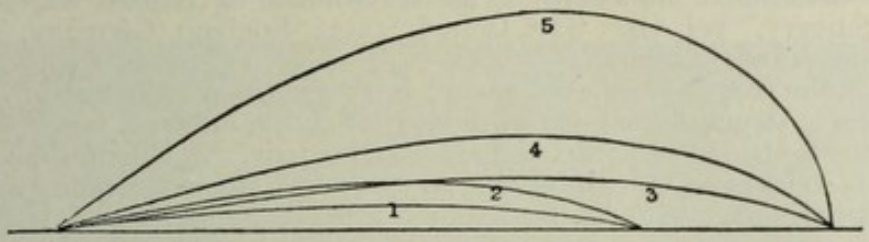


FIG. 98.—Trajectories of bullets from certain rifles: 1, Trajectory of Lee-Enfield at 1500 yards, action-point, 81 feet; 2, trajectory of Martini-Henry at 1500 yards, action-point, 178 feet; 3, trajectory of Lee-Enfield at 2000 yards, action-point, 194 feet; 4, trajectory of Martini-Henry at 2000 yards, action-point, 357 feet; 5, trajectory of Snider at 2000 yards, action-point, 866 feet; horizontal scale, 1/24000 (1 inch = 2000 feet); vertical scale, 1/12000 (1 inch = 1000 feet). Vertical measurements are represented on twice as large a scale as horizontal measurements (Spencer).

The point of first catch for cavalry is about 8½ feet and for infantry about 6 feet above the ground.

The more nearly vertical the line of the bullet's descent, the shorter is the danger zone; the less vertical the line of descent, the longer is the danger zone. The higher the culminating point at the trajectory, the more vertical is the line of descent, hence the shorter is the danger zone; the lower the culminating point, the flatter is the trajectory, and the less vertical the line of descent, hence the longer the danger zone. The chief object of improvements in rifles is to lower the trajectory (that is, make it less curved) and thus lengthen the danger zone, render marksmanship more accurate, and insure velocity.

Power of the Bullet to Wound.—According to Spencer ("Gunshot Wounds"), this depends upon its energy and the ease with which its energy is converted into work on striking. Energy is largely a matter of range. At short range energy is enormous, but it rapidly diminishes as the range is increased. At 3000 yards energy is only about one-sixteenth of what it is at 300 yards. The ease with which a bullet converts energy into work depends upon (see Spencer, Ibid.): (1) The area of the cross-section of the bullet. The larger the bullet, the worse the wound. (2) The deformation of the bullet. Such deformation enlarges the area. A bullet that expands on striking is said to *mushroom*. The modern bullet seldom deforms much unless its jacket has been more or less torn off (Figs. 101 and 102); and it inflicts, as a rule, a much less grave injury than does the soft bullet. It has been found that this very humanity of the bullet is at times regarded as an objection. The bullet lacks "stopping power" unless it strikes a vital part or a large bone, and a wounded man may continue to fight and charge. Civilized men will usually stop when hit, but savages very often will not. Hence, in warfare with barbarous people, it was once upon a time the custom to modify the bullet. A portion of the soft bullet at the apex of the projectile was left exposed, and such a bullet was said to be uncovered or to have a *soft nose*. It was called a *Dumdum* bullet, because such missiles were first made at Dumdum, the ordnance factory near Calcutta. When a Dumdum bullet strikes, it spreads and expands, or "mushrooms," and inflicts an extensive and dreadful wound, which stops the most ferocious savage or the most fanatical tribesman. These expanding or deformable

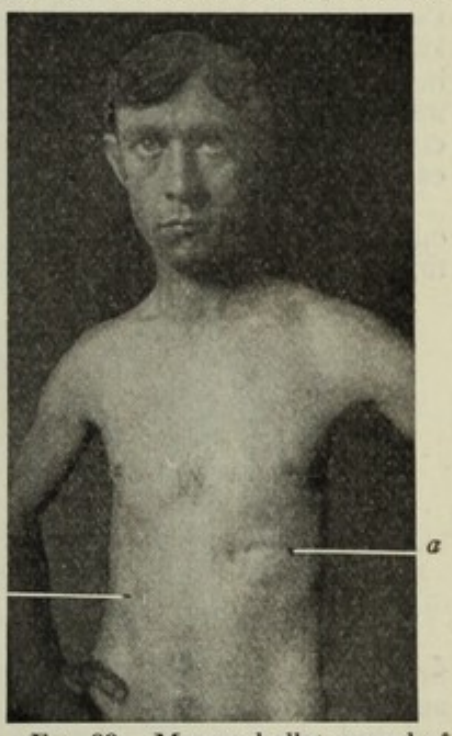


FIG. 99.—Mauser bullet wound of chest: *a*, Wound of entrance; *b*, point where bullet was extracted (Major Charles F. Kieffer, U. S. A.).

bullets are often wrongly called "explosive bullets." They were forbidden by The Hague Convention, although Stevenson and some other surgeons maintain that they are more humane than were the bullets of the Snider or the Martini-Henry rifle. Soldiers in a tight fix may perhaps file off the hard end of a bullet, exposing the soft nose, and so learn to make for themselves Dumdum bullets. The present bullet of the United States Army is pointed and will produce wounds "which will resemble the wounds made by the 'deformable' bullets whose use is forbidden in civilized warfare" (Borden in "Keen's Surgery," vol. vi). The United States, England, Germany, Turkey, and France now use pointed bullets.

The Resistance Encountered.—If energy is great (as at close range) and a very resistant tissue is struck (bone), dreadful injury may be inflicted, but if a tissue with little resistance is struck but little damage may be done. At a long range the energy of the bullet is so lessened that the danger to resistant tissue will be much less; whereas injury of soft parts may be much the same as at closer range.



FIG. 100.—Deformation of leaden bullets (natural size) (Seydel).

The Nature of the Wounds Inflicted by the Small Projectile.—The effect of lessening the size of the bullet is to decrease its wounding power, because, other things being equal, the larger the bullet, the greater its wounding power. In many instances the modern bullet will make a clear track, without laceration or comminution. It was thought, as has been stated, that this projectile would prove humane, that it would kill comparatively few, and that the wounded would receive injuries which would incapacitate them, but from which most of them would recover. Recent wars have indicated that at a range of over 1500 yards the ogival headed bullet, as a rule, penetrates cleanly, making a wound that heals by first intention. Sir Frederick Treves expressed his experience by saying, "the Mauser bullet is a very merciful one."

Very many studies have been made of the action of the modern bullet, and numerous experiments have been carried out—firing through boxes filled with wet sand, firing into thick oak, firing at cadavers at fixed distances with reduced charges, and

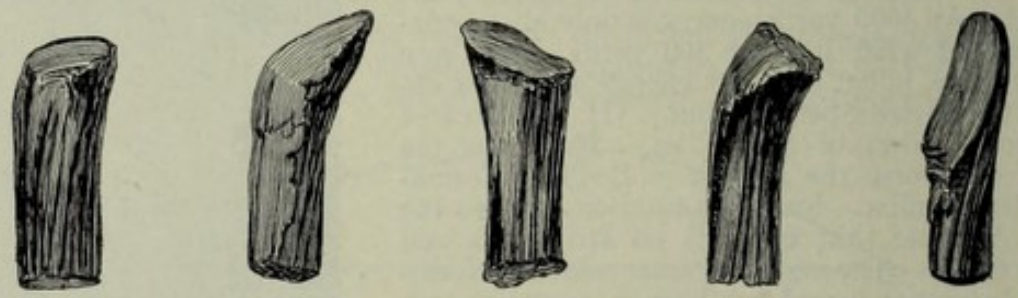


FIG. 101.—Deformation of small-caliber jacketed bullets (after Bruns).

firing at corpses and at live horses with service charges. De Nancréde, some years ago, wisely cautioned us to remember that experiments upon the cadaver, employing reduced charges and standing at fixed distances, are uncertain in their provings. "The difference," he said, "between the velocity of rotation and the angle of incidence with reduced charges at fixed distances and service charges at actual distances is marked. The tension of living muscle and fascia, as compared with dead tissues, and the physical change of semiliquid fat of adipose tissue and medulla to a more solid condition by the loss of animal heat, influence the results" (Ibid., "Gunshot Wounds," Roswell Park's "Surgery by American Authors").

All the theoretical conclusions derived from experiment and the observations made on the occasional victims of suicide or homicide have been put to the test of war in recent years, and we now draw our deductions from a study of the wounds in the Greco-Turkish War, the Spanish-American War, the South African War, the taking of Pekin, the Russo-Japanese War, the Balkan War, and particularly from

the tremendous and ferocious World War. Preconceived opinions have, in many particulars at least, been confirmed. It has been found that many wounds are non-infected and are apt to heal by first intention unless inflicted by ricochet, which deforms the bullet (often tearing off its jacket or making it mushroom) (Fig. 102), or unless the bullet is deviated from the straight path with the point forward and enters with its side to the front. This event is apt to happen with the pointed bullet, not with the unpointed bullet. If it does happen a bit of clothing will be liable to lodge in

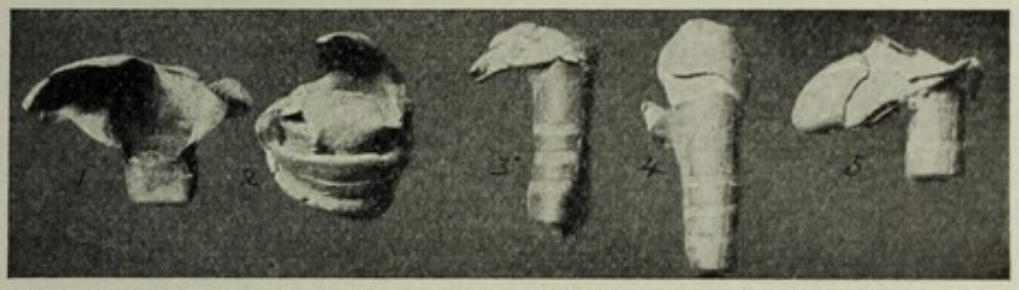


FIG. 102.—1, Empty Krag jacket removed from thigh after penetrating 6 inches at 340 yards; 2, 3, 4, 5, lodged Krag bullets removed from wounds after deflection from frozen ground. Ranges from 50 to 300 yards.

the tissues, the wound will be lacerated, and infection will be inevitable. As a matter of fact, in the trenches infection was very common after bullet injuries and surgeons were forced to regard all wounds as infected. The infection comes from the dirt-begrimed skin and clothing of the soldier. At a range of 1500 yards or more, if the bullet enters point on, the wounds are commonly clear tracts, without much splintering of bone or laceration of tissues. The wound of entrance is extremely small and could be overlooked by a careless observer. It is usually circular, it may be triangular.



FIG. 103.—Showing a large "explosive" wound of exit resulting from a rifle ball, causing the entire loss of the middle third of the ulna (Fauntleroy).

The bullet is far less liable to lodge in the body than was the older bullet. If it perforates, the wound of exit is usually small, and may be either round or a slit. These facts are true when the bullet goes through point on. Otherwise it tears a great laceration. The wound of exit is large if the injury has been inflicted at close range, or if bone has been splintered and fragments have been driven along with the bullet (Fig. 103).

Theoretically, the projectile does not flatten, but it has been found that in many

instances it does flatten a little (Fig. 101). Its coat is apt to be torn off when it strikes hard bone at a distance of less than 1800 yards. Treves has pointed out that if a bullet smashes a bone and lodges, the shell, as a rule, peels off from the core. Then the bullet may be distorted or broken into fragments. When a hard-jacketed bullet is "traveling over 2000 feet per second" it "will hold together" and penetrate any human structure "without breaking up, but as the velocity drops, there comes a point when the resistance is too great for the momentum of the bullet to be overcome quickly, and then the bullet piles up on itself, just as it does when it strikes a very hard object, and the lead crowds to the front part of the bullet till the nose of the jacket bursts. When this happens the wounds are very serious and have given rise to rumors of the use of 'dum-dum' or soft-nose bullets or of explosive bullets" (Wadsworth in "International Clinics," Vol. IV, Twentieth Series). At long range the bullet may lodge, or it may also do so if it hits a man after bounding from a stone, hard ground, or a piece of metal. It may lodge in compact bone. In Cuba 10 per cent. of the wounded suffered from lodged bullets. In the Russo-Japanese War less than 10 per cent. of the wounded suffered from lodged bullets. I do not know the proportion in the World War.

It is seldom that bits of clothing are carried in with the bullet, but sometimes they are, and some fabrics are more liable to be carried in than others. Threads are not unusually carried in on the roughened areas cut into the bullet by the grooves of the rifling. If the bullet ricochets from stony ground, bits of stone may enter the tissues.

Blood-vessels are likely to be cut and not pushed aside, as was often the case with the old-time bullets. Cases of arterial contusion and subsequent secondary hemorrhage are, however, occasionally met with. If a large vessel is struck and cut, primary hemorrhage will be profuse and may prove rapidly fatal. In many cases external hemorrhage is slight and the vascular injury may not be suspected. In such a case a pulsating hematoma forms. The modern bullet is seldom deflected in the tissues, but, as a rule, it passes straight ahead. The skin is usually split by it. Fascia and muscle are likely to be much damaged, but in a transverse wound of muscle the fibers may be separated rather than destroyed.

Although under most circumstances this bullet is humane, it has been found that in some instances it pulpifies structure for a considerable distance around the track of the ball, producing what is known as an *explosive effect*. The cause of this condition has been much debated, though it never means that the bullet has exploded. Some think that it is always due to comminution of bone and the blowing of bone-fragments ahead of and around the ball. Most believe that the sudden impact against the tissues engenders waves of force, which cause explosive and distant damage. Certain it is that an explosive effect causes horrible and often hopeless injury.

Explosive effects are most frequently seen at close range, when the velocity of translation and the frequency of rotation are most marked. Such injuries were seen in the marines killed at Guantanamo, in persons killed during the Milan riots, and in many instances in South Africa, China, Manchuria, France, and Belgium.

The bullet from the revolver usually employed in civil life has no explosive action at all; and the old-time large, soft bullet possessed it only at a very close range. The modern rifle projectile, at 300 yards or less, causes great splintering and comminution of bone. It may produce explosive effects up to 500 yards, but it does not invariably do so. At 900 yards and over it causes great smashing and comminution of bone (Posnett in "Lancet," Sept. 5, 1914). At 1300 yards a single bullet may entirely destroy the cranium. Explosive effects may at times occur at longer distances upon the liver, spleen, kidneys, and lungs, and upon hollow viscera containing fluid. At a distance of 500 yards or less a bone will usually be shattered into many fragments; whereas, at a range of 1500 or 2000 yards the bone will, as a rule, be cleanly perforated, usually without comminution.

It is extraordinary how little trouble may follow a wound by a modern projectile and how quickly healing can occur. This is due to the facts that the tissue is cleanly perforated, that foreign bodies are seldom carried in, and that the wound rarely becomes infected unless the soldier's clothing and skin are very dirty or unless the bullet struck some object on the ground before striking the man. This freedom from infection is not due to the bullet being sterile. It is not sterile, and when the gun is fired the bullet does not heat sufficiently to destroy bacteria certainly. The bullet is carried in a dirty belt or pouch, is handled by dirty hands, and is not clean when put into the rifle, but its sides may be scraped cleaner by the rifling and the burning powder may disinfect it in part. The point, however, contains bacteria on its surface. They are

few in number if the bullet flies direct to its mark and if the soldier and his clothing are free from mud and dust. If the bacteria are few in number they are scattered in the tissues; and, in most instances, are overcome by tissue resistance. The clean track of the bullet which is usual in wounds inflicted at ordinary fighting ranges impairs tissue resistance much less than a badly contused and lacerated wound. In some observed cases there have been almost no symptoms after perforation of the lung. In others, none after perforation of the abdomen, a joint, or the skull. The bullet, if reasonably clean, when it has become stationary seldom does harm unless lodged in the brain. In most conflicts outside of Belgium and France the modern rifle has proved to be humane and its humanity is largely a matter of range. At a range of 1500 yards or over modern rifles in which ogival headed projectiles are used are humane weapons. The pointed bullets, unless they strike exactly point on, are not humane and may inflict ghastly wounds.

What used to be called a *wind contusion* is a severe and often a dreadful injury. The skin being unbroken, bone may be broken, viscera ruptured, tissues torn asunder. The older surgeons believed that such an injury was produced by the wind pressure, a projectile passing close to, but not touching the surface. We know now that they result from a projectile's glancing along the surface, the elasticity of the skin saving it from immediate destruction, although in many instances it sloughs later.

A small bullet in striking never gets hot enough to burn a part. Fragments of high-explosive shells, hand grenades, shrapnel, and bombs are hot and may burn clothing and tissues. A burn of the tissue thus inflicted complicates the contusions and lacerations (Magnus in "Medizinische Klinik," Nov. 5, 1916). It is needless to say that bullets are never deliberately poisoned.

Symptoms.—*Pain* is seldom severe in wounds of the soft parts, but violent, immediate pain is felt when a bone or a nerve is injured; the pain is usually stinging or burning, but is seldom of long duration, except in bone injuries, spinal cord injuries, and nerve injuries. Sometimes a man does not know he has been struck. It is common to have anesthesia or numbness and loss of muscle function about the wound for several hours or days.

Shock is very variable (page 189). In some cases it is scarcely noticeable, in others it is overwhelming. It is most marked in wounds of bone, muscle, the spine, the abdomen, and the extremities. It is greatly aggravated by hemorrhage. Hemorrhage may be great if a large vessel is struck. Cases of vessel injury have increased notably since the introduction of pointed bullets. Many are undiagnosticated because of slight external bleeding, the small wound in the vessel and the unequal retraction of muscle layers keeping blood from the surface wound. Even when a large blood-vessel is struck bleeding may be moderate or even scanty; yet when the projectile is removed it may become violent. In such a case the projectile and a clot about it acted as a plug (Potherat in "Arch. des maladies du cœur," Nov., 1916). If the vessel is in a limb it is seldom that much blood escapes externally, but a large hemorrhage occurs in the tissues. Such cases reach the hospital for treatment, and are spoken of as "traumatic aneurysms" or hematomas. They were not uncommon in South Africa, and there were many of them in the World War. The condition is not true aneurysm, but, as Auvray says, is a hematoma ("Bull. et mém. de la Soc. ed Chir. de Paris," April, 1915). The external opening may close, or infection may creep in through the opening. Secondary hemorrhage is uncommon. When it does occur it is usually a result of infection, but it may arise, as in a soft-bullet injury, from contusion of a vessel. If a great vessel is divided in the chest or abdomen, the patient rapidly bleeds to death on the field, and seldom reaches the hospital at all. A military bullet may cause arteriovenous aneurysm. Many cases have been reported.

Primary infection is rare except in wounds received during trench fighting. The bullet wound tends to remain uninfected unless bits of clothing or other foreign bodies have been carried in, unless the bullet glanced from the ground or some object before striking the man, unless it was deformed, unless the wound was at close range, or unless unnecessary and uncleanly probing was practised. If suppuration occurs, it is apt to remain localized unless the bullet was grossly infected in one of the ways already stated. Pyemia and true septicemia are rare after wounds by reasonably clean bullets. In the Russo-Japanese War suppuration seems to have been common. In the Japanese hospitals at least 60 per cent. of wounds of the soft parts by undeformed bullets suppurated. At most in only 1 case out of 10 does the bullet lodge. (Reports on Russo-Japanese War by Maj. Chas. Lynch, Medical Department, General Staff, U. S. A.) It is stated that among the Russians suppuration occurred in 30 per cent.

of the cases. More wounds suppurated in winter than in summer. The Russians used a larger bullet than the Japanese, and the wound inflicted by the Russian bullet was far more liable to suppurate than was that produced by the Japanese projectile. Practically all wounds of bone made by Russian bullets suppurated. (Lynch, Ibid.) The above remarks upon the military projectile do not apply in all particulars to the pointed bullet adopted by the United States (model of 1906). It is of the same caliber as its predecessor, but it is 0.17 inch shorter, 70 gr. lighter, and its point is decidedly sharper. The muzzle velocity is 400 yards per second greater. Point-blank range has been extended from 600 to 718.6 yards. Because the new bullet is short and because the center of gravity is toward the base the bullet is easily deflected and is prone to enter the tissues sideways, inflicting a frightful wound instead of the usual small puncture of the ogival headed bullet of 1903. La Garde has pointed out that even the skin resistance may cause the bullet to turn. Hence it is evident that the bullet of the Springfield now in use is distinctly not a humane weapon; it will inflict horrible injury and is very apt to kill the victim outright (Lt.-Col. Borden, U. S. A., in "Keen's Surgery," vol. vi).

The Machine or Rapid-fire Gun.—From this gun rifle cartridges are fired. The gun is automatic and can fire 550 shots a minute. The wounds caused by the projectiles of the machine gun are identical with those produced by projectiles fired

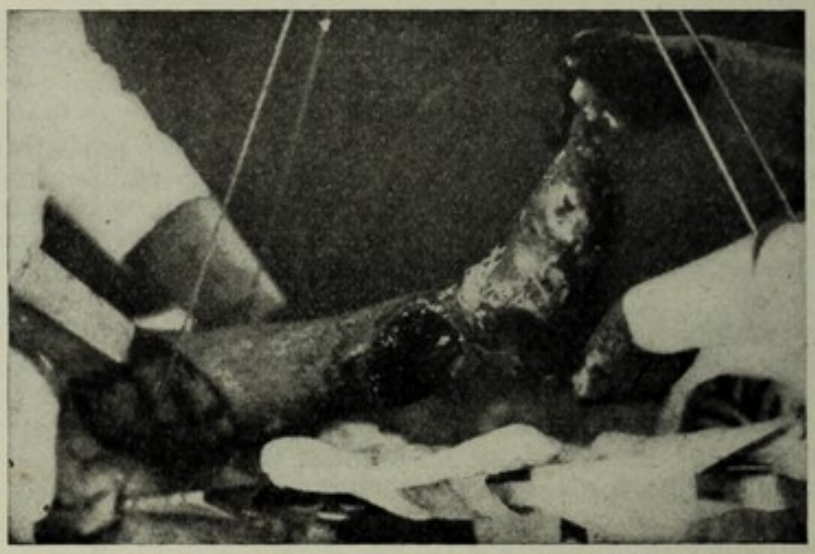


FIG. 104.—Compound comminuted fracture of the lower third of right leg, the result of a high-explosive shell wound, involving ankle-joint and foot. Treated satisfactorily in a modified Blake splint, with extension from an anklet secured around dressing. The discoloration shown in the photograph is due to the silver nitrate solution used to control especially the virulent infection (Fauntleroy).

from the rifle. The 3-inch quick-firing field gun can be fired from 15 to 25 times a minute (Report on the Medico-Military Aspects of the European War by Surgeon A. M. Fauntleroy, U. S. N.).

Artillery Shells.—A shell is a metallic case containing a bursting charge of explosive. The shell may produce havoc by means of its own fragments or by bullets which it holds being blown out by the explosion within. Shells are cylindroconoidal in shape and are fired from rifled cannon. The *high-explosive shell*, which is usually made to explode on impact, kills and maims by means of the numerous pieces into which it is blown by the explosion. A high-explosive shell weighs from a few pounds to a ton. The *shrapnel shell* is a metal case containing a charge of explosive which is fired by a time fuse. The case also contains many spherical bullets. The bullets may be hard, but are usually of soft lead, each about ½ inch in diameter, and tend to mushroom on striking. A 3-inch shrapnel shell weighs 18 pounds and contains about 350 bullets. The bursting charge does not burst the shell but merely opens its head or base and drives out the bullets.

The *high-explosive* shrapnel shell can be used as shrapnel, and is then fired with a time fuse; or can be used as a high-explosive shell, and then detonates on impact.

Shell wounds are always infected. Shrapnel wounds are contused and lacerated. Bone is smashed. Extensive hematomata form. The deformed bullets are apt to carry in bits of clothing. Lodged bullets are common. Of course the emptied case may

kill or wound a man. The high-explosive shell drives shell fragments, dirt, and bits of clothing into the tissues.

Shell concussion is not shell shock. Shell shock or, to use a better term, war shock, is traumatic neurasthenia and hysteria (page 240). A high-explosive shell may cause instant death when it explodes near a man, and yet the man may show no sign of an external wound. Death may have been so sudden that the dead retain in death the last attitude, perhaps even the final gesture of life ("Brit. Med. Jour.," Aug. 14, 1915). It is quite common for men near such an explosion to escape being struck, but to be hurled about or to be thrown a number of feet in the air. A man who is not killed instantly gets up, although he is terribly weak and shaken, but in a few hours he is apt to pass into collapse and perish. Shell concussion may cause cerebral or spinal bleeding (as indicated by bloody cerebrospinal fluid), rupture of the lung, or rupture of the hollow organs ("Brit. Med. Jour.," Aug. 14, 1915). It has been suggested that either an enormous and temporary increase of atmospheric pressure, or the ensuing temporary vacuum, is responsible for the physical injury.



FIG. 105.—Hand-grenade wounds of the face and other parts of the body (Fauntleroy).

Grenades.—These weapons are small, explosive shells which are used largely in trench fighting. Some are thrown by hand, some are projected by a rifle. Some are exploded by a fuse, some by percussion. On explosion the shell breaks into numerous pieces. Grenade wounds are torn and contused, the fragments of the casing lodge in the tissues and are apt to carry in dirt and often particles of clothing. All such wounds are infected.

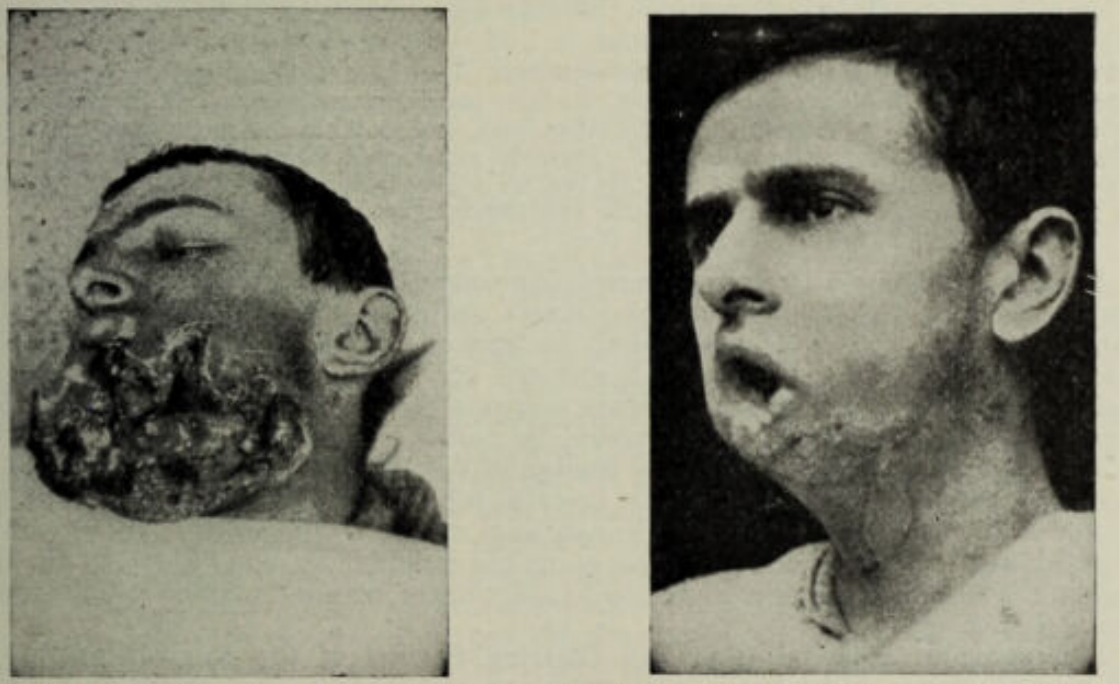


FIG. 106.—Operative stages shown in a series of two photographs of the same case (Fauntleroy).

Other bombs that are used are *aërial bombs*, some of which are *incendiary*, some of which are explosive—and trench *mortar bombs*, each composed of a very thin metallic casing and containing a large charge of high explosive. Trench mortar bombs are used at close range, 350 yards or less.

Position and Functions in Battle of Hospitals, Military Officers, etc.—(See Col. T. H. Goodwin in the "Military Surgeon," June, 1917.) From a quarter to half a mile back of the front fighting line and within range of rifle fire are the regimental aid posts.

1. **Regimental Aid Posts.**—One, two, or several of these posts are placed back of a battalion. When the fighting is in the trenches an aid post will probably be in a dugout, when it is in the open it will be placed at the safest near spot. These aid posts have medical officers, hospital corps men, and stretcher bearers. Aid posts move with their respective regiments. The medical officers belong to the regiments at the front. The effort is to gather up the wounded and bring them in as quickly as possible. The theory is that when a man is wounded, he, a comrade, a medical officer, a hospital corps man, or a stretcher bearer should at once apply a dressing and, if there is a compound fracture of a limb, a temporary splint should be applied before bringing the man in. As a matter of fact it is seldom that anything at all is done until the wounded man reaches the regimental aid post. The gathering of the wounded is usually a dangerous task, sometimes so dangerous that it must be deferred until night. The slightly wounded walk back, those more seriously hurt are borne on stretchers. In the regimental aid post no grave operations are performed and only first aid is given. It is a busy place and often full of peril from bombs and bullets. After first aid has been extended all of the patients go to the field ambulance unless transport facilities are ample, in which case those very seriously injured are sent direct to the field hospital or to the evacuation hospital. Patients are moved to the dressing station in the most feasible manner (horse or mule ambulance, stretchers, etc.).

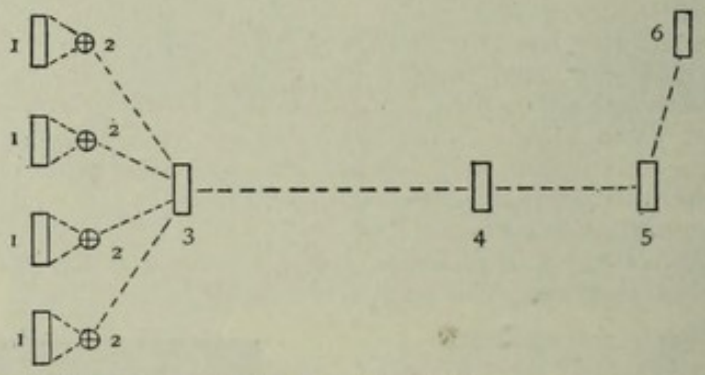


FIG. 107.—1. The fighting front of the battalion. There are surgeons, stretcher bearers, and hospital corps men. 2. Regimental aid posts. At these points first aid is given. 3. Field ambulance. 4. Field hospital (6 to 12 miles instead of 3 miles back, and may have to move again and again). 5. Evacuation hospital. 6. Base hospital. Patients who cannot walk are brought from 1 to 2 by stretcher bearers; from 2 to 3 by stretcher bearers or perhaps horse or mule ambulance; from 3 to 4 by field ambulance; from 4 to 5 by motor ambulance; from 5 to 6 by ambulance train.

2. **Field Ambulance Dressing Station (Advanced Dressing Station of the English Army).**—This post is farther back and better protected than the aid post. It is in charge of a medical unit. Here dressings are applied or changed, trivial operations are performed, serious external bleeding is arrested, etc. All surgical emergencies are first of all weeded out and sent back quickly and directly to the field hospital. Patients in general are moved to the field hospital by motor ambulances.

3. **Field Hospital (Main Dressing Station of the British Army).**—From here those whose wounds are trivial walk to the hospital for the slightly wounded (Corps Rest Station of the English Army). Such men soon return to the front. Those who are wounded more severely are gathered in motor ambulances and taken to the field hospital. The field hospital is from 6 to 12 miles to the rear and may have to be moved over and over again.

4. **Evacuation Hospital (Casualty Clearing Station of the English Army).**—In this hospital most of the grave operations are performed. The former idea was to send many or most of the wounded requiring serious operations to a base hospital, but this practice was abandoned except in certain head injuries, and instead of a casualty clearing station the station became (as Bloodgood says) a casualty hospital. Patients, more or less quickly, after operation are moved by motor ambulance or ambulance train to the base hospital.

5. **Base Hospital (Stationary Hospital of the English Army).**—The base hospital

is far back of the firing line. In it certain operations are performed and patients are treated until convalescent from their injuries. From the base hospital patients go to the convalescent hospital.

6. **Convalescent Hospital.**—This is far away from the zone of fighting and may be in another country or across the sea. Transportation may be by train, transport, or hospital ship.

Treatment of Wounds in War.—On a previous page we set forth some of the conditions under which a military surgeon must act, conditions vastly different from those encountered by the surgeon in civil life and which may dictate a different course of action.

The wound inflicted by the bullet of a military rifle is very different in nature and in danger from the wound inflicted by a revolver bullet. In the former, if a large vessel is struck, it is usually perforated or divided, and profuse bleeding occurs, either into a cavity or in the tissues. If the bleeding occurs in a cavity the patient usually dies on the field, and does not reach the first dressing-station at all. If it occurs in the tissues a "traumatic aneurysm" forms. In revolver bullet wounds primary hemorrhage is seldom severe. Wounds with revolver bullets are very apt to suppurate. Wounds with the undeformed hard-jacketed projectiles that have not ricocheted very commonly escape primary infection unless such conditions exist as were found in the trenches.

Wounds that in civil life might require only a resection, may in military practice require amputation. The promise of aseptic healing may lead the military surgeon, if conditions are favorable, to treat without operation many bullet wounds which in civil life would be operated upon at once, and both surgeons would be right in the different courses pursued by them. In the trenches, however, every wound was regarded as infected.

In civil life the rule is absolute to open the abdomen for every case of gunshot wound entering that cavity. The experience of all military men in recent wars before the World War was that in treating patients wounded in the abdomen during open fighting by rifle bullets more cases get well under a policy of non-interference than with laparotomy. In trench fighting this is not true. It is probably not true in wounds from the pointed bullet. In military surgery laparotomy can be performed only when there is "*time to do it.*" It was seldom performed before the World War unless there was hemorrhage or else certain evidence or a very strong probability that an organ or viscus had been struck or perforated. On account of the difficulties in the treatment of the wounded in military life, as compared with civil life, military surgery is a pure specialty; and the details of the treatment of wounds in war must be sought for in treatises by military surgeons. The watchwords of the military surgeon years ago became—preserve asepsis and avoid meddlesome interference.

Trench warfare differs vastly from fighting in the open, and in it to follow the rules of extreme conservatism would be disastrous folly. In trench warfare the surgeon regards practically all wounds as infected. Many of them are huge and lacerated, much skin being lost and dreadful compound, comminuted fractures existing (Lt.-Col. Keefer in "Military Surgery," June, 1916). Aseptic surgery has been abandoned totally, and antiseptic surgery has replaced it. Free drainage is imperative if the wound was not excised. Many wounds are left wide open and plugging with gauze is condemned because it tends to dam up discharge. The wounds are either extirpated and sutured or are extirpated, treated with an antiseptic fluid, and sutured secondarily. Even in the field under fire it is desirable, if possible, to apply an antiseptic to the wound and to dress the wound. This is usually impossible. The wounded man is lucky if he can be brought into his own lines. Many wounded men must lie for hours between the lines until shrouding night enables rescue parties to bring them in. At the earliest possible moment the clothing is cut away (if the wound is under the clothing). If possible the wound and skin about it are washed with alcohol and painted with iodin (tincture, diluted one-half with alcohol) and then the dressings are applied. If this cannot be done the dressings are applied at once. The dressing should be absorbent and, if possible, antiseptic rather than aseptic gauze. Absorbent cotton should be placed over the gauze, and a bandage of linen, muslin, or gauze should be applied to hold the dressing in place.

It may be said here that for injury of limbs amputation is seldom necessary. It is done when the great vessels are injured, when the soft parts are grievously lacerated, when an articular surface is badly comminuted, and perhaps when there is menacing infection. Excision of a joint is occasionally performed when there is comminution.

Frequently, a wound of an articulation is recovered from after incision, disinfection, and free drainage.

The custom was to let many lodged bullets alone. If the wound is infected, or is known to contain foreign material other than the bullet, the bullet and all other foreign material must be removed. A bullet in the brain should be removed, and at the first minute possible when proper facilities are obtainable. Serious hemorrhage always calls for operation. Tie the vessel in the wound if possible; if not, tie the main trunk above, and if this fails, amputate.

In warfare at the present day an attempt is made to limit the death-rate from gunshot wounds by protecting them from infection at an early period after the accident. Esmarch offered a suggestion which has been adopted in the armies of all civilized countries. Every officer and private soldier carries a package which contains antiseptic dressings, and at the first opportunity after the infliction of a wound, if possible on the field, these dressings are applied by the soldier, by a comrade (for even the privates are instructed in the application), or by an ambulance man. If not applied on the field, they are applied at the first dressing-station by a surgeon or a hospital steward. In the United States Army the first-aid package is carried in a metal case to prevent contamination and damage by moisture. The case is hermetically sealed, but can be easily opened. It is carried hooked to the cartridge belt. It contains two bandages, two compresses of absorbent corrosive sublimate gauze, and two No. 3 safety-pins, all wrapped in waxed paper. One compress is stitched to the center of each bandage, and the bandage is so folded that the compress can be opened without touching its inner surface. Each private of the hospital corps and the orderly of each medical officer carries hermetically sealed tubes—each tube contains 1 gm. of iodin and 1½ gr. of iodid of potassium. By adding 50 c.c. of water or alcohol a proper antiseptic solution is obtained. In regard to the procedures practised for wounds of special regions, see Regional Surgery, Wounds of Chest, Wounds of Abdomen, etc. It is now a routine to give antitetanic serum after all wounds in war.

Treatment of Shell Wounds.—Sometimes a shell, failing to explode, acts like a solid shot, kills a man instantly, tears off a limb, or produces some other fearful mutilation. Large bursting shells not only wound and slay by means of fragments, but may cause severe burns by flame, cause grave disturbance or death by fumes, or injure or kill by concussion blast.

The usual shell injury is by splinters or fragments, which lacerate and are apt to become embedded. The shell, by striking iron, stone, etc., makes a multitude of small projectiles. Fragments commonly carry in with them portions of dirt and bits of clothing and shell wounds are always infected wounds. Large fragments may produce horrible mutilation. A fragment or splinter of a shell becomes a missile. On a war boat, a shell, striking part of the boat, fills the air with missiles, some being splinters from the shell, some splinters from the steel of the boat. Fragments of shell vary in size. One man may be struck by many fragments, wounds may be deep or superficial, may be horrible pulpifications, grave lacerations, or slight tears. Fragments become embedded and may or may not be deeply lodged. Fractures are common. Wounds by shrapnel are bullet wounds. Of course the emptied shrapnel case may itself inflict a wound.

Treatment.—Depends considerably upon the nature of the injury. Such wounds are lacerated invariably, infected grossly, and contain foreign bodies. Amputation of a limb or resection of a joint may be necessary. Lodged fragments are to be removed.

Free incision and removal of foreign bodies are the basic procedures in most cases. Then the wound is treated by extirpation of all injured tissue and suturing, or the Carrel-Dakin plan or some other method which aims to frustrate the effects of infection (see page 228). Antitetanic serum is always given to prevent tetanus.

Shell Gases.—(See Watt and Irvine, "Brit. Med. Jour.," Aug. 14, 1915.) An exploding shell gives off dangerous gases from the smokeless powder. These gases are oxids of nitrogen, carbon dioxid, and carbon monoxid. Such gases may produce immediate unconsciousness and asphyxia (poisoning by CO and CO_2). Some of these cases die rapidly, others recover.

A man who gets a dose of the nitrous gases may feel for a time constriction of the chest and headache and may suffer from cough. All the symptoms may pass away and yet in six or eight hours he may develop bloody expectoration and dyspnea and die rapidly from the pulmonary edema.

Treatment.—It has been found that an emetic given early may prevent symptoms.

It acts as a purgative to the bronchial tubes and air cells. Rest in bed is required. The development of moist râles at the pulmonary bases calls for immediate venesection, inhalations of oxygen, and administration of atropin (Watt and Irvine, Ibid.).

I have long employed a practically identical method for firemen, the victims of nitrous fumes, and so far Philadelphia has not lost a fireman from that cause. It is my custom to bleed the patient.

First Field Dressing.—In most cases it is impossible to give any treatment or apply any dressing until the wounded man reaches the regimental aid station. If it is possible bleeding should be arrested by a tourniquet. The wound should be moistened with iodin and covered with antiseptic dressings, and if there is a fracture the limb immobilized on some sort of emergency splint (a rifle is commonly used). A hypodermic injection of morphin brings great comfort and makes transportation far easier to bear. A surgeon may at times have an opportunity to arrest hemorrhage by ligation. As Hull says ("Surgery in War") practically all wounds are grossly infected to their very depths with anaërobic bacteria and no superficial painting with iodin can do more than lessen the danger of secondary infection.

In the regimental aid post the wounded man receives first aid if he has not already obtained it. Hemorrhage is arrested, wounds are disinfected and dressed, fractures splinted, stimulants and morphin are given as indicated. If possible he is given an injection of antitetanic serum (page 143). From here the wounded man goes to the Field Ambulance, the Field Hospital or the Evacuation Hospital, according to the nature of the injury, the degree of shock, and the facilities for transportation. He has on the first aid dressing and wears a tag on which is written the nature of his injury. Severe shock may cause the retention of a man for some hours before it is safe to move him. If antitetanic serum has not been given it is at once administered no matter how trivial the wound. It used to be the custom to leave the first-aid dressing untouched unless indications called for interference. The hope was to get healing under the

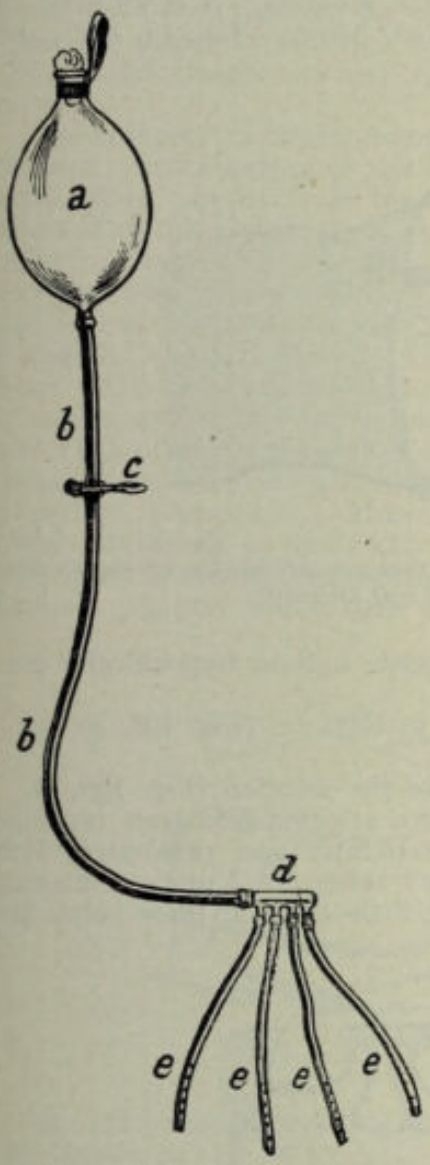


Fig. 108.—Carrel's irrigation apparatus: *a*, Reservoir for Dakin's fluid; *b*, the main distributing tube; *c*, the metal pinch-cock; *d*, glass tube with multiple openings; *e*, *e*, *e*, *e*, final distributing tubes closed at distal end, but perforated with openings of 1 mm. each (Carrel and Dehelly).

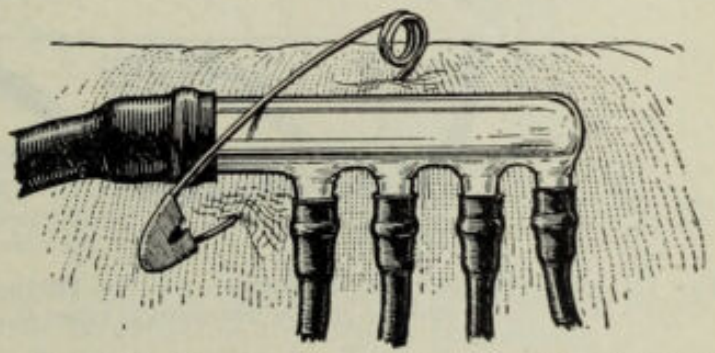


Fig. 109.—Showing Carrel's glass tube (Fig. 108, *d*) to connect the main distributing tube (Fig. 108, *b*) from the reservoir to multiple final small distributing tubes (Carrel and Dehelly).

first-aid dressing. That plan has been abandoned. The first-aid dressing is to be removed, as it is invariably infected if applied on the field or in the regimental aid post and is often so tight as to constrict the part. For a trivial and superficial wound, the wound and surrounding skin should be cleansed with alcohol to remove dirt and blood clot. A 2 per cent. solution of iodin is to be painted upon the wound and the skin about it. This is the best time to excise a severe wound or, at least, to open it more

widely, remove foreign bodies, remove hopelessly damaged tissue, disinfect, and drain freely. Counteropening may be necessary. Various disinfectants have been used.

If there is a fracture the limb must be immobilized. If the wound of a limb is very extensive the extremity should be immobilized even when there is no fracture.

The Carrel-Dakin Technic.—The Carrel-Dakin treatment aims to open up every recess, sac, and sinus of a wound, and by placing tubes in all of them secure free drainage and enable the surgeon to keep the wound full of a fluid which gives off chlorin. By this plan even a badly infected wound may be so sterilized as to permit of secondary suturing.

I take from Dr. Keen's book ("Treatment of War Wounds") a description of the method in which he quotes Lyle ("Jour. Amer. Med. Assoc.," Jan. 13, 1917, and others).

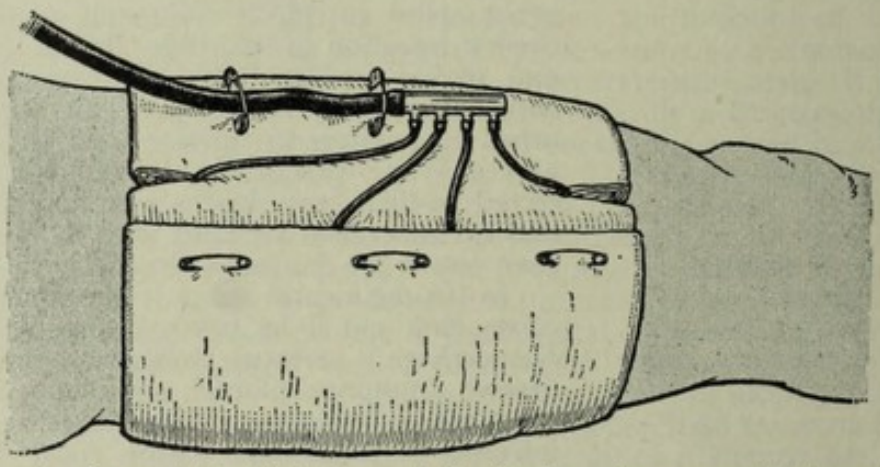


FIG. 110.—Showing the mode in which the small distributing tubes are carried through the dressing to the various parts of the wound (Carrel and Dehelly).

"*Necessary Materials.*—1. A solution of 0.5 per cent. sodium hypochlorite prepared by the Dakin and Daufresne technic.

"2. A glass container with a capacity of from 500 to 1000 c.c. (Fig. 108, *a*).

"3. Two yards of moderate-sized rubber tubing.

"4. An adjustable clamp for controlling the flow of the solution (Fig. 108, *c*).

"5. Rubber instillation tubes about 25 cm. long, with assorted diameters (average size No. 16 French). These tubes are tied at the extremity and perforated with holes made with a punch. The primary and secondary tubes are 7 mm. in internal diameter, the final distributing tubes 4 mm., and the little holes in these tubes are only 1 mm. (1/25 inch) in diameter.

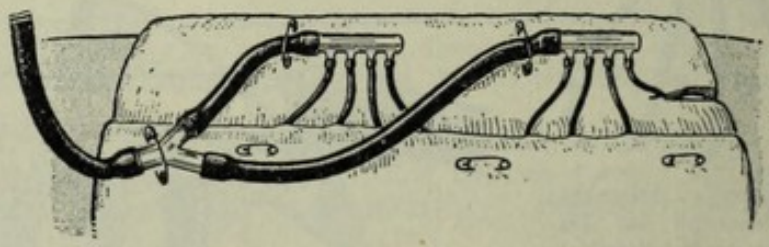


FIG. 111.—Showing a similar distribution as in Fig. 110, by means of a Y-tube, thus doubling the number of final distributing tubes (Carrel and Dehelly).

"6. Ordinary rubber tube drains, from 25 to 35 cm. long, without lateral holes.

"7. Glass connecting and distributing tubes (Figs. 110-111).

"8. The dressings consist of cotton surrounded by gauze. The cotton consists of a layer of absorbent cotton with a thicker layer of non-absorbent cotton. These dressings are about 3 cm. thick, and of different sizes. Three different sizes are sufficient—one large enough to surround the leg once, a second to surround the arm, the third still smaller. Webbing straps with buckles to fasten the dressing in place.

"9. Sterilized pieces of gauze impregnated with yellow petrolatum to be used in the protection of the skin.

"Operative Technic to Prepare the Wound for the Introduction of the Antiseptic.—The future course of the wound is directly dependent on the thoroughness of the first

surgical act. This should be carried out under the strictest aseptic precaution and at the earliest possible moment. It consists of a thorough, methodical, mechanical disinfection of the wound, with the extraction of all shell fragments, particles of clothing, dirt, etc. (For the new stereofluoroscopic method of extracting foreign bodies see page 1456.)

"The operative field is painted with tincture of iodin, and the bruised and necrotic skin edges of the wound are trimmed away with a sharp knife. The knife and forceps are then put aside. With new instruments the wound is laid open like a book and gently explored for shell fragments, pieces of clothing, pockets, etc. Everything that could have been infected by the traumatism or could become the source of infection is removed. All non-infected tissues and tissues unlikely to become infected are preserved.

"Gentleness of manipulation is the keystone of the technic. Brutalization of the traumatized tissue is a technical crime. In many of the cases it will be found that fibers of clothing, dirt, grass, etc., are encrusted in the muscular surfaces of the wounds. To avoid overlooking this blood-stained débris the track of the projectile must be lightly but methodically resected. Great conservatism is exercised in the removal of comminuted fragments of bone. The same minute and careful mechanical cleansing is carried out on osseous wounds as in the soft parts. Before placing the instillation tubes a careful revision of the wound is made, and particular attention paid to securing a perfect hemostasis. Muscular tissue infiltrated with blood is difficult to disinfect.

"There is another reason special to the employment of Dakin's solution which calls for a thorough hemostasis.

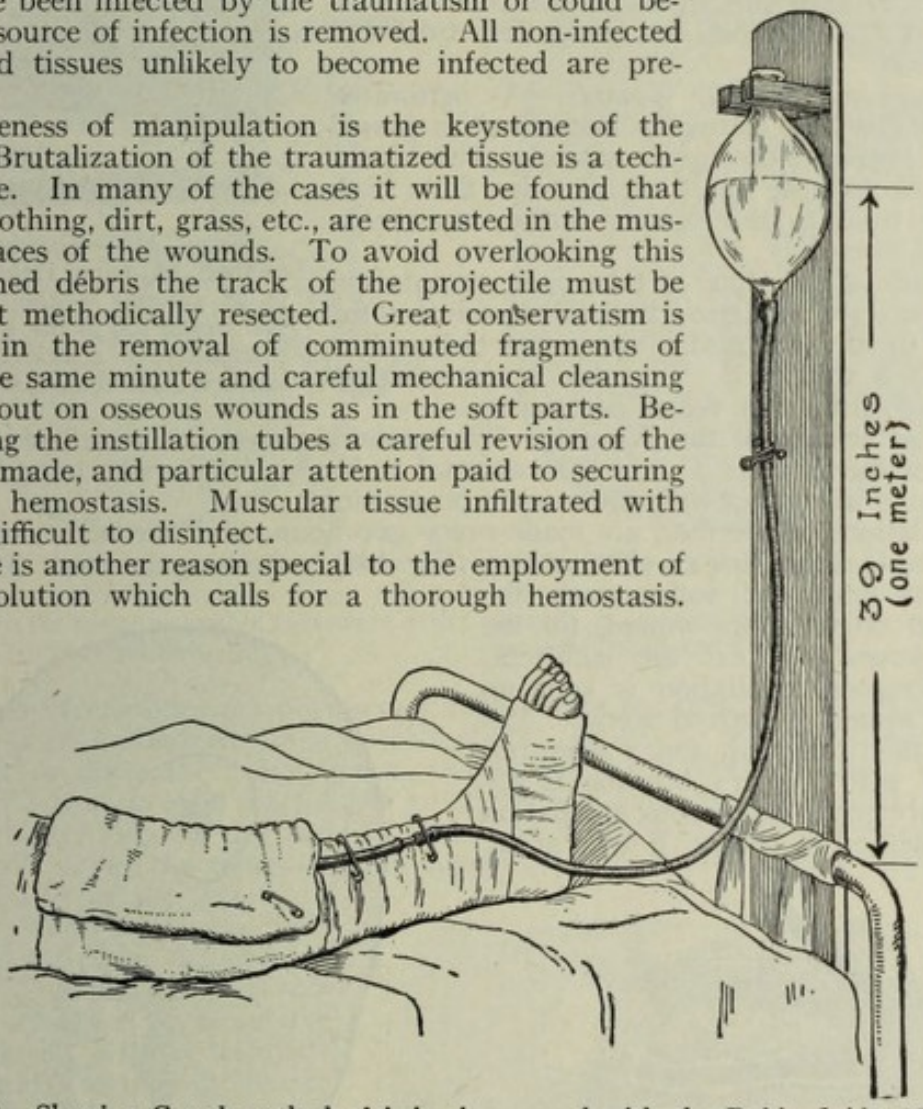


FIG. 112.—Showing Carrel method of irrigating wound with the Dakin fluid. Note on the main distributing tube the pinch-cock below the reservoir. The wound is covered with the dressing, which is fastened by safety-pins. The distributing tube is similarly held in place by being pinned to the plaster cast (Carrel and Dehelly modified).

Owing to its hemolytic property Dakin's solution has the power of dissolving recent blood-clots. A poor hemostasis invites the danger of a secondary hemorrhage.

"Counteropenings for drainage are rarely employed. If the necessity for their use should arise, one should avoid making them at the most dependent point, as the goal of technic is to keep the liquid in contact with *all* the surface of the wound.

"The Introduction of the Instillation Tubes.—The guiding principle is to place the tubes so that the liquid will come into contact with every portion of the wound. The placing of the tubes will vary with the nature of the wound.

"*Superficial Wounds.*—A thin layer of gauze is placed over the wound, and on this the requisite number of instillation tubes. The tubes are secured to the wound-edges by a rubber cuff and suture or a two-way-flow tube is used. If the tubes are placed directly on the surface, they become encrusted and the orifices are blocked with granulations. Too thick a layer of gauze should not be used, as it will become clogged with the wound secretions and prevent the solution from reaching the wound.

"*Penetrating Wounds.*—In the simple type, a tube without lateral perforations is introduced to the depth of the cavity and the solution allowed to well up from the bottom (Fig. 113). In a large tract terminating in a cavity with irregular collapsible walls a little gauze is introduced to support the walls of the cavity and allow a more thorough distribution of the fluid. Penetrating wounds with the point of entrance in a dependent position (as the buttock, posterior surface of the extremities, and the back) are treated with perforated tubes dressed with toweling (Fig. 115). These dressed tubes keep the antiseptic in contact with the wound. A suitable non-perforated tube can also be used.

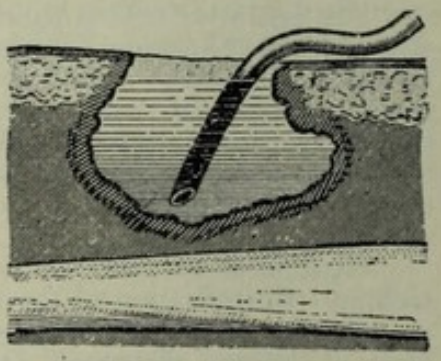


FIG. 113.—Showing Carrel's method of using Dakin's solution in an anterior wound and keeping the wound full of the solution so as constantly to attack the infecting bacteria (Carrel and Dehelly).

"*Through-and-through Wounds.*—A perforated tube with the tied extremity uppermost is passed from the lower to the upper wound. The liquid, escaping through the small lateral holes, flows back along the tract to the inferior orifice, moistening the entire wound.

"Wounds of the hand or foot, open amputation stumps, etc., are immersed in Dakin's solution for from ten to fifteen minutes every two hours until the wound is sterilized. The skin is protected by smearing it with sterile yellow petrolatum.

"The After-care of the Wounds.—The materials used are described above. In the care of the wounds a strict instrumental technic is employed, the gloved hands never coming in contact with the wounds or dressings.

"Instillations of the fluid are made every two hours (day and night) by releasing the adjustable clamp (for a second or two) (Fig. 108) controlling the flow. The amount of solution employed varies with the nature and extent of the wound; for the average wound, 10 c.c. are sufficient. This interrupted instillation is kept up until the wound is proved sterile. The tubes are then removed, and a compress moistened with Dakin's solution is applied. Formerly a continuous instillation was the method of choice: if used at all, it should be discontinued in from twenty-four to forty-eight hours. The rate of instillation is from 5 to 20 drops a minute, according to conditions. The object is to moisten the wound surfaces and not flood the bed.

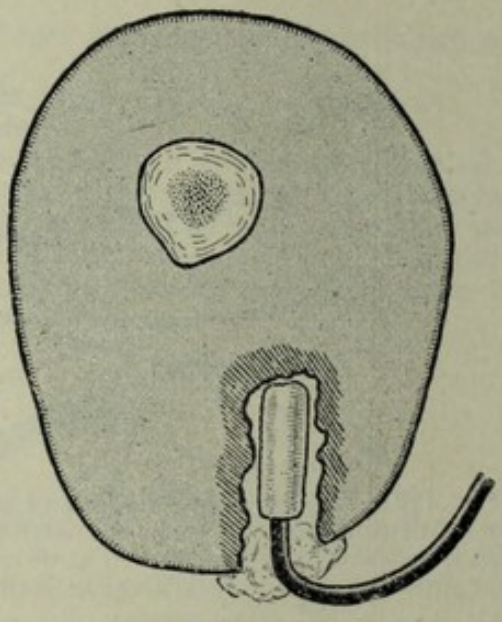


FIG. 115.—Mode of irrigating a wound in a posterior position. Observe that the distributing tube is here necessarily surrounded with toweling, otherwise the fluid would escape almost immediately. This toweling should be firmly sewed to the distributing tube by silk and not by catgut, so that it may not become detached and be left in the wound (Carrel and Dehelly).

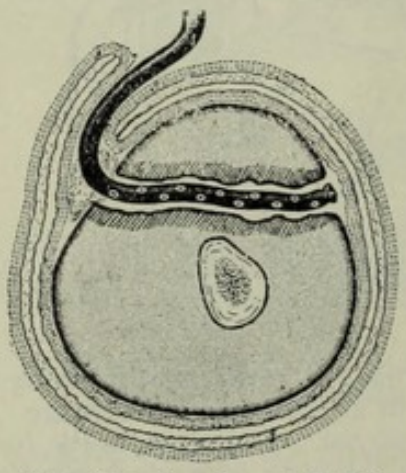


FIG. 114.—Showing the method by which the distributing tube enters the wound through the dressing without being constricted (Carrel and Dehelly).

"Once a day—oftener, if necessary—the wound, the tubes, and the flow of the liquid are inspected. Flushing the wound shows if the solution is being delivered as planned, and mechanically washes away the excess of wound secretion.

"The Carrel method is not a continuous irrigation. It is a mechanical attempt to deliver an antiseptic of definite chemical concentration to every portion of a surgically prepared wound and to insure its constant contact for a prolonged period.

"Systematic Bacteriologic Examination of the Wound.—This consists in a regular determination of the number of microbes on the wound surfaces. This is done by transferring with a standard loop a portion of the secretion to a slide and counting

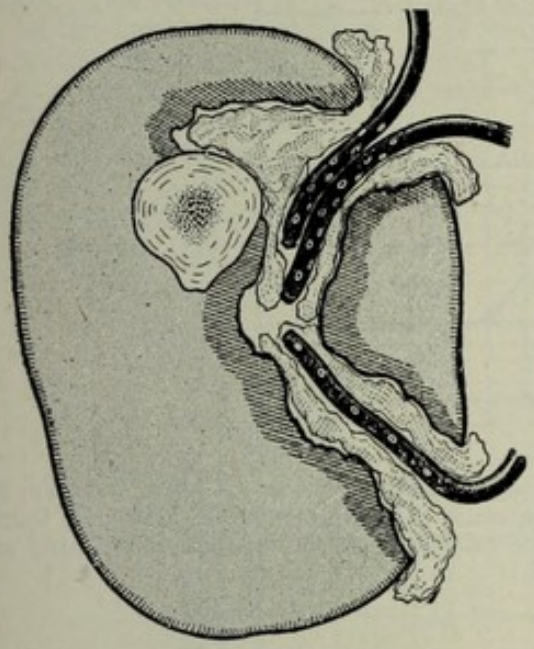


FIG. 116.—Showing the *improper* way of placing the distributing tubes. They are in contact with the gauze instead of in contact with the wound (Carrel and Dehelly).

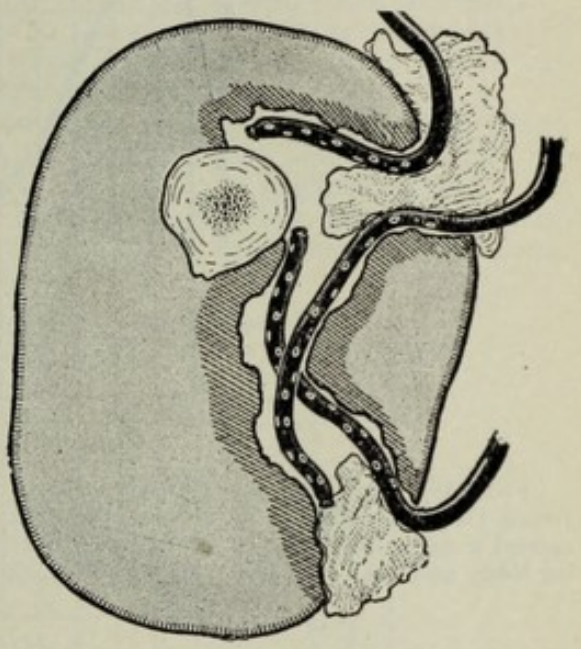


FIG. 117.—The *correct* way of placing the distributing tubes so that the Dakin fluid comes directly in contact with all the surfaces of the wound (Carrel and Dehelly).

the number of microbes per microscopic field. This is carried out every second day, and the results are entered on a suitable chart. When the microbes are absent from the wound on three successive counts, the wound is considered sterile. Though not absolute, the bacteriologic control is of great practical value as a therapeutic guide. . . .

"It is better to begin the bacterial chart one or two days after the reception of the patient. As a rule, the germs begin to appear after the ninth or tenth hour. There is an initial rise on the second or third day. This remains so for a few days, and then the descent begins. Wounds on the soft parts are sterilized in from five to eight days. Greatly traumatized wounds require a longer time. Fractures can be sterilized in from two to four weeks. If sequestra are present, they must be removed to obtain an asepsis.

"Wounds sterilized by the Carrel method are readily reinfected if the treatment is stopped.

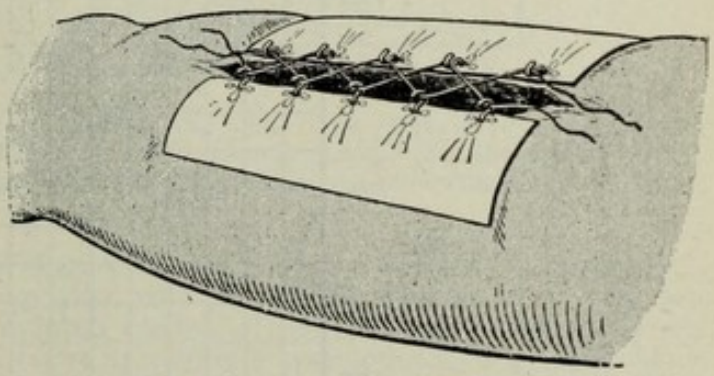


FIG. 118.—The edges of a wound being drawn together by rubber elastic traction (Carrel and Dehelly).

"Reunion of Wound.—When, by three successive tests, the bacteriologic examination shows the wound to be sterile, it is closed by careful layer sutures. In the favorable cases this can be done on the fifth day. The average time for the soft parts is from seven to nine days.

"In cases in which sutures cannot be employed the wounds are closed by adhesive straps passed in such a way that, besides pulling the edges of the wound together, they make a compression around the whole circumference of the limb, or a 'corset lacing' (Fig. 118). Care must be taken not to have the circular bandage, if this be used, too tight.

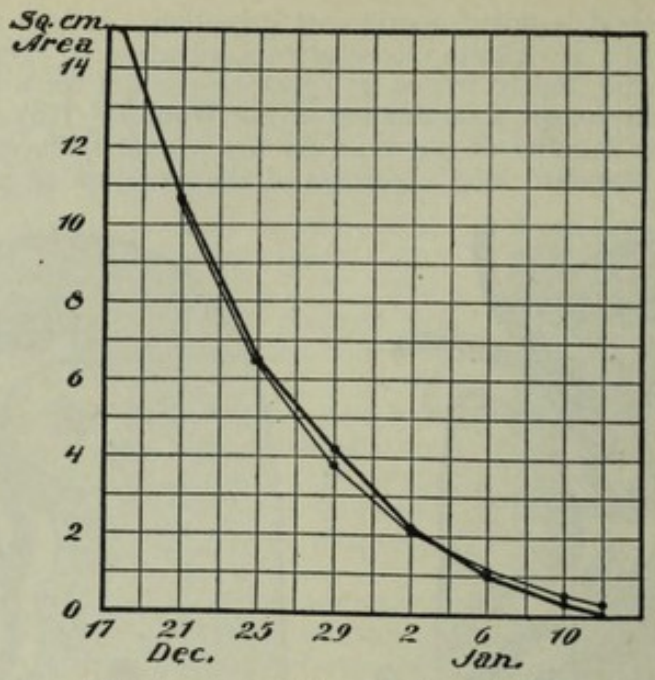


FIG. 119.—On December 17th the area of the wound was 16.2 sq. cm. A slight infection between December 27th and 29th, when one micro-organism in two microscopic fields was found, caused a slight deviation of the actual curve from the calculated curve. (Kindness of Carrel and du Noüy and the "Jour. Exp. Med.," 1916, xxiv, 454.)

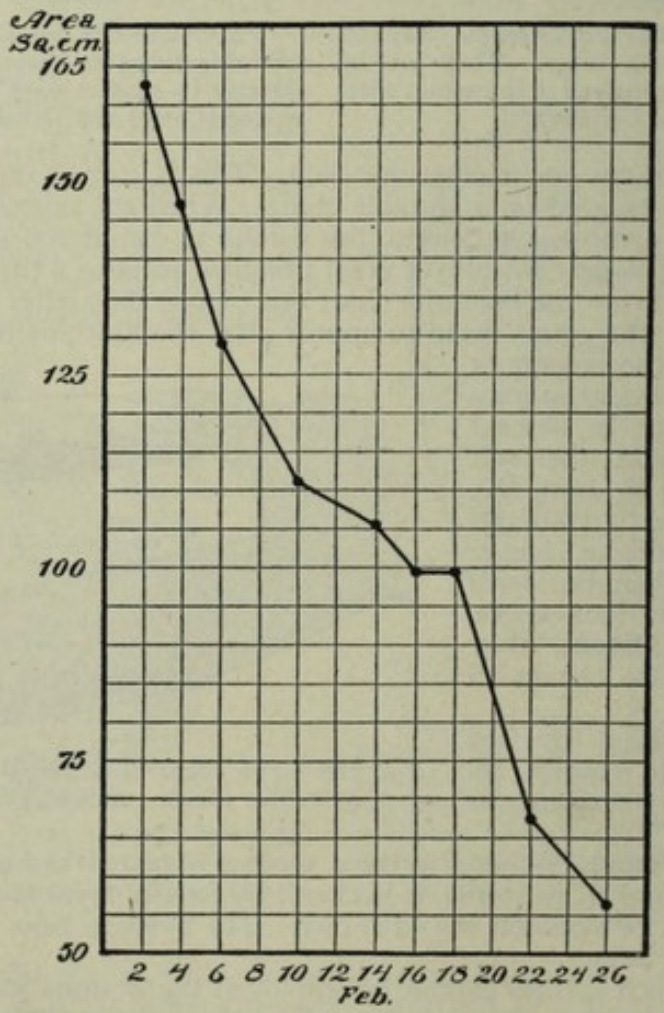


FIG. 120.—Wound of the abdominal wall. The horizontal part of the curve from February 16th to 18th represents a period of slight infection. As soon as the wound was sterilized chemically the curve descended abruptly. (Kindness of Carrel and Hartman and the "Jour. Exp. Med.," 1916, xxiv, p. 437.)

"For extensive wounds two Canton-flannel bands are prepared, the length to be slightly longer than the wound, the breadth to be a little less than half the circumference of the limb. On the hemmed edges shoe-hooks are inserted every 2 cm. The limbs are painted up to the edges of the wound with a resin varnish or Heusner's glue (see Fig. 118), and the wooly side of the Canton flannel applied. One should wait until the traction strips are firmly adherent before lacing them with rubber bands. The tension of the rubber bands rapidly draws the wound edges together."

In the entire treatment of these wounds even the gloved hands never are allowed to touch any dressing or the wound. Everything is handled by forceps, which can be so much more certainly disinfected than hands or even gloves.

When a wound has filled up and is in condition to cicatrize, Carrel and Count du Noüy, a French physicist, by means of a "planimeter," are able to measure the exact area, *i. e.*, the number of square centimeters, in the most irregular wound. The number of square centimeters is entered on a chart (Figs. 119–121, vertical numbers) every second day. The dates are entered according to the horizontal numbers.

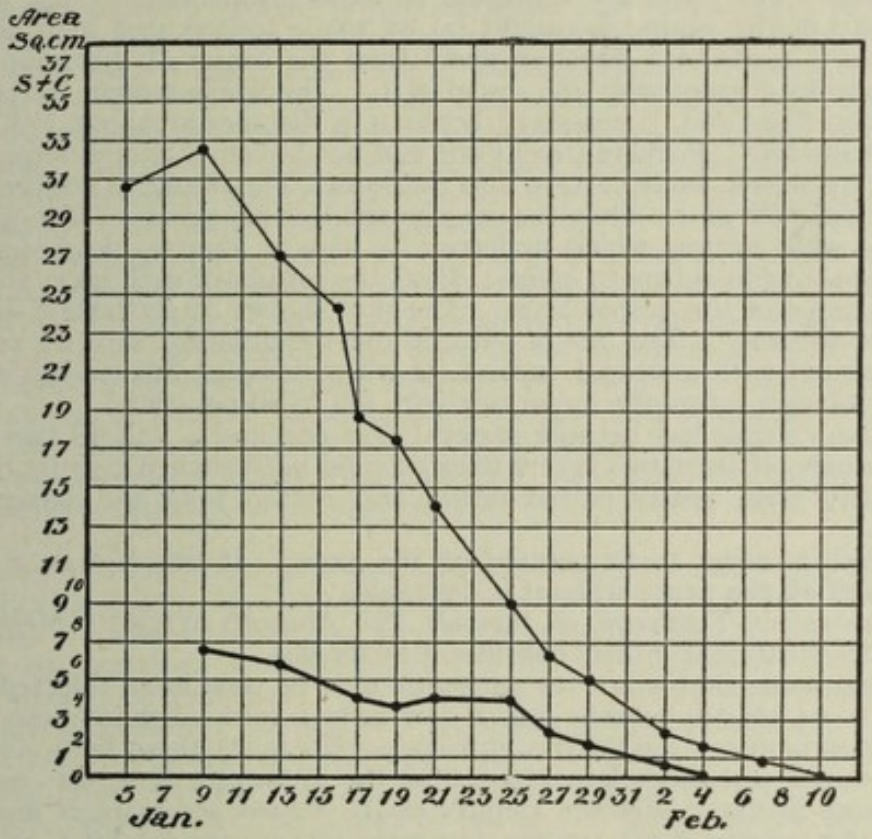


FIG. 121.—Shell wounds with fracture of the radius and ulna. The curves of both wounds tend to unite. Note that the larger wound, 33 sq. cm., healed far more rapidly than the smaller wound, which was less than 7 sq. cm. on the same date. (Kindness of Carrel and Hartman and the "Jour. Exp. Med.," 1916, xxiv, p. 442.)

After three or four observations have been entered, a "curve of healing" is established. By prolonging this curve they can predict with almost absolute accuracy the day on which a given wound will be completely healed. It is remarkable how nearly the "actual" curve and the "calculated" curve in a normal case coincide (Fig. 119). Any renewed infection, of course, disturbs this curve, but, curiously enough, if the infection is quickly overcome, the healing process undergoes acceleration and the healing will still be brought about at or very near the predicted date. Of course, any prolonged infection would considerably delay the healing. Another curious fact brought out by these curves is that large wounds heal at a more rapid rate than small wounds (Fig. 121).

Excision of Wounds.—Long ago Desault and others practised excision. Excision of the tissues about an infected wound is advised by Carrel as a preliminary to treatment by Dakin's fluid. Moynihan and others warmly advocate excision of wounds (recent or of some duration) and immediate suturing, the idea being to extirpate infected tissues and secure aseptic wounds. The treatment was suggested in the World War by Col. Gray of the R. A. M. C.

Gray's views are set forth below (quoted by Major Hull, R. A. M. C., in his book on "Surgery in War," from Col. Gray's article in the Journal of the Royal Army Medical Corps).

A wound of any length may be so treated. The sooner it is done the better and it is not necessary to wait until the wound is clean. If a large mass of inflammatory tissue surrounds the wound, excision is to be deferred, because the bacteria are deep in the tissues and will make trouble when invaded tissues are subjected to the pressure of sutures. By treating such a wound with hypertonic salt solution we can make the parts ready for excision and suture in forty-eight hours. Other contraindications are the existence of extensive pockets, the exposure of bone which it is "inadvisable or impossible to remove," and the exposure of large vessels or nerve trunks. In any case, however, the infected skin edges, superficial connective tissue and muscles should be excised.

In some cases bony prominences are removed with the infected muscles (tip of the acromion or a vertebral spine). The operation is usually performed under infiltration anesthesia. The parts are subjected to iodin disinfection. "The skin close to each extremity of the wound is caught up by tissue forceps in a loop of thread and slight traction is made in a direction away from the center of the wound and at an angle of about 45 degrees with the sound skin. The whole wound is then cut away *en masse* (skin, flesh, and, if necessary bone) at a distance of about 1/3 to 1/2 inch from the raw surface." Pockets are cut out and not broken into and bony prominences are removed by chisels, bone cutters, and rongeurs. The wound is washed with saline fluid and packed with gauze while the surgeon changes his gloves. "The wound should be closed by wide sutures which underrun its floor so that no dead spaces are left. It may be necessary to suture in layers. If so, the sutures of each layer should include some of the tissue of the deeper layer. The skin should be accurately approximated by a few fine sutures." The line of sutures and the adjacent skin for several inches should be painted with a wound varnish, of which mastic, dissolved in some rapidly evaporating solvent, forms the important part (40 to 50 per cent.).

"When the varnish has become sticky (after one and a half to two minutes), a covering of gauze, at least two layers thick, should be stretched tightly and smoothly over the sticky area, gently patted down, and cotton wool and bandages applied fairly firmly."

The varnish is never to be painted on the gauze. If this is done it will not be possible to peel off the gauze when it is desirable.

Hypertonic-saline Treatment of Wounds (Sir Almroth Wright's Method).—Some approve of this treatment, others consider it inefficient.

Wright maintains that whatever antiseptic may be used in an infected wound, the infection runs an almost definite course and lasts a fairly definite time, unless it is abolished by something besides the antiseptic. He takes these facts as proofs that something besides and more important than the antiseptic is at work in the wound.

"The tissues in the immediate vicinity of the wound are more or less devitalized not only by the severity of the trauma, but especially by the condition called by some 'local shock,' peculiar to gunshot wounds. Antiseptics will tend to maintain this state of lowered vitality and to favor microbic attack. Every efficient antiseptic is more or less toxic and irritating, so the less they are introduced into wounds the better" ("Surgery of War" by Major Alfred J. Hull, R. A. M. C.). Hull goes on to point out that the patient's tissues possess far more power to destroy invading organisms than any antiseptic, therefore the surgeon should aim to stimulate the forces, offensive and defensive, residing in the patient himself.

All know the value of free drainage and the removal of foreign matter, destroyed tissue and blood-clot. Sir Almroth Wright adds to these expedients the establishment of "free lavage of the wound by lymph laden with antibodies which act in the tissues lining the wound as well as, but to a less extent than, on its surface.

"The lymph in the depth of the wound becomes more inert as its antibodies are used up in the fight with micro-organisms and must be drained away, otherwise it becomes a pabulum for their growth" (Hull, Ibid.).

Hypertonic solutions of sodium chlorid are used to cause lymph lavage. The salt may be applied by continuous irrigation through a fine tube, the wound being drained by gauze, by immersion of the part in a continuous saline bath, by keeping gauze wet with salt solution in contact with the raw surface or by placing tablets of salt here and there in the wound, the serum of the patient making the necessary solution.

For irrigation or immersion a 5 per cent. solution is used. In very septic cases a 10 per cent. solution is used. When the wound becomes clean, normal salt solution is used. In a short time this is abandoned and the wound is then merely dressed with gauze moistened in normal saline solution.

The treatment by solid salt was devised by Col. Gray, R. A. M. C. The wound is irrigated with salt solution (5 per cent.), is packed with gauze wet with a solution of the same strength, and "wrapped in the gauze are tablets of salt. Every portion of the wall of the cavity must be in contact with the gauze or the treatment will fail. Into the depth of the wound a large drain is placed" (Hull, Ibid.).

One great advantage of this method is that transportation of the patient does not interfere with it.

Rutherford Morison's Method.—Many surgeons commend it highly. The wound is enlarged, every pocket is opened up, devitalized and necrotic tissue is removed, granulation tissue is freely curetted, bleeding is arrested, foreign bodies are removed, and also any loose pieces of bone. The wound is packed with gauze while the surgeon changes his gloves. The wound is now sponged out with methyl alcohol. "Onto the raw wound surface a thin layer of a preparation known as Bipp (bismuth subnitrate or carbonate 1 part, iodoform 2 parts, paraffin in quantity sufficient to make a soft paste). With a gauze swab this paste is rubbed well into the wound, which is then sutured from end to end without drainage" ("American Addresses" by Sir Berkeley Moynihan). The wound is usually found healed in ten days. Moynihan believes the success of the method is due far more to the careful mechanical cleansing of the wound than to the iodoform and bismuth.

Chemical Warfare by Asphyxiating, Irritating, or Poisonous Gases and Smoke.—We have already stated that the gases from exploding shells are dangerous and may be fatal. But this elimination of gases is an incident, not a design. High-explosive shells are thrown for other purposes. It was reserved for the Germans in the World War to invent and deliberately use irritating, asphyxiating, and poisonous gases. Long before Christ the fumes of burning sulphur and the smoke from resinous wood were used in warfare. The Chinese for ages employed the "stinkpot," a shell of earthenware filled with combustibles which in bursting gave out foul and asphyxiating gases. The Germans reinvented gas warfare, and made of it a science of superlative cruelty and horror.

Such gases were first used at Ypres on April 22, 1915, on a French division (report of Field-Marshal Sir J. D. P. French, quoted by Victor Lefebure in "The Riddle of the Rhine"). The effects upon men entirely unprepared and unprotected were dreadful in the extreme. More than 5000 were killed and there were "many more times that number of casualties" (Lefebure, Ibid.). General Fries states ("Journal of Industrial and Engineering Chemistry," 1920) that out of 275,000 American casualties in the great war, 75,000 were caused by gas. Early in the World War about 35 per cent. of those gassed died. Toward the end of the war, because of the use of masks and of training against gas attacks, the mortality fell to "25 per cent. or less" (Fries, Ibid.).

There are four different ways of using gas. (See Lt.-Col. George W. Norris, M. C. N. A., in "Jour. Amer. Med. Assoc.," Nov. 30, 1918.)

1. *Drift, Cloud, or Cylinder Gas.*—This gas plan was employed largely in the earlier gas attacks. Liquid chlorin or phosgen (carbonyl chlorid) was usually used. The wind had to be in just the right direction and blowing at the rate of from 4 to 12 miles an hour. In using cloud gas the element of surprise is necessary and the proper degree of concentration of the vapor is often impossible of attainment. The gas is eliminated from a number of cylinders, usually at night or early in the morning. "The gas is heavier than air, sinks into trenches, dugouts and shell holes, and is unaffected by mist, rain, or water-courses. Such attacks have been made on a 5-mile front and have produced intoxication at points 6 miles behind the lines" (Lt.-Col. Norris, Ibid.). A change of wind during a gas attack may drive the gas back upon the lines of those who are employing it. A knowledge of the direction and force of the wind is imperative to both combatants. "Various devices were employed to serve as wind vanes. Anything that could easily be seen by the enemy naturally drew fire. A simple vane was then devised, consisting of a stick with a thread about a foot long fastened at the upper end of it, and with a small piece of cotton wool at the end of the thread. The strength of the wind was indicated by the rise of the cotton wool from a vertical position. Night was soon found to be the best for chlorin gas attacks, because the moving air then has a greater tendency to flow down any slopes, and to keep the gas cloud near the ground. By day, on the other hand, the general tendency of the air is upward,

and this is likely to dissipate the gas" (Prof. Robert De C. Ward in "The Scientific Monthly," June, 1918).

2. *Artillery Shell Gas.*—These shells are used at long range as precursors to attacks of infantry and to silence troublesome batteries. Each shell contains an explosive charge and a liquid which is liberated and gives out gas when the shell bursts. A great concentration of gas can be placed in a given area, especially if the ground is "low or wooded" (Lt.-Col. Norris, Ibid.). The Germans were the first to use gas shells. They did so in the summer of 1915, employing lacrimators.

3. *Mortar Gas.*—Shells of great size can be hurled by mortars at least 2000 yards. Many mortars are fired at once by electricity, an intense concentration of gas being suddenly delivered without any warning. "After such attacks 40 per cent. of casualties with 15 per cent. of fatalities are not uncommon. When one reflects that an 8-inch shell contains 2½ gallons of volatile liquid, it is not difficult to understand why this should be so" (Lt.-Col. Norris, Ibid.). The Livene projector was a mortar invented by the British. At times thousands of them were set off at the same time. Such a discharge produces a huge cloud of concentrated gas, originating "as cloud as far as a mile away from the point of discharge. In other words, the advantages of cloud attack could be used with a much smaller dependence on wind direction and with a much greater factor of local surprise" (Lefebure, Ibid.).

4. *Hand Grenade Gas.*—Gas grenades are used to clear out trenches and dugouts. Lt.-Col. Norris (Ibid.) sets forth the different types of gases; viz.:

(1) Lacrimators or tear gases (acetone, xylene, or bromid of benzen). Tear gas causes violent irritation of the eyes, profuse lacrimation, and the victim becomes at least temporarily blind.

(2) Sternutators or sneezing gases (diphenylchlorarsin). This gas causes at once fierce cough, violent sneezing, headache, profuse flow of saliva, vomiting, and retrosternal pain. It keeps a man from getting on a mask or causes him to take it off if he gets it on, hence sneezing gas is sent as a preliminary to attack by another gas. The second gas used is toxic, and catches unmasked men.

(3) Suffocating gases. These irritate the lungs and cause death by pulmonary edema. Among them are phosgen, diphosgen, chlorin, chloropicrin, oxychlorcarbon, and bromacetone (also a lacrimator).

(4) Vesicating or mustard gases (dichlorethylsulphid, dichlormethylether). The skin, eyes, and respiratory tract are irritated and blistered, intense inflammation and commonly sloughing follow. Bronchopneumonia is the cause of death. Mustard gas will hang for days in trenches, shell holes, houses, cellars, and valleys.

(5) Gases which destroy the function of the red corpuscles of the blood.

Carbon monoxid, which causes asphyxia.

Arsin, which produces hemolysis followed by jaundice, nephritis, hemoglobinemia, and gastro-intestinal disorder.

Clouds of smoke may be employed as a screen for troop movements and also for the purpose of carrying gas.

Smoke mixed with poison gas may drive a man to remove his mask. There is no doubt that some forms of smoke consisting of **particulate clouds,** will find its way through a mask which is intended solely for vapor. If soldiers remove their masks they can be quickly overcome by toxic gas of the enemy. The smoke itself may aid in carrying in the gas through the mask, or the smoke, by threatening suffocation, may drive men to remove their masks and thus render them easy victims to gas.

The problems of the use of smoke for this particular purpose were in process of solution toward the end of the World War.

Another possibility of warfare is the use of chemicals in shells to neutralize the chemicals being employed by the enemy.

It was a discovery of the Germans that certain substances ground up to the last possibility are capable of entering the masks and carry with them agents such as phosgen. For instance, the German Blue Cross shell carried arsenic materials which it was hoped would penetrate the masks.

Victor Lefebure (Ibid.) points out in the tactical point of view the value of chemicals containing persistent substances that will remain for a considerable time in a region and exert a dangerous effect upon the ground or upon any body with which they may come in contact. Mustard gas is a persistent substance and so are some of the lacrimators. Some persistent substances are decidedly volatile.

Diphenylchlorarsene (a solid and finely powdered sneezing compound) is a temporary substance and so are most of the volatile substances like phosgen. Persistent

substances may make an area impossible of occupation by soldiers and one not to be used in movements of troops.

Prevention of Gassing.—The first gas attack produced such dreadful effects on the surprised troops that it became necessary to hastily improvise masks. The first masks made were relatively inefficient compared with the later helmets; they were nevertheless of enormous service. The introduction of mustard gas with its tremendously irritant effect upon the skin, and of penetrating power which enabled it to go through clothing and even boots, called for improved masks.

It did not seem feasible to grease soldiers all over before an engagement to protect them from mustard gas before the helmet or mask was put on. The mask protects to a great extent the head and neck from mustard gas, but the body and extremities are unprotected. It is put on when the gas is seen approaching. It must fit snugly and cover the eyes as well as the nose, face, and neck. It must have no holes in it and in every way be in perfect order. If possible a soldier in the trenches should carry two masks or helmets, because one may be put out of function by a bullet hole. One is carried so that it can be applied rapidly. There are many different types. An excellent mask is made of mackintosh and has a piece of transparent celluloid in front of the eyes. In front of the mouth and nose are a number of small, round openings. Back of these and within the mask is a pocket perforated by a number of holes and containing a pad. Air sucked in passes through the pocket and pad into the mask.

Just before the mask is used the soldier removes from the pocket of the mask the pad which contains bicarbonate of sodium and hyposulphite of sodium, pours some water on this pad, puts the pad in the pocket, and puts on the mask. The soldier carries also a little bottle of water for this purpose and also carries a tin box of extra powders. These masks proved wonderfully efficient.

The gas helmet respirator was much better than the earlier masks. It was made of "a flannel helmet with a celluloid film eyepiece and was called the hypo-helmet. The fabric was impregnated with the same solution as the cotton waste pads described above" (Victor Lefebure, Ibid.). This helmet "with the modified phenate impregnation" was very valuable against phosgen. Later it was furnished with a mouthpiece for exhalation and was called the tube helmet. Later still hexamine was used as the antagonistic chemical. Because of the use by the Germans of lacrimatory materials the eyepieces were made as goggles and their rims were surrounded by rubber sponges. The British Box Respirator was a later and admirable device. It contained a filter in a canister and other improvements. Permanganate of potash was used as the filter chemical. At the time of the Armistice the English were using the small box respirator. The material used as a filter consisted of finely ground pumice stone containing potash and dusted on the outside with a very absorbent variety of charcoal.

1919 Model American Mask.—"*Facepiece.*—This facepiece is made of rubberized stockinet about 1/10 inch in thickness. The stockinet is on the outside only and is for the purpose of strengthening and protecting the rubber which is of very high grade. The facepiece is died out as a single flat piece from the stockinet which is furnished in long rolls. The die is of such shape that when the facepiece is sewed there is but one seam, and that between the angle tube opening and the edge under the chin. This seam is sewed with a zigzag stitch with the stockinet sides flat together. The seam is then stretched over a jig, so as to form a flat butt joint. This seam is then cemented with rubber cement and taped, inside and out, to make it thoroughly gas-proof.

"The eyepiece openings are of oval shape with the longer axes horizontal and considerably smaller than the finished eyepieces. The eyepieces being circular, the cloth is stretched to accommodate them, giving the necessary bulge to keep the cloth and metal of the eyepieces away from the face. The harness has three straps on each side. Instead of the single strap over the top of the head, two straps lead from directly over the eyes, both being made of elastic the same as the other straps. All six straps are brought together around a pad of felt and cloth about $2\frac{1}{2}$ x $3\frac{1}{2}$ inches at the back of the head. This pad makes the harness much more comfortable.

"The rubberized stockinet is reinforced on the inner or rubber side with thin bits of cloth at all points where the straps are sewed on. The strap across the temples just above the ears is sewed at two points, one about $\frac{1}{2}$ inch from the edge and the other about 2 inches from the edge. This is for the purpose of helping press the cloth against the temples, thereby adding to the gas-tightness for those heads that have a tendency to be hollow at the temples. The lower strap is just above the chin and is for the

purpose of giving gas-tightness in that vicinity. All of the straps except the two over the top of the head are attached to the pad with buckles, and are thus capable of exact adjustment.

"The eyepieces are of triplex glass in metal rings with rubber gaskets. In pressing the rings home, the rubberized stockinet is turned and held securely so that there is no possibility of pulling them out. The angle tube containing the outlet valve and the connection to the corrugated tube connecting with the canister is the same as with the latest model R. F. K. mask. The only difference as regards the corrugated tube is that a greater length is needed with the new carrier under the left shoulder. The total length of the tube for this model is about 24 inches. On the inside of the facepiece and connected to the angle tube inlet is a butterfly baffle of rubber, so ar-



FIG. 122.—Mask drill. Position No. 3. Showing location of carrier under the left arm. (Courtesy of Surgeon-General Ireland, U. S. A.)



FIG. 123.—Soldier with gas mask in position. This is the latest army model mask and side carrier as developed by the Chemical Warfare Service. (Courtesy of Surgeon-General Ireland, U. S. A.)



FIG. 124.—Mask drill. Position No. 2. To remove mask. (Courtesy of Surgeon-General Ireland, U. S. A.)

ranged that the incoming air is thrown upward and over the eyepieces, thus keeping them clear no matter how much the exertion or what the temperature, except in certain rare cases when the temperature is down at zero Fahrenheit or below.

The Canister.—"The canister is radically different from the canisters used in the R. F. K. and earlier types. In the first place, it is longer, the total length finished being 8 inches. It has two inlet valves at the top end protected by a tin cover instead of the single inlet valve at the bottom of the earlier types. The two inlet valves are each 5/8 inch in diameter and are made up of square flat valves on the end of a short rubber tube. The rubber tube is fitted over a short metal tube. Gas-tightness is obtained both by the pressing of the valve against the round edge of the metal tube and by the pressure of the edges against each other. These valves, while delicate, are proving very satisfactory and being simply check valves to prevent the air going

back through the canister, they are not vital. In case of failure, the eyepieces would fog somewhat and the dead air space be increased by that held in the inlet tube.

"The canister consists really of two parts—an outer casing that is solid and an inner perforated tin casing. Around the perforated tin is fitted a filter of wool felt 3/16 inch in thickness. This wool felt is very securely fastened by turning operations to solid pieces of tin, top and bottom, so that no air can get into the chemicals without passing through the filter. Thus the air coming through the inlet valves at the top circulates around the loosely fitting outside corrugated case to all parts of the filter, and after passing through the filter continues through the perforations of the tin into the charcoal and soda-lime granules.

"The chemicals are packed around a central wedge-shaped tube extending about two-thirds the length of the can. The wedge is enlarged at the top and made circular where it passes through the top of the can to connect with the corrugated tube. The wedge-shaped inner piece is made of perforated tin and is covered with thin cloth to prevent dust from the chemicals passing into the tube and thus into the lungs. The cans are filled from the bottom and are subjected to two mechanical jarring operations in order to settle the chemicals thoroughly before the spring which holds them in place is added. The outer tin cap protecting the inlet valves has two openings on each side, but none at the ends of the canister.

"The carrier is a simple canvas case nearly rectangular, about 1 foot wide and 15 inches in length. The width is just sufficient at the back to hold the canister and the front part to hold the extra length of corrugated tube and the facepiece. There are two straps, one passing over the right shoulder and the other around the body. The one passing over the right shoulder has two V-shaped seams at the top so as to change the direction of the strap over the shoulder in order that it will pull directly downward instead of against the neck. The flap closing the case opens outward.

"It has the usual automobile curtain fasteners. A secondary fastener at the top of the opening is arranged so that when the tube is adjusted to the proper length and the mask is adjusted to the face of the wearer, the flap can be buttoned tightly over the corrugated tube and held tightly. This prevents water from entering the case."

Treatment.—A victim of a suffocating gas may show symptoms at once or may not show them for several or many hours. Chlorin produces immediate symptoms. phosgen or diphosgen may cause no symptoms for a time, then symptoms may develop rapidly after some or a number of hours, and then develop pulmonary edema. Death is due to dilatation of the heart and pulmonary edema may arise. Even cases of apparently slight gassing are regarded with anxiety and are given treatment.

A man gassed with phosgen or diphosgen must not walk or make an unnecessary movement. Severe cases are kept in the field hospital for several days. When acute symptoms disappear the victim is sent to the evacuation hospital. Lt.-Col. Norris (Ibid.) sums up the treatment as follows: (1) Absolute rest; (2) warmth; (3) venesection; (4) removal of clothing; (5) oxygen inhalations; (6) cardiac stimulation (camphor, digitalin, spartein, caffein), and (7) fresh air. He further says that atropin is useless and that opium, emetin, depressants, and expectorants are contraindicated. A victim of mustard gas may not begin to suffer severely for some hours. The gas penetrates the clothing, even the boots. The sexual organs may suffer severely. The entire body must be washed with soap and water and the hair should be clipped closely. Lt.-Col. Norris (Ibid.) advises that the eyes, nose, and mouth be douched with a 1 per cent. solution of bicarbonate of sodium, followed by instillations of a bland oil. Dichloramin-T of a strength of 0.5 is the best treatment for the eyes, as it antidotes most gas and it is an antiseptic. (Major J. E. Sweet introduced its use for this purpose.) Cocain is injurious. An eye shade is used, but is lifted at intervals to let fluid escape. The eyes usually recover. Skin burns are treated with paraffin, petrolatum, or an alkaline dusting-powder (talc, zinc oxid, or carbonate of magnesium). It is proper to prick a blister, but it is not proper to permit the fluid to flow upon adjacent skin (Lt.-Col. Norris, Ibid.).

Steam inhalations with benzoin are used for cough; so are codein or morphin. (See Lt.-Col. Norris in "Jour. Amer. Med. Assoc.," Nov. 30, 1918.)

Burns by Liquid Fire.—Liquid fire is a return to the old idea of Greek fire, a material which gradually disappeared from warfare after the introduction of gunpowder. Shells containing combustible gas and incendiary shells are used.

Liquid fire is used by means of a flame projector. The apparatus is carried on the back like a fire extinguisher and it throws a liquid which takes fire in the air. It can be used with effect to a distance of 80 or 90 feet. It is employed particularly in close

range fighting, especially in the streets of a town. Liquid fire produces horrible burns. Inhalation of flame causes instant death. The burns are treated with a paraffin preparation.

War Shock.—We use this term in preference to shell shock so that it may not be confused with shell concussion, which is a condition in which there are structural injuries and in which instant death may occur (page 223). War shock does not differ from the like condition seen in civilians. War shock is a condition of exhaustion of the nervous system. The man's "nerve" has snapped under the strain of responsibility, bombardment, the constant sight of death and mutilation, fatigue, cold, wet, hunger, home-sickness, etc. All sorts of hysterical and psychical phenomena arise. There may be temporary blindness, deafness or aphasia, distressing insomnia, hideous dreams, paralysis, melancholy depression, vivid hallucinations, or maniacal excitement. Under change of scene, rest, suggestion, etc., the patients recover. The treatment should be directed by a neurologist.

Trench Foot.—This condition has been very common. It was at first thought to be frost-bite, but whereas it occurs particularly in cold weather it may be seen when the thermometer is above freezing. It is due to a combination of cold, wet, tight shoes and circulatory constriction by ill-adjusted leggings or puttees. In severe cases there is infection of the skin and subcutaneous tissues. In most cases only one foot suffers. In ordinary cases there are edema and areas of cutaneous hyperesthesia and anesthesia in congested zones, with pain, tenderness of the heel and ball of the foot, and of the muscles of the leg. In more severe cases discoloration is wide-spread and darker, and even the toe-nails darken. Swelling is greater. Vesicles form and rupture, ulcers being exposed.

In the worst cases gangrene may develop. There is some danger of tetanus. The condition can be prevented by keeping the feet clean and greased, wearing rubber boots, and carefully avoiding circulatory obstruction. When it arises the foot should be slightly elevated and the parts dressed with a preparation of camphor and borate of sodium in water. In severe cases give antitetanic serum. Amputation is seldom required. The average victim returns to duty in from three to five weeks (J. C. Bloodgood on "Military Surgery" in "Progressive Medicine," Dec., 1917).

Poisoned Wounds.—A poisoned wound is a wound into which some injurious substance, chemical or bacterial, has been introduced. This poison may be the product of bacteria which are capable of self-multiplication, or it may be chemical, and hence incapable of multiplication. There are three clases of poisons[1]: (1) mixed infection, as septic wounds, dissection wounds, and malignant edema; (2) chemical poison, such as snake-bites and insect stings; and (3) infection with such diseases as rabies, glanders, etc.

Septic or **infected wounds** are those which putrefy, suppurate, or slough. Septic wounds should be opened freely to secure drainage, and hopelessly damaged tissue should be curetted or cut away. The wound and the skin about should be painted with iodin. In some cases complete excision of the wound is practised. In others the wound is kept wide open and is treated with Dakin's fluid or Dakin's oil. If the older plan of attempted immediate disinfection, followed by tubular drainage or packing with gauze is employed, the part should be subjected to heat applied by means of hot fomentations or by the electric light. In many cases antitetanic serum should be given. The part must be kept at rest and internal treatment should be stimulating and supporting. If lymphangitis arises, the skin over the inflamed vessels and glands is to be painted with iodin and smeared with ichthyol, and quinin, iron, and whisky are to be given internally. The temperature is watched for evidence of general infection or intoxication. The patient must be stimulated freely, nourishing food is given at frequent intervals, pain is allayed by anodynes if necessary, and sleep is secured. In infected wounds of the extremities Bier's treatment is useful.

Dissection wounds are simple examples of infected wounds, and they present nothing peculiar except virulence. They affect butchers, cooks, surgeons who cut themselves while operating on infected areas, those who make postmortems, and those who dissect. A dissection wound inflicted while working on a body injected with chlorid of zinc possesses but few elements of danger unless the health of the student is much broken down. If a wound is simply poisoned by putrefactive organisms, there is seldom serious trouble. Postmortems are peculiarly dangerous on subjects dead of some septic process. When a wound is inflicted while dissecting, wash it under a strong stream of water, squeeze, and suck it to make the blood run, paint

[1] "American Text-book of Surgery."

skin and wound with iodin, lay it open if it be a puncture. It should be kept open and be treated by Dakin's oil. The custom has been to leave it open, dress with moist gauze, apply heat, and keep the part at rest. Trouble, of course, may follow, but often it is only local, and a small abscess forms. It should be treated by hot antiseptic fomentations and early incision. Occasionally lymphangitis arises, adjacent glands inflame, and constitutional symptoms develop. It is seldom that true septicemia arises unless the wound was inflicted while making a postmortem upon a person dead of septicemia or while operating on a septic focus. If glands enlarge and soften, it may be necessary to remove them surgically.

Malignant edema or **gangrenous emphysema** arises most commonly after a puncture. It is due to a specific bacillus which produces great edema. The emphysema which soon arises is due to mixed infection with putrefactive organisms. Pus does not form, but gangrene occurs. The disease is identical with one form of gas gangrene (see page 99).

Symptoms.—These are identical with those of gas gangrene with emphysema. There is a rapidly spreading edema, followed by gaseous distention of the tissues and by gangrenous cellulitis. The zone of edema is at the margin of the emphysema, and the process spreads rapidly. The emphysematous zone crackles when pressed upon. The area of edema is covered with blebs which contain thin, putrid, reddish matter, and the skin becomes mottled. If a wound exists, the discharge will be bloody and foul. If incisions are made, a thin, brown, offensive liquid flows out. High fever rapidly develops, the patient becomes delirious, and coma may follow. In many cases death ensues in from twenty-four to forty-eight hours.

Treatment.—If malignant edema affects a limb after a severe injury, amputate at once, high up. If it affects some other part or begins in a limb after a trivial injury, make free incisions, excise all suspicious tissue, employ Dakin's fluid and stimulate freely (see page 228). Administer preventive doses of antitetanic serum.

Stings and Bites of Insects and Reptiles: Stings of Bees and Wasps.—A bee's sting consists of two long lances within a sheath with which a poison-bag is connected. The wound is made first by the sheath, the poison then passes in, and the two barbed or twisted lances, moving up and down, deepen the cut. The barbs on the lances make it difficult to withdraw the sting rapidly, and it may be broken off and remain in the flesh. Edematous, discolored swelling quickly arises. The pain is severe and burning. Besides bees, hornets, yellow jackets, and other wasps produce painful stings like bee-stings. The sting of a wasp is rarely broken off in the tissues because the beards on the darts are shorter; hence the sting is not so firmly fixed in the flesh, and also because these insects are more rapid and nimble in their actions. Stings of bees and wasps seldom cause any trouble except pain and swelling. In rare cases syncope occurs. Wide-spread urticaria may develop. Erysipelas or phlebitis may arise. In some unusual cases a sting is fatal; persons have been stung to death by a great number of these insects. We know little of the nature of the poison of wasps and bees. It was long thought to be formic acid, but we now know that the bee sting is acid and the wasp sting alkaline (Edward R. Speyer in the "Times." Quoted in the "Lancet," Sept. 6, 1919). Whether acid or alkaline, the sting introduces certain toxic materials, probably poisonous proteins.

Symptoms.—If general symptoms ensue, they appear rapidly, and consist of great prostration, vomiting, purging, and delirium or unconsciousness. These symptoms may disappear in a short time, or they may end in death from heart failure. Stings of the mouth may cause edema of the glottis.

Treatment.—To treat a bee-sting, extract the sting with splinter forceps if it has been broken off and is visible in the wound. If it is not visible, squeeze the part lightly in order to expel it, or at least expel the poison. Pressure may be most satisfactorily made by means of the barrel of a key. The acidity of the poison is counteracted by touching with ammonia or washing the part in ammonia-water, or soaking in a strong solution of common salt or carbonate of sodium. The part may be dressed with lead-water and laudanum, a solution of washing-soda, or a solution of common salt. If constitutional symptoms appear, stimulate. Wasp stings may be washed with vinegar or some other acid substance. Stings of bees and wasps are well treated by touching with pure carbolic acid or tincture of iodin. For bee stings of the mouth use an alkaline gargle; for wasp stings, an acid gargle.

Other Insect Bites and Stings.—If a tick bites a person it clings to its victim. If an attempt is made to pull it off a barb remains in the tissues and an abscess follows. If a little ammonia is dropped on a tick the insect will at once withdraw its

barb. A tick bite never causes constitutional symptoms. The mandibles of a *poisonous spider* are terminated by a movable hook which has an opening for the emission of poison. The bite of a large spider is productive of inflammation, swelling, weakness, and possibly death. The bite of the poisonous spider of New Zealand produces a large white swelling and great prostration; death may ensue, or the victim may remain in a depressed, enfeebled state for weeks or even for months. The *tarantula* is a much-dreaded, large, brown, hairy spider of the southwestern part of the United States. In Europe the name is given to an entirely different kind of spider. The bite of a Texas tarantula is very painful and may be dangerous. The scorpion has in its tail a sting. The sting of the *scorpion* produces great prostration, delirium, vomiting, diaphoresis, vertigo, headache, local swelling and burning pain, followed often by fever and suppuration, and occasionally even by gangrene, but it is rarely fatal. *Centipedes* must be of large size to be formidable to man, and the symptoms arising from their stings are usually only local.

Treatment.—To treat the bite of a poisonous spider or sting of a scorpion tie a fillet above the bitten point; make a crucial incision, favor bleeding, and paint the wound with pure carbolic acid or some caustic or antiseptic (if in the wilds, burn with fire or gunpowder); dress antiseptically if possible, and stimulate as constitutional symptoms appear. Slowly loosen the ligature after symptoms disappear. Chloroform stupes and ipecac poultices are recommended; also puncture by a needle and rubbing in a mixture of 3 parts of alcohol and 1 part of camphor (Bauerjie). Antiscorpion venene is recommended by Todd for scorpion stings.

Myiasis.—When the larvæ of dipterous insects are deposited in the tissues the condition is called myiasis. Certain varieties of flies sting with the ovipositor and lay their eggs in the skin, in the ear, or in the mucous membrane of the nose. The bot-fly may do this, and the larvæ or maggots of bot-flies are called bots. Inflammation arises in the area containing the ova and suppuration may occur. The symptoms may be grave. Myiasis is most common in tropical and subtropical countries, but the blue-bottle fly may be responsible for the condition in temperate climates. Myiasis of the genito-urinary tract has been described.

Treatment.—For the disease in superficial parts incision and application of pure carbolic acid to kill the larvæ. If in the nasal passages inhalation of chloroform may prove fatal to larvæ.

Larvæ in the ear can be expelled by swabbing with cotton damp with chloroform (T. De Almeida, Jr., in "Archivos Brasilieros de Medicina, Brasil," June, 1919).

Maggots in Wounds.—In tropical countries especially flies may lay eggs in wounds and maggots form in immense numbers. Larrey saw many such cases. I have seen maggots several times in foul leg ulcers. Antiseptic dressings prevent such an occurrence and antiseptics will destroy larvæ. Iodin is very successful.

Chigger.—The chigger, or sand flea, is common in the tropics and subtropics. The female when impregnated may enter an abrasion or may pass through "the soft skin, especially in the sole between the toes" or "around the nails" (Madden in a "System of Surgery," edited by C. C. Choyce).

Inflammation occurs and the body of the flea is recognizable as a small black spot. Suppuration may occur and the flea may be cast out with the pus. Sinuses may arise and persist. There is some danger of erysipelas, tetanus, and gangrene (Ibid.).

Treatment.—Apply a hot solution of bicarbonate of soda for some hours, enlarge the opening with a knife, remove the insect without breaking it up, and dress the part antiseptically (Ibid.).

Fish Stings.—The spines of many fish inflict a poisoned wound, as they are covered with an irritant material obtained from the skin. The spines of the catfish are known to do this. Certain fish actually inject poison along a spine, the poison coming from a receptacle or bag. Fish stings are very painful, are septic, and are apt to be followed by lymphangitis, erysipelas, erysipeloid, gangrene, or general sepsis.

Treatment.—Incise, favor bleeding, swab with pure carbolic acid or iodin, and apply hot antiseptic fomentations.

Snake-bites.—The poisonous snakes of America comprise the copper-heads (red vipers or upland moccasins), water moccasins (rice snakes or cotton-mouths), harlequin snakes (coral snakes), and rattlesnakes. The cobra of India is the most combative and deadly of reptiles. In some countries great numbers of people and the lower animals are killed by poisonous serpents. Consular reports show that in India during the years from 1887–1911 inclusive 543,991 human beings and 187,436 cattle were killed by poisonous snakes. The average human death-rate was 21,700

a year. The coral snake is found in the southeastern United States, and is common in South Carolina, Georgia, and Florida. It is often discovered in sweet potato fields.

The extremely belligerent water moccasin, which is semi-aquatic, infests "the lagoons and sluggish waterways of the southeastern portion of the United States" ("Reptiles of the World," by Raymond L. Ditmars).

The copperhead, or upland moccasin, is found east of the Mississippi River from Florida to Massachusetts, and west of the Mississippi in Texas. In the South it lives on plantations, in the North in or near forests (Ibid.). In practically every part of the United States there dwells some variety of rattlesnake. Fifteen species are catalogued as dwelling within our borders (Ibid.). Some inhabit prairie, some desert, some rocky land, some timber regions, some dwell adjacent to water. The diamond-back rattlesnake is the most poisonous serpent of the United States. A small rattler is not nearly so dangerous to life as a big rattler. Next to a big rattlesnake in poisonous power comes the water moccasin. Mr. Ditmars characterizes the coral snake as "highly formidable" and the copperhead as "highly venomous." Statistics seem to contradict the belief that the copperhead is very dangerous. Prentiss Willson ("Jour. Amer. Med. Assoc.," Aug. 27, 1910) claims to have established 99 instances of persons bitten by copperheads. There were only 5 deaths. It is quite possible that some of those who recovered after being bitten thought they were bitten by copperheads when in reality the assailants were non-poisonous serpents. Willson's figures make the statistics of recovery highly favorable. "Most snake-bites are from non-venomous snakes. The Colubers of the middle west are very belligerent serpents and attack with satanic fury" (W. M. Winton in "Popular Science Monthly," May, 1916). It used to be taught that there is no essential difference in the action of venoms of different varieties of snakes, and that the venom of an Indian cobra is practically identical with the venom of an American rattler, any apparent difference in action depending upon difference in toxic power and the different dose of poison introduced. We now know that there are essential differences in venoms (Leonard Rogers in "Lancet," Feb. 6, 1904). The natural toxic power of the poison varies in different species and also in different members of the same species. The venom remains poisonous when dried. Poison injected into a vein may prove almost instantly fatal. The poison is not absorbed by the sound mucous membranes. Poison is harmless when given by the mouth and swallowed, but if directly introduced into the intestines of an animal it is certainly fatal. The pancreatic ferment destroys the toxic power of the venom (R. H. Elliot in "Brit. Med. Jour.," May 12, 1900). The venom is discharged through the channeled fangs of the reptile, having been forced out by contractions of the muscles of the poison-bag. The coral snake, like the cobra, has short and rigid fangs. Rattlesnakes, cotton-mouths, and copperheads have long and movable fangs. A coral snake bites like a cobra. It grasps the object, sinks in its fangs, and then advances its fangs by chewing, thus inflicting several wounds. In viperine snakes the teeth lie along the back of the mouth and are only erected when the reptile strikes. The maxillary bones of the rattlesnake are very short and move with great freedom at the prefrontal articulation. The fangs are canaliculated, are attached to the maxillary bones, and move with the bones. Some mildly poisonous snakes have grooved fangs. The poison gland drives the poison into the canals of the fangs. The canal emerges from the front of each fang near the tip. The fangs, when depressed, are carried in a fold of mucous membrane. When the animal is ready to strike the fangs are erected into a vertical position and carried to the front of the mouth. S. Weir Mitchell showed that the poison gland is really the parotid gland. In amphibia and some reptiles the parotid is a mucous gland. In higher mammals it is a serous gland. In poisonous snakes the gland partakes of the nature of both varieties (Noguchi in "Carnegie Inst. Pub.," iii). Cope describes the movement used by the rattlesnake in biting. The body springs forward, but never more than two-thirds of the reptile's length, the jaws seize the tissues and then the fangs penetrate and move to and fro as the poison emerges from them. Snake-poison is a thin, greenish-yellow, turbid, sterile fluid, of acid reaction, and of a distinctive odor. The two chief poisonous principles are called venom-peptone and venom-globulin (Gustave Langmann, "Medical Record," Sept. 15, 1900).

Symptoms.—Rogers ("Lancet," Feb. 6, 1904) divides poisonous snakes into two classes: the *colubrines* (of which the cobra, ash, and coral snake are examples) and the *viperines*, which are not so poisonous (this class includes rattlesnakes and African puff adders). Moccasin and copperhead venoms resemble rattlesnake venom, but contain more of the neurotoxic elements. Colubrine venom, according to this observer, causes paralysis of the respiratory center and of the motor end organs of the phrenic nerves,

destruction of red blood-corpuscles, lessened coagulability of blood, and death by respiratory paralysis. The violent and rapid action is upon the nervous system. The hemolytic effect, though present, is slower. Viperine venom is violently hemolytic and causes paralysis of the vasomotor center and great destruction of red corpuscles. In laboratory experiments some viperine venoms are found to cause thrombosis, but don't do so in man. Death from any one of them is due to vasomotor paralysis. The mortality from snake-bites varies. The mortality in India from cobra bites is about 25 per cent. (Sir Joseph Fayrer). The mortality in America from rattlesnake bites is about 20 per cent. According to Willson the mortality from copperhead bites is only 5 per cent. ("Jour. Amer. Med. Assoc.," Aug. 27, 1910). The local symptoms are: pain, soon becoming intense; mottled swelling of the bitten part, which may become enormous, and which is due to edema and extravasation of blood, and assumes a purpuric discoloration. The *bite of a cobra* produces inflammation and marked spreading edema. It may be recovered from without symptoms or with trivial symptoms; it may induce profound systemic involvement. The general symptoms begin in a comparatively few minutes. The coagulating power of the blood is lost, and there is great destruction of red corpuscles. The patient is terror-stricken and soon becomes unable to stand because of weakness of the legs. Glossopharyngeal paralysis arises, and talking and swallowing become impossible. There is a profuse flow of saliva, perhaps nausea and vomiting. The patient may be dull mentally, but is not unconscious. The paralysis becomes wide-spread, and finally the diaphragm and respiratory center become involved, and death occurs from respiratory paralysis. Artificial respiration may prolong life for hours (Sir Joseph Fayrer). Bad cases usually die in three or four hours, but life may last for many hours. A *rattlesnake* bite produces severe pain and mottled swelling from blood extravasation. In some cases there is enormous swelling from edema and blood; the discoloration in such a case is purpuric. The blood of the victim quickly undergoes hemolysis and loses the power of coagulation. It was previously stated that in laboratory experiments it has been shown that viperine poison may produce thrombosis, but it does not do so in man, as it contains a very small amount of the coagulating element (Rogers). Extravasations of blood occur in serous and mucous membranes and in the skin, petechial spots frequently arising upon the cutaneous surface. There may be free bleeding from mucous surfaces and great extravasation beneath the conjunctivæ. These blood extravasations are due, according to Flexner, to destruction of vascular endothelium. General symptoms begin in from a few minutes to several hours. The symptoms are those of profound shock, possibly with delirium. There are usually muscular twitching and convulsions, and finally paralyses are noted in most cases (pharyngeal palsy, paraplegia, and ascending paralysis). There may be complete consciousness, or there may be lethargy, stupor, or coma. Death may occur in about five hours, but, as a rule, it is postponed for a number of hours. If death is deferred for a day or more, profound sepsis may come upon the scene, with glandular enlargement, suppuration, and sometimes gangrene

Treatment.—Cases of snake-bite must, as a rule, be treated without proper appliances. The elder Gross was accustomed to relate in his lectures how he had seen an army officer blow off his finger by a pistol the moment after it was bitten by a rattlesnake, and thus escape poisoning. If the bite is upon a limb, and it usually is, twist several fillets at different levels above the bite to prevent the dissemination of the poison from the limb throughout the body. If possible the fillets should be elastic, but in an emergency any available material must be used. As soon as fillets have been applied above the bitten area make crucial incisions to the depth of each bite. A rattlesnake bite, a copperhead bite, and a water moccasin bite show but two punctures. A coral snake bite shows several. After incising the wound, cup it if possible, and cauterize it with pure nitric acid or by a cautery. There is no danger in sucking the wound, provided there are no abrasions upon the lips, cheeks, or tongue. Before sucking, fill the mouth with a dilute solution of permanganate of potash, to oxidize and thus destroy the poison. An expedient among hunters is to cauterize the wound by pouring a very little gunpowder on the excised area and applying a spark, or by laying a hot ember on the wound. Some surgeons inject in many places about the wound a 10 per cent. watery solution of chlorid of calcium to neutralize chemically the poison. Some advocate injecting the area about the bite with a strong solution of chlorid of gold. It has been taught that if a man is bitten by a large and deadly snake, the surgeon, if one is at hand, should at once amputate well above the bite.[1] Wynter Blyth pointed out that permanganate of potassium mixed with an equal weight of cobra venom renders

[1] Charters James Symonds in "Heath's Dictionary of Practical Surgery."

the venom inert. A number of surgeons have treated rattlesnake-bites by injecting in and about the wound a 1 per cent. solution of permanganate of potassium, but this plan is not certain. Rogers ("Lancet," Feb. 6, 1904) says we should tie fillets around the limb above the bitten part, take a knife and enlarge the wounds, and rub in crystals of permanganate. The fillets are not to be removed suddenly, and they had best be kept on for some time. Remove the highest constricting band first; if no symptoms come on after a time, remove the next, and so on; if symptoms appear, reapply the fillets. Permanganate of potash is not a successful treatment for cobra bites. In cobra poison the neurotoxic element predominates. It would seem to promise more against rattlesnake venom in which the hemolytic element predominates. Whatever local treatment is employed, stimulants are given. Some give strychnin hypodermically; others, ether; others, digitalis. Halford, of Australia, advocated the intravenous injection of ammonia (10 min. of strong ammonia in 20 min. of water). Adrenalin as given in shock is indicated if there is a marked fall in blood-pressure, and autotransfusion and external heat are also indicated. If the respiration is failing, artificial respiration and oxygen inhalation are required. Few beliefs are held more tenaciously than that large amounts of whisky or brandy should be given to the victim of snake venom. And yet this belief is false. In a person badly poisoned by snake venom the medullary centers are depressed and threatened with paralysis. Large doses of alcohol increase this tendency and may hasten death. It is well known that if a drunken man is bitten by a large poisonous snake he is practically certain to die because the depression produced by alcohol is enormously accentuated by the venom. Moderate doses of whisky or brandy are useful (1 to 1½ ounces every half-hour). The wounds made by the incisions of the surgeon are kept open for a number of days by the insertion of bits of rubber tissue, and warm and moist antiseptic dressings are used. Attempts are being made to obtain a curative serum. Animals can be rendered immune by giving them at first small doses of the poison and gradually increasing the amount administered. It is asserted that the serum of immune animals will cure a person bitten by a venomous snake. Cures have been reported after the use of Calmette's antivenene serum. Antivenene is obtained by immunizing a horse by injecting attenuated venom. The mixture to be attenuated consists of 80 parts of cobra venom and 20 parts of viperine venom. It takes a number of months to obtain strong antivenene. The dose is from 10 to 20 c.c. hypodermically, repeated if necessary in three or four hours. It seems certain, however, that no single serum can antidote the venom of all varieties of serpents (A. T. F. Macdonald, of Australia), and it has been shown that, though Calmette's antivenene is antagonistic to colubrine venom, it is inert against viperine venom. Again, as Rogers says, it deteriorates quickly in a hot climate and is seldom on hand when wanted. The horse can be immunized against rattlesnake venom, and antivenene (anticrotalus serum) obtained from the horse may be used against rattlesnake poison, but very large doses are necessary. Captains Acton and Knowles ("Indian Journal of Medical Research," vol. iii, No. 2) treat poisoning from a cobra bite or the bite of Russel's viper as follows: Place a firm fillet around the limb and above the wound. Infiltrate the area about the wound with a strong solution of chlorid of gold. Inject subcutaneously 100–200 c.c. of antivenene. If symptoms of venom intoxication arise give further and larger doses.

The **poisonous lizard** (*Gila monster*), of the southwestern United States, can certainly kill small animals, but it is doubted by many that its bite is ever fatal to man. When we recall, however, that small animals which die of the poison present symptoms identical with those produced by serpent venom, we should regard the Gila monster with careful respect.

The lizard bites and hangs on. Each tooth of the lower jaw has a conducting channel for poison and there is a poison gland for each tooth.

The treatment of a bite of the Gila monster is practically the same as for a snake-bite.

Anthrax (**malignant pustule, charbon, milzbrand, wool-sorters' disease,** or **splenic fever**) is a term formerly used by some as synonymous with ordinary carbuncle, but it is not here so employed. It is a specific contagious disease resulting from infection with the bacillus of anthrax. Cattle anthrax has long been known. Virgil refers to it (Ponder in "Lancet," Nov. 4, 1911). Pollender showed more than fifty years ago that a rod-shaped organism is present in the blood of animals dying from splenic fever. Duvaine insisted that the organisms caused the disease. Koch proved it in 1876. The spores of this bacillus are highly resistant. Animal anthrax is particularly common in the East and in Russia, and is frequently met with in Germany,

Italy, and South America. In Italy animal anthrax is prevalent. In that country from 1890 to 1904 there were 36,426 cases with 7308 deaths, a mortality of 20.1 per cent. (Schwartz in "N. Y. Med. Jour.," June 22, 1918). In some regions so many cases arise year after year that the district obtains an evil notoriety. It is stated that in Novgorod, Russia, in four years "56,000 horses, cattle and sheep, and 528 men perished from anthrax" (Frank S. Billings in "Twentieth Century Practice"). It is a rare disease in the United States, but since the start of the World War it has increased. In Philadelphia cases occasionally occur in workers in the woolen mills. The author has seen 8 cases of human anthrax, 6 of which occurred in Philadelphia and 2 in New Jersey. Herbivora are most liable, next omnivora, but carnivora seldom suffer. Anthrax, as met with in man, is a disease contracted in some manner from an animal with splenic fever. It may be contracted by inoculation while working around diseased animals, while handling or tanning their hides, or sorting their hair or wool; brush-makers, spinners, workers in horn and combers, rag sorters, veterinary surgeons, clippers, stockmen, cattlemen, meat inspectors, laboratory workers, farmers, and butchers may become inoculated. Infection may take place through the hair-follicles of unbroken skin. Menschig reported 2 such cases ("N. Y. Med. Jour.," Nov. 18, 1905). Anthrax may be conveyed by eating infected meat or by drinking infected milk. Flies may carry the poison. Inhalation of poisoned dust may infect the lungs. Catgut ligatures may be contaminated and carry the poison. Blood-stained wools and hides are a particular peril. It is stated that in England 1 out of 7000 leather markers dies of anthrax each year (Ponder in "Lancet," Nov. 4, 1911). Ponder points out that 40 per cent. of English cases (arising among those working in the hide, skin, and leather industries) are due to Chinese or East Indian goods; that no anthrax has ever been traced to wet salted hides; that infection may rise at wharf, dockyard, or tannery; that the pulmonary form occurs particularly among wool workers; that among those who work with hides, skin, and leather cutaneous anthrax is the common form, and intestinal anthrax is extremely rare. Brown and Simpson ("Jour. Amer. Med. Assoc.," Feb. 24, 1917) report an outbreak of anthrax among Massachusetts tannery workers. There were 25 cases in the course of four months. For a full discussion of "Anthrax as an Occupational Disease," see John B. Andrews in "Bulletin of the U. S. Bureau of Labor Statistics," Jan., 1917. Shaving brushes of horse hair have proved vehicles for the bacteria or spores (Knott in "Brit. Med. Jour.," Feb. 3, 1923). Anthrax bacteria have been grown from a brush five years old (Kingsbury in "Brit. Med. Jour.," March 10, 1923). In Pennsylvania during the past twelve years, 119 tannery workers and 4 hide and skin workers developed the disease, 123 in all. Twenty per cent. died. (Editorial in "Jour. Amer. Med. Assoc.," July 1, 1922.)

In all probability some slight cases are recovered from without being recognized. This would explain the fact that it is particularly among recent employees that anthrax seems to occur (Mitchell, "Brit. Med. Jour.," April 4, 1911). Many older employees may be immune because they have had the disease. Various attempts have been made to render animals immune (Pasteur, Woolbridge, Hankin). Pasteur's method has been used in France with decided success, but with less success in other countries. Pasteur devised a method for vaccinating animals against anthrax by injecting attenuated cultures beneath the skin. First, a much-attenuated culture is used and later a stronger one. When an animal has been actively immunized, its blood-serum contains protective materials of a specific nature and may be used therapeutically. The immunity is regarded by some authorities as "a phagocytic immunity" (Jordan's "General Bacteriology"). Certain organisms are antagonistic to anthrax (the streptococcus of erysipelas, the pneumococcus, the Micrococcus prodigiosus, and the Bacillus pyocyaneus).

Forms of Anthrax.—There are two forms of the disease—external and internal. Internal anthrax may be intestinal from eating diseased meat, laryngeal or pulmonary from inhalation of poisoned dust. Intestinal anthrax arises only when the bacilli in the meat contained spores. Koch and others have pointed out that the non-sporulating bacteria are destroyed by the gastric juice. Internal anthrax is quick in progress, and death sometimes takes place within twenty-four hours of the onset of symptoms. It cannot be diagnosticated with certainty unless bacilli are found in the blood.

External anthrax may be *anthrax carbuncle* or *anthrax edema*. *Anthrax carbuncle* (*malignant pustule*) appears on an exposed portion of the body, on the face, neck, hand, or finger in 90 per cent. of cases of external anthrax. In 2 of my cases it was upon the temple, in two upon the cheek, and in two on the neck. It appears in from twenty-four hours to six days after inoculation, and presents an itching, burning papule

with a purple center and a red base; in a few hours the papule becomes a vesicle which contains bloody serum, and the tissues about the papule become swollen, reddened, and indurated. The vesicular condition does not become pustular because the anthrax bacillus is not pyogenic (hence the term "malignant pustule" is a misnomer). Pus only appears when sloughing begins and is due to secondary infection. The vesicle bursts and dries, the base of it swells and enlarges, other vesicles appear in circles around it, and there is developed an "anthrax carbuncle," which shows a black or purple elevation with a central depression surrounded by one or more rings of vesicles. The surrounding tissues become purple, and great edema may spread widely, the vesicles grow very large, new vesicles form, and gangrene may occur. Pain is trivial or absent. Lymphatic enlargements may occur, but pus does not form unless sloughing takes place. The constitutional symptoms may rapidly follow the local lesion, but may be deferred for a week or more. The patient feels depressed, has obscure aches and pains, and is feverish, but usually remains about for a short period. In some cases with constitutional symptoms there is no elevated temperature, and such cases are frequently fatal. After a time most patients develop rigors, high irregular fever,

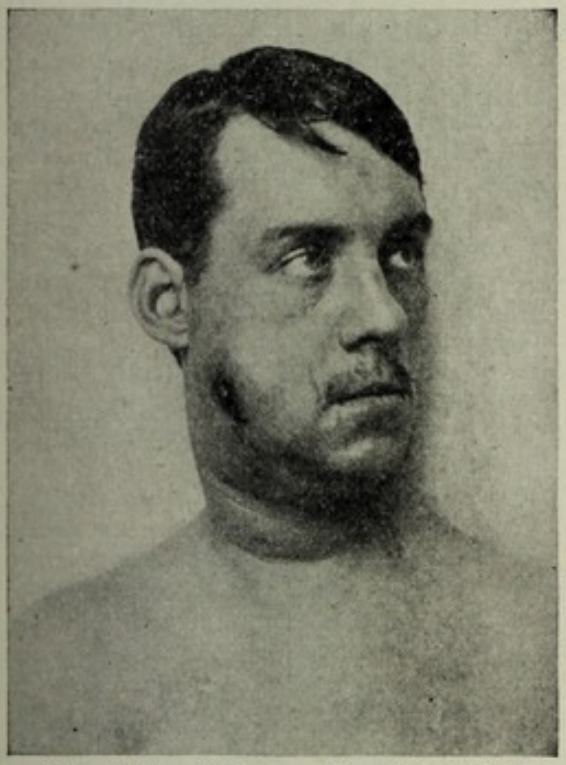


FIG. 125.—Anthrax. Case in author's wards in Philadelphia Hospital, recovered. Treated by ipecac both externally and internally.

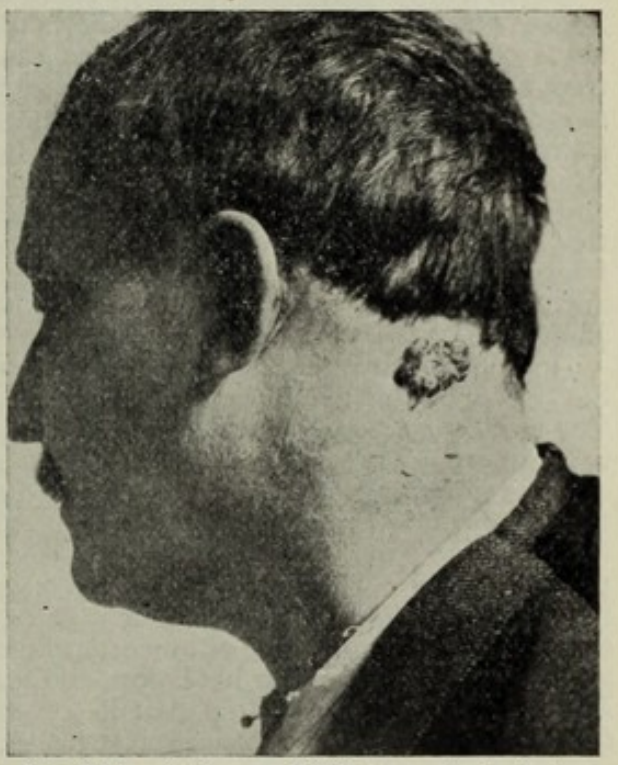


FIG. 126.—Anthrax. Fifth day. Junk dealer.

sweats, acute fugitive pains, diarrhea, delirium, typhoid exhaustion, dyspnea, cough, and cyanosis. The temperature is frequently markedly subnormal for some little time before death. In cutaneous cases which get well a line of demarcation forms about the pustule and the gangrenous area is rather rapidly cast off, a granulating surface remaining.

Anthrax Edema.—An area of edema surrounds a malignant pustule and often spreads widely, but in cases of external anthrax without a pustule there is edema alone. This lesion occurs in connective tissue, especially loose tissue. It is a spreading, livid edema, with an ill-defined margin. There is no pain and usually no vesication and no fever. In severe cases, however, there is fever, vesicles form, and gangrene may arise. Anthrax edema differs from cellulitis in the absence of pus formation, and from malignant edema by the less disposition to result in gangrene. In 2 of the cases I have seen there was anthrax edema. In Horwitz's case in the Philadelphia Hospital the forearm, arm, and shoulder were enormously edematous. In Keen's case in the Jefferson College Hospital the forearm and arm were edematous.

Bacilli in the Blood in All Forms of Anthrax.—In some cases they are found, in others they are not. To find them is extremely ominous, as most cases with bacilli-

laden blood die. Bacilli are seldom found until thirty-six hours before death (Mitchell in "Brit. Med. Jour.," April 1, 1911). In fatal cases the blood always contains bacilli.

As a result of the general infection the spleen usually and the liver sometimes enlarge. Hemorrhages occur into the muscles and beneath serous membranes.

Diagnosis.—The occupation of the patient is highly significant. The malignant pustule is distinguished from an ordinary carbuncle by the following points: The malignant pustule has a central depression; a dark, dry, adherent eschar; is surrounded by vesicles; is painless; free from suppuration and without tenderness. In an ordinary carbuncle the center is elevated; there are signs of inflammation; multiple foci of suppuration soon become visible; sloughing occurs and there are usually severe pain and tenderness. Anthrax bacilli are found in the fluid of the pustule and if the case progresses will be found in the blood.

Prognosis.—If anthrax has a visible lesion and if constitutional symptoms are absent or slight, recovery is probable. When bacilli are found in the blood the prognosis is very bad. Becker knows only of 3 such cases which survived ("Münchener medicinische Wochen.," Jan. 23, 1912). Of Becker's 44 cases which had no bacilli in the blood, 43 recovered; truly remarkable figures! There were 11 with bacilli in the blood and all died. A case which is to be fatal always shows bacilli in the blood, at least within thirty-six hours of death. Even apparently bad cases with negative blood findings are apt to recover (Becker, Ibid.). During six years the Board of the Bradford woolen industry reported that in 71 cases of anthrax 24 died (15 internal and 9 external). The former estimate of the death-rate from external anthrax was from 25 to 30 per cent. If a lesion is upon the face the prognosis is much worse than if it is upon an extremity, and if upon the upper extremity it is worse than if it is upon the lower. It is claimed that the death-rate has been notably reduced by modern treatment, and under serum treatment is said to be but little over 6 per cent. In a series of 15 cases of external anthrax reported by Royer and Holmes there were 3 deaths ("Therapeutic Gazette," Jan., 1908). Eleven of these cases received serum, and of the 11, 2 died.

Pulmonary anthrax and intestinal anthrax have been regarded as invariably fatal, but vastly better results may be looked for hereafter if the diagnosis can be made. The usually estimated mortality for pulmonary anthrax is 50 to 75 per cent. (Ullman in "Surgery, Gynecology, and Obstetrics," April, 1916).

Prevention of Human Anthrax.—Spores are the great danger. Unfortunately, there is no known disinfectant for wool which will kill spores and not injure fabric (London letter in "Jour. Amer. Med. Assoc.," Feb. 17, 1912). Blood-stained wools are the great peril. The blood contains the spores and formalin will not penetrate dried blood. Wet salted hides are thought to be almost safe, and governmental regulation to prevent the importation of any other kind would, to a great degree, prevent anthrax among those who work in hide, skin, and leather industries (Ponder in "Lancet," Nov. 4, 1911). It has been stated that in a few instances the disease has been contracted from wet salted hides, but such occurrences are rare. When a surgeon assumes charge of a case of anthrax he must take means to safeguard others. Every excretion and discharge from the patient should be disinfected and incinerated. Flies and other insects should be kept out of the room by careful screening. If death occurs the body should be cremated and a necropsy is not admissible.

Treatment of External Anthrax.—If a person is wounded by an object suspected of carrying the infection, cauterize the wound by the hot iron or fuming nitric acid. A sufferer from anthrax must be isolated in a well-ventilated room, and flies and other insects must be excluded. All dressings are to be burned, all discharges asepticized, and after the removal of the patient the bedclothes are burned and the room disinfected. If there are bacilli in the blood excision seems scarcely worth while, but may be done. If there are no bacilli in the blood a malignant pustule should be entirely excised, and the wound mopped out with pure carbolic acid or burned with the hot iron. If there is an extensive area of edema, it should be freely incised down to the deep fascia at several points. The area about an anthrax edema or an excised pustule should be injected every sixth hour with a 5 per cent. solution of carbolic acid. The wound and the edematous area should be dressed with hot antiseptic fomentations, and, if dealing with an extremity, a splint is applied. Excision should be practised for pustule even when glands are enlarged. When excision cannot be performed make crucial incisions through the lesions, mop the wounds with pure carbolic acid, and inject about and in the pustule carbolic acid (1 : 20) every six hours until the disease abates or toxic symptoms appear. Dress the part as directed above. In a successful case the adherent eschar is finally separated

by the influence of the fomentations. Davaine advised the following plan: Inject the pustule and the tissues about it at many points every eight or ten hours with 1 part of tincture of iodin diluted with 2 parts of water or with a 10 per cent. solution of carbolic acid, or with a 0.1 per cent. solution of corrosive sublimate; dress with wet antiseptic gauze and apply an ice-bag. Personally I would not use an ice-bag on an area of infection, but would prefer heat. In Keen's very severe case of anthrax edema multiple incisions were made, carbolic acid was injected into sound tissues above the edema, and the part was dressed with hot antiseptic fomentations. Recovery followed. Constitutional treatment in anthrax edema, malignant pustule, or internal anthrax must be sustaining and stimulating. Maffucci gives carbolic acid internally, and also uses it externally. Davies-Colley uses ipecac locally and gives 5 gr. by the mouth every four hours. Statistics indicate that the serum treatment is of the greatest value. The material is known as Sclavo's serum; it is obtained from the immunized ass, and it was introduced into practice in 1897. It is perfectly harmless and may be given in a vein or subcutaneously. Sclavo injects 40 c.c. in different regions of the wall of the abdomen. Usually the temperature begins to fall in an hour; if improvement is not obvious in twenty-four hours, the dose is repeated. Intravenous injection is reserved for severe cases, the dose being 10 c.c. into a subcutaneous vein of the dorsal surface of the hand. The serum can do no harm and should always be given. If given early, all cases but very severe ones will recover (Legge's Milray Lectures, "Brit. Med. Jour.," March 18, 1905). In 1915 Adolph Eichhorn introduced his serum. He gave an animal a serovaccination by the Pasteur method and then inoculated it at intervals with virulent cultures. Fourteen to sixteen days later he used this serum to treat anthrax in man, giving an intravenous injection of from 30 to 60 c.c. every sixth to tenth hour until three doses were taken (Schwartz, Ibid.). Becker ("Münch. med. Woch.," Jan. 23, 1912) has given salvarsan, and he believes it saved the life of a very ill man. Eleven cases of human anthrax were treated by injections of arsphenamin, and all recovered (Louw and Pyber in "South African Med. Rec.," July 22, 1922). Peptone has been used in treatment; from 20 to 30 c.c. injected daily into the muscles. The persistence of anthrax infection in a room was well shown in the record of Keen's case. The infection lingered on the floor of the room in which the patient had been operated upon for a long time. Three disinfections were necessary before it became impossible to obtain anthrax bacilli from the contaminated floor. This indicates that such a case should be operated upon in a room not regularly used for operations.

In a case of internal anthrax give serum or perhaps peptone.

Hydrophobia, Rabies, or Lyssa.—Hydrophobia is a spasmodic and paralytic disease due to inoculation with virus from a rabid animal. Inoculation is nearly always from a bite, but may be through a wound or prick or abrasion having been licked by a rabid animal. The disease does not appear to arise except as the result of inoculation. It is most common in dogs and wolves, but it may develop in any warm-blooded animal. It has been noted in domestic cats, wild cats, squirrels, coyotes, mountain lions, jackalls, monkeys, asses, horses, mules, goats, foxes, cattle, sheep, and hogs. Cats are said to cause 6 per cent. of the human cases (Cumming in "Jour. Amer. Med. Assoc.," May 18, 1912). Lack of water is never a cause. It is far more common in the carnivora than the herbivora. In Russia wolves are responsible for many cases. It is said that poultry may suffer from it. Human hydrophobia in most instances follows dog bites. Probably about 30 or 40 per cent. of the people bitten by mad animals develop the disease, if not given the Pasteur treatment. If the bite is on an exposed part, it is far more apt to cause rabies than if the rabid animal's teeth passed through clothing. The saliva is the usual vehicle of contagion, but other fluids and tissues contain the virus, especially the brain, medulla, cord, pancreas, spleen, and suprarenal glands. The blood and urine do not contain it. The poison cannot pass the unbroken skin, but Sir David Semple says it can pass sound mucous membrane ("Brit. Med. Jour.," Sept. 13, 1919). It is important to remember that the saliva of a dog may be infected four or five days before the dog presents any symptoms. Placental transmission has been reported. Hydrophobia has been known for centuries. It is not spoken of by Hippocrates, but is described in animals by Aristotle, Pliny, and Celsus, and is alluded to by Ovid, Horace, Virgil, and Plutarch. Celsus first described the disease in man and first used the term "hydrophobia." Aristotle thought that men were not liable to hydrophobia. The disease has always excited the greatest fear and horror. Southey tells us in his "Commonplace Book" that it was the French custom to bleed to death or to smother deliberately victims of hydrophobia. Such murders were regarded as

justifiable, and a man who killed his brother pleaded justification on the ground that the brother was hydrophobic. At the present day some ardent antivivisectionists with the audacity of ignorance and the acrimony of fanaticism deny the existence of the disease called rabies. The fact that an infant bitten by a rabid animal may develop rabies proves that the disease is not due to the imagination. Transfer of the disease can be certainly made from animal to animal, as Pasteur proved. Hydrophobia is invariably fatal. No causative micro-organism has been demonstrated. One must exist, but it is probably a filter passer and escapes detection because of its very small size.[1] In 1903 Negri found within the ganglion cells of the brain and medulla certain cells which are now called *Negri bodies*. They are found in 95 per cent. of autopsies on hydrophobics. Some believe that these bodies are protozoal and cause the disease. It is generally held that they result from cellular changes brought about by the disease. Most of them are too large to be filter passers and they are not found in the salivary glands. Their presence in large numbers is considered as diagnostic, but they have been found in other conditions, viz., in those dead of arsenic poisoning, old age, cerebral embolism, and other conditions (Semple, Ibid.). It used to be thought that the disease was particularly apt to arise in hot weather, but it is now known that it may occur any time of the year. There was a veritable epidemic of it among the animals in Greenland in 1860, and at that time the temperature averaged 25 degrees below zero (F. W. Dudley in "Jour. Amer. Med. Assoc.," Dec. 19, 1908). It is common in Russia. No portion of the world is completely exempt. No constant lesions except Negri bodies have been certainly demonstrated in those dead of rabies. Gowers believes that in the spinal cord there is hyperemia, but no infiltration with cells, whereas in the medulla, especially about the respiratory center, there are hyperemia and cellular infiltration of the perivascular spaces; but such perivascular infiltration can occur in some other acute conditions and hence is not characteristic. What is known as the *rabic tubercle* is found in the medulla and about the motor cells of the upper part of the spinal cord. Each tubercle consists of an aggregation of embryonal cells, which destroy and finally replace the nerve-cells which they surround. Babés thinks the tubercle characteristic. Infiltration of the ganglia with epithelioid cells and round cells has been held by some to be characteristic, but both the rabic tubercle and ganglion infiltration occur in other conditions. The disease is extremely rare in the United States and the author has not seen a single case.

If a dog is poisoned with barium carbonate the symptoms are similar to those of rabies ("Penna. Health Bulletin," Aug., 1909).

Symptoms.—The period of incubation of human hydrophobia is from a few weeks to several months, and it has been alleged that it may even be two years, but it is very doubtful if there is ever a period of incubation of over six or seven months. The average incubation period in man is forty days (Ravenel). The initial symptoms are mental depression, anxiety, sleeplessness, restlessness, headache, malaise, and often pain or even congestion in the cicatrix. The anxiety which is usually present may be deepened into actual fear. In dogs the condition of fear is so evident that Cælius Aurelianus centuries ago called the disease *pantophobia* (fear of everything). The previously mentioned symptoms are quickly followed by dysphagia. It is not only water that is difficult to swallow, but everything the patient tries to drink or eat. The difficulty in swallowing results apparently from apnea produced instantly when an attempt is made to swallow. Curtis points out that the difficulty is not spasm of the pharynx and larynx, but a sense of immediate suffocation due to reflex stimulation of respiratory inhibition. If spasms occur—and they may occur—they are secondary to this suffocative state, a state in which the action of the diaphragm ceases for a time. The air-passages become congested and the sufferer makes frequent and painful efforts to expel thick mucus, and the efforts produce paroxysms of suffocation. Between the paroxysms the patient is evidently somewhat breathless, and Warren tells us that his speech is not unlike that "of a child who has recently been crying and is endeavoring to control itself" ("Surgical Pathology and Therapeutics"). As the condition grows worse, suffocative attacks, which were at first induced by attempts at swallowing, are caused also by bright lights, sudden or loud noises, irritations of the skin, or even thinking of swallowing. At length suffocative paroxysms occur spontaneously and the patient jumps, or hurls himself about, or the muscles of the entire body are thrown into clonic spasms. Tonic spasm does not occur. A condition of general hyperesthesia exists,

[1] Since the above was written Noguchi has announced the discovery of what he believes to be the causative protozoön.

The mind is usually clear, although during the periods of excitement there may be maniacal furor with hallucinations which pass away in the stage of relaxation. The temperature is moderately elevated (101° to 103° F. or higher). The spasmodic stage lasts from one to three days, and the patient may die during this stage from exhaustion or from asphyxia. If he lives through this period, the convulsions gradually cease, the power of swallowing returns, and the patient succumbs to exhaustion in less than twenty-four hours, or he develops ascending paralysis which soon causes cardiac and respiratory failure. In what is known as *paralytic rabies*, a very rare form of the disease in human beings, the attack comes on with the same early symptoms met with in the commoner form, but paralysis soon begins about the bitten part and spreads to all the limbs and to the trunk.

In hydrophobia death is almost inevitable. Practically all cases in which it is alleged that recovery ensued were not true hydrophobia, but hysteria. Wood says that in hysteria, especially among boys, "beast-mimicry" is common, the sufferer snarling like a dog; and in the form known as "*spurious hydrophobia*," in which there may or may not be convulsions, there are a dread of water, emotional excitement, snarling, and attempts to bite the bystanders (in genuine hydrophobia no attempts are made to bite, and no sounds are uttered like those made by a dog).

Lyssa is separated from lockjaw by the paroxysms of suffocation and the absence of tonic spasms in the former, as contrasted with the fixation of the jaws and the tonic spasms with clonic exacerbations of lockjaw.

Wohl believes that the principles of the Abderhalden reaction may be applied in the early diagnosis of rabies. If cellular metabolism is brought about by the virus, protective ferments should be formed. Wohl tests for the protective ferments and in rabbits subjected to subdural inoculation with rabic virus, finds them the third day ("Amer. Jour. Med. Sciences," 1915, cxlix).

Chances of Infection.—Of those bitten by rabid animals—what proportion are infected? The estimate varies from 16 to 60 per cent. Semple says the truth lies between these extremes. Bites through the exposed skin, especially of the head and neck, are most dangerous. Clothing is somewhat protective. Multiple bites and deep bites are worse than single bites and superficial bites. The wolf has long teeth and flies at the throat, hence wolf bites are particularly dangerous. If hydrophobia develops, death is certain. Careful local treatment applied early may secure immunity. The Pasteur treatment will do so almost certainly.

Prevention.—The best prevention is to take up stray dogs and to force maudlin owners to muzzle their dogs. When a person is bitten by a supposed rabid animal and is seen soon after the injury, constriction should be applied if possible above the wound, the wounded area should be incised, allowed to bleed freely, and should then be washed with a 5 per cent. solution of formaldehyd and dressed for twelve hours with a like solution. It is held that formaldehyd is a specific disinfectant of the virus (Cumming in "Jour. Amer. Med. Assoc.," May 8, 1912). If not seen for a day or two, open the wound and scrub with a 5 per cent. solution of formaldehyd. Many physicians advocate excising the wounded area and cauterizing with pure nitric acid, a hot iron, or the Paquelin cautery. Fuming nitric acid is warmly commended by Paul Bartholow and others. Ravenel believes it may save a man even after twenty-four hours have elapsed since the bite. Most reports indicate that cauterization is useless after eight or ten hours and is probably not very valuable after three or four hours (Semple, Ibid.). After the wound has been treated with formaldehyd or cauterized it is to be dressed antiseptically. In any case, early or late, send the patient at once to a Pasteur institute. If the animal which inflicted the injury was not hydrophobic, no harm will result from inoculations; if it was hydrophobic, preventive treatment may save the patient. The method known as the preventive treatment was devised by Pasteur. If the virus of a rabid dog (street rabies) be placed beneath the dura of another dog, it *always* causes hydrophobia in about fourteen days, and invariably causes death. The virus can be attenuated by passing it through a series of monkeys. It can be intensified by passing it through a series of rabbits. After a series of passages through rabbits it takes on a fixed virulence (fixed virus). To obtain attenuated preparations in a convenient form Pasteur made emulsions from the spinal cords of hydrophobic rabbits, the animals having been dead two or three weeks. He found that the emulsion obtained from the rabbit longest dead was the weakest. He injected a dog with emulsions of progressively increasing strength and made the animal immune to hydrophobia. Patients were injected with emulsions made from the dried spinal cords of hydrophobic rabbits. The emulsion contains attenuated virus, and day

by day the strength of the virus injected is increased. These emulsions cause the body cells to form antitoxin, and either the virus of street rabies does not develop at all or by the time it begins to develop a quantity of antitoxin is present to antagonize it. The report of the Parisian Pasteur Institute shows that since its foundation there has been a mortality of 0.5 per cent. The smallest estimate of infection in those bitten is 16 per cent. Hence at the highest the mortality after the Pasteur treatment is one-thirty-second of the mortality noted among those not so treated. Semple (Ibid.) records that a rabid dog bit 15 Indians. Eight received the treatment, and not one developed hydrophobia. Seven did not receive the treatment, and within three months 5 of them became rabid. Ravenel, in 1901, estimated that 55,000 persons had been treated by the Pasteur method and that less than 1 per cent. had died. The value of this plan is definitely established. The general public believes that the dog which did the biting should be killed. The dog should, if possible, be locked up and watched rather than killed. It may be proved in this way that it did not have hydrophobia. If it were necessary to kill the dog, or if the dog was killed at once or soon after having inflicted the bite, the physicians of the New York Pasteur Institute advise that the dog's head be cut from the body with an aseptic knife and a piece of the medulla oblongata be abstracted. The bit of medulla should be placed in a mixture of equal parts of glycerin and water which has been previously sterilized by boiling. The bottle should be sealed and sent to the institute, in order that inoculations may be made upon animals to prove the existence or absence of hydrophobia. Babés tubercles and Negri's bodies are at once sought for in the specimen, and if they are found, treatment should be started at once upon the bitten patient. In the paroxysms of hydrophobia the treatment in the past was purely palliative. If we employ only palliative methods, keep the patient in a dark, quiet room, relieve thirst by enemata, saturate him with morphin, empty the bowels by enemata, attend to the bladder by regular catheterization, and during the paroxysms anesthetize. Murri, of Bologna, claimed he cured a case of hydrophobia by injecting emulsions of cords of rabbits dead six, five, four, and three days respectively. In such a desperate disease it would be proper to try this remedy. A serum has been prepared by Tizzoni and Centani which they claim is successful in treating the disease as experimentally induced in the laboratory. The remarkable suggestion has come from Tizzoni that rabies be treated with rays of radium, it having been shown that rabic virus can be destroyed by radium.

Glanders, Malleus, Farcy, or Equinia.—Glanders is an infectious eruptive fever occurring in horses, mules, and asses, sometimes noted in goats, hogs, dogs, cats, and some other animals, and communicable to man. Cattle, house mice, house rats, white mice, and white rats are immune. The disease is most common in the horse and is due to the Bacillus mallei. These bacilli are found chiefly in the nasal discharge and the recent nodules. There are few in older ulcerations. They are not found in the blood. Human glanders is by no means as uncommon as was once thought. Not a few cases die undiagnosticated. In one paper 156 cases of chronic glanders were discussed (Robin, "Studies from the Royal Victoria Hospital of Montreal," 1906). If the nodules occur in the nares, the disease is called "glanders," if beneath the skin, it is termed "farcy." The Bacillus mallei is communicated to man through an abraded surface or a mucous membrane. Bernstein and Carling reported 6 cases of human glanders. They say: "In none of our cases was there definite evidence of the point of inoculation or path of infection, and the general evidence, clinical and experimental, on both of these questions is so conflicting that the time is hardly ripe for the expression of decided opinions. The hypothetic paths are by direct inoculation through a wound or by the hair-follicles, by inhalation, or by ingestion ("Brit. Med. Jour.," Feb. 6, 1909). The characteristic lesions are infective granulomata in the nares, skin, lungs, and subcutaneous tissue. In the nares granulomata result in ulcers and under the skin break down into abscesses. In some cases there is no nasal discharge. Multiple abscesses anywhere should excite suspicion of the existence of glanders. From the site of inoculation the bacilli are disseminated and the cutaneous and muscular structures and lungs become involved. There is usually a remittent fever. There is no known method of immunizing animals and mallein has no immunizing power. One attack does not prevent another. Man may be infected from a diseased animal, and as the common source of infection is the horse, the usual victims are those who use or work about horses, and yet people who have never been about horses may develop the disease. The period of incubation after infection is four or five days.

Acute and Chronic Glanders.—In acute glanders there is septic inflammation at the point of inoculation; nodules may form in the nose and ulcerate; there is profuse nasal discharge; the glands of the neck enlarge; there is weakness, frontal headache, chilliness, pain in the back and limbs; often diarrhea; after a time the muscles become painful; there is fever, the evening temperature being 100° F. or higher and the morning temperature being lower. Chills may occur. There may be chest pains, severe muscular pain, bronchitis, and signs of pulmonary congestion. The lungs may be infected by inspiration of the bacilli in the discharge of the ulcers. It may not be suspected that the patient has glanders and the diagnosis of typhoid may perhaps be made. Twelve to fourteen days after the beginning of the trouble little hard lumps arise in the muscles and just beneath the skin. In a few days the lumps soften, break down, and discharge a bloody fluid which contains the bacilli of glanders. In a number of cases an eruption resembling smallpox appears on the face and about the joints, and this exanthem is usually prophetic of approaching death. It differs from smallpox in not being umbilicated. Leukocytosis may or may not exist. In chronic glanders there are like symptoms which last six weeks or more. Acute glanders is nearly always fatal. Chronic glanders lasts for weeks, is rarely diagnosticated, being mistaken for catarrh, may be recovered from, but if not thoroughly eradicated will sooner or later eventuate in a fatal acute condition. The mortality of glanders is about 90 per cent.

Acute and Chronic Farcy.—Acute farcy arises at the site of a skin inoculation; it begins as an intense inflammation, from which emerge inflamed lymphatics that present nodules or "*farcy-buds*." Abscesses form, but the pus differs in appearance from ordinary pus, is often gelatinous, and may be red in color. There are joint-pains and the constitutional symptoms of sepsis, but no involvement of the nares. In it nodules occur upon the extremities, these nodules break down into abscesses and eventuate in ulcers resembling those of tuberculosis or, perhaps, of syphilis. The ulcers form rapidly and often heal.

Diagnosis of Glanders and Farcy.—Mallein is a concentration of the glycerin broth in which the bacilli of glanders have been grown. Injection of mallein into an infected animal produces a significant reaction (fever, malaise, restlessness, perhaps a distinct rigor, sometimes vomiting, marked swelling at the point of inoculation). The dose used is 10 to 15 min. (Bernstein and Carling in "Brit. Med. Jour.," Feb. 6, 1909).

Mallein has proved of high diagnostic value in the hands of veterinarians. The reaction when it is injected into an animal with glanders is like the reaction produced by tuberculin on a tuberculous animal.

Animal injection is very valuable in diagnosis. The highly susceptible guinea-pig is used for this purpose. The doubtful material (nasal mucus or pus or a tissue fragment) is injected into the peritoneal sac of a male guinea-pig. Usually in three or four days the testicles enlarge and later suppurate.

The pig is killed and the pus examined for the bacillus of glanders. Testicular enlargement does not always occur even when the inoculated material was from a lesion of glanders. In some cases it occurs after weeks. As a rule, it does occur in a few days.

In the lesions of glanders the bacilli of the disease are few in number and in many lesions are mingled with other bacteria, hence the bacteriologic diagnosis is always difficult and is often impossible without animal inoculation. The value of an agglutination test is as yet undetermined, but it is regarded with confidence by some.

Treatment.—In treating this disease the point of infection should be at once incised, cauterized, dusted with iodoform, and dressed antiseptically. The skin over enlarged glands and swollen lymphatics is to be painted with iodin and smeared with ichthyol. Bandages are applied to edematous extremities. Ulcers are curetted, touched with pure carbolic acid, dusted with iodoform, and dressed antiseptically. In glanders the nostrils should be sprayed at frequent intervals with peroxid of hydrogen and syringed with a solution of sulphurous acid. The mouth must be rinsed repeatedly with solutions of chlorate of potassium. Abscesses are to be opened, mopped with pure carbolic acid, and dressed antiseptically. Stimulants and nourishing diet are demanded imperatively. Morphin is necessary for the muscular pain, restlessness, and insomnia. Digitalis is given to stimulate the circulation and kidney secretion. Sulphur iodid and arsenite of strychnin have been used. Diseased horses ought at once to be killed and their stalls should be torn to pieces, purified, and entirely rebuilt. A man with chronic glanders should be removed to the seaside. The nasal passages

must be kept clean and the ulcers must be cauterized and dressed with iodoform gauze. Nutritious foods, tonics, and stimulants are necessary.

Treatment of recent cases by frequent small doses of mallein finds advocates. It has been suggested that injection of the serum of the blood of an immune animal (the ox, for instance) might be serviceable. Most observers assert that serum of naturally immune animals and the serum of animals which have been repeatedly injected with mallein are equally worthless.

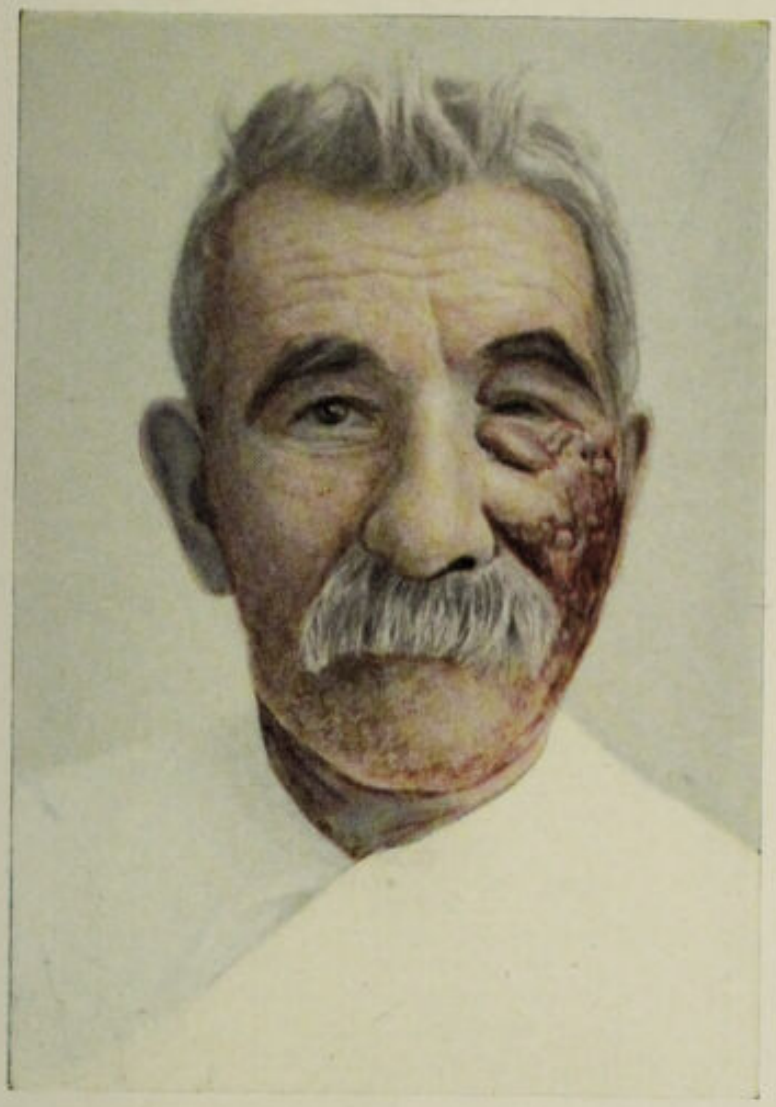
Actinomycosis (*streptotrichosis*) is a specific infectious disorder characterized by chronic infiltrating, granulomatous inflammation, and is due to the presence in the tissues of some variety of streptothrix. It is generally believed that the *Actinomyces bovis* or ray fungus is the only cause of the disease. Some writers believe that other members of the streptothrix group may be responsible. The responsible organism is the one described by Wolff and Israel (Mattson in "Surg., Gynec. and Obstet.," April, 1922). The streptothrices are usually regarded as molds, but they possibly constitute a transition stage between filamentous fungi and bacteria. At present many pathologists use the term "actinomyces" as the generic name for the various forms of these parasites. Other pathologists designate them as streptothrix forms, of which the Actinomyces bovis is one. In 1877 Bollinger recognized and described these parasites as causative of disease in cattle. In 1878 Israel described human actinomycosis. Acland, in 1884, reported the first English case of human actinomycosis. Some of the varieties of streptothrices are pathogenic, others do not seem to be. Some forms are anaërobic, others are aërobic. They are not killed at once by drying, but months after may develop if placed under favorable conditions. When growing in the tissues they usually form numerous distinct yellow, reddish, black, or gray aggregations, each about the size of a sand grain, and called from their color *sulphur grains* or *red pepper grains*. They grow from mycelia. Usually the growths lie in thick and sticky purulent matter. If purulent matter containing growths is rubbed between the fingers, it will give a gritty sensation like sand if the growth is not very recent. The grit is due to lime-salts. The growth of the fungi causes the formation of an infective granuloma, and great masses of granulation tissues may form with collections of necrotic or purulent matter here and there, and zones of fibrous tissue. The fungi are easily discovered in the sulphur grains by the microscope, but if the fungi are mycelial and are scattered instead of being gathered into granules it is difficult to discover them. This disease occurs in cattle (*lumpy jaw*) and in pigs, and can be transmitted to man. The source of the fungi is probably outside of the animal body, first saprophytes in certain soils, next in the inner husks of barley and other grains and in grasses, and from such media it becomes able to infect animals and men (Mattson, Ibid.). Animals are inoculated by eating the contaminated grasses, scratches on the mucous membrane of the tongue, mouth, or pharynx, or decayed teeth being inoculated. In man the fungus may be taken in with food, by chewing the mold-bearing grass or straw, or by inhalation of contaminated dust. Direct infection from animals is more common than was believed formerly. Its development seems dependent upon processes of decay. Organisms may lodge and develop in a breach of mucous continuity, a crypt of the tonsil, or a hollow tooth.

Lord, of Boston, has found the parasite in carious teeth of those believed free from actinomycosis, and has produced actinomycosis in guinea-pigs by inoculating them with the contents of carious teeth ("Publications of the Massachusetts General Hospital," Oct., 1911). Lord reaches the conclusion that true actinomycosis (the disease due to ray fungi) arises from within the individual, carious teeth being the cause. It has not been certainly demonstrated that the organisms inhabit normally the mouth or gastro-intestinal canal of the human being (Mattson, Ibid.).

The disease is at first local; later there may be general blood infection, and abscesses may form in the lung, liver, kidney, etc.

The fungi may pass into the lungs, causing pulmonary actinomycosis; into the intestines, causing intestinal actinomycosis; into the skin, the bones, the subcutaneous tissues, the heart, the brain, the liver, the urinary organs, etc. Abdominal actinomycosis is the commonest form and comprises nearly 50 per cent. of cases.

Cutaneous actinomycosis may be secondary to visceral infection with the disease, may be a purely local condition due to inoculation of a wound, or may be associated with some adjacent area of bone infection. The gummatous form of actinomycosis resembles a gummatous syphilitic area, and in it many small purulent pockets open by fistulæ. Cases of human actinomycosis until recently were looked upon as sarcomata. Many sinuses form, ulcers develop, but large abscesses do not arise.



Author's case of facial actinomycosis.

In actinomycosis there is no spread by lymphatics until very late in the case. In fact, the adjacent lymph-glands are very seldom involved unless there is secondary pyogenic infection, and if metastasis occurs it takes place by the veins. The condition causes but slight pain. A diagnosis must be made from syphilis, sarcoma, carcinoma, and tuberculosis. The formation of a tumor, followed by sinuses and ulceration, the ulcer having thin, non-indurated, undermined edges and edematous granulations, and adjacent pus cavities joining by sinuses, the appearance of the pus and the microscopic study of the discharge are significant. An actinomycotic ulcer may partially heal here and there. It has been stated that an individual with actinomycosis may react to tuberculin like a person with tuberculosis (see page 153). The muscular and connective tissues become infiltrated and hard, as though a coagulating material had been injected into them (Poncet and Bérard in "Lyon Médicale," March 27, 1904). Edema and induration extend wide of the active focus of disease (Plate 1). Actinomycosis may last for years or it may prove fatal.

In the anthracoid form there are no distinct purulent collections, but many fistulæ discharge pus at various points (Monestié).

An area of cutaneous actinomycosis is characterized by the existence of violet, blue, gray, or black maculæ, varying in size from that of a pin's head to that of a bean, the center of each macule being white and containing a minute quantity of pus (Derville).

In actinomycosis of bone the bone enlarges and becomes painful, the parts adjacent swell from infiltration and soften, pus forms and reaches the surface through fistulæ, and the skin becomes involved secondarily.

Abdominal actinomycosis takes origin from the gastro-intestinal tract, an actinomycotic nodule of the intestine having ulcerated, adhesions having formed, and an actinomycotic abscess having arisen, or actinomycotic disease of the intestine having spread. In over 50 per cent. of cases of abdominal actinomycosis the cecum is the part attacked. A fecal fistula may form and the liver may be involved. At least 150 cases of actinomycosis of the appendix have been reported. A mass containing putrid pus develops. If not evacuated fistulæ form. It is a very chronic condition, and although fistulæ may heal, they break open again and again (Short in "Lancet," Sept. 14, 1907). The fungi may be found in the stools.

The mortality of actinomycosis depends upon the site of infection, the question of secondary infection, and the plan of treatment. If pyogenic infection occurs, fatal pyemia may arise. The prognosis is reasonably good in many cases. The majority of cutaneous cases (nearly 90 per cent.) and many osseous cases can be cured. The mortality in the abdominal cases is large. Grill says that of 77 abdominal cases treated surgically, 45 died, 22 recovered, and 10 were improved. Frazier ("Keen's System of Surgery") tells us that the mortality of the reported cases of actinomycosis in the United States was 47 per cent., and quotes Jiron as follows regarding the mortality of the various forms: Face and neck, 11 per cent.; thorax, 83 per cent.; abdomen, 71 per cent.; brain, 100 per cent. Actinomycosis has a strong tendency to redevelop even after apparently thorough excision. A case of cutaneous actinomycosis of the arm, seen by the author, was operated on twenty times. Ulceration took place into the axillary artery and death was narrowly averted. Recovery finally ensued. I have seen 4 cases of human actinomycosis: one was the patient just referred to; another was a mattress stuffer (straw being used) with lesions upon the chest and jaw and recovering after operation; the third was a stable hand, who died from lesions of the face, jaw, and neck; the fourth was a railroad watchman who had nothing to do with horses (Plate 1).

Treatment.—Free excision if possible; otherwise incision, scraping, cauterization with pure carbolic acid or silver nitrate, and packing with iodoform gauze. If possible, remove the entire area; if not possible, remove all that can be safely taken away. Sinuses must be widely opened, each collection of pus must be drained, and granulation tissue if not extirpated must be scraped away with a sharp spoon. Give internally large doses of iodid of potassium. This drug alone has cured many cases. It is given for a week or two and is then discontinued for one week. The *x*-rays or radium may be used in association with iodid treatment. It is curious that though iodid of potash seems to influence the disease favorably, the fungus will live unharmed in a 2 per cent. solution of that drug (Harbitz and Grandahl in "Amer. Jour. Med. Sci.," Sept., 1911). In a fistula from intestinal or appendical actinomycosis give potassium iodid and sulphate of copper (Bevan) and irrigate the sinuses with diluted tincture of iodin. Victims of actinomycosis should be placed under the best hygienic conditions, should

live as much as possible in the sunlight and open air, and should be given nutritious diet, tonics, and often stimulants.

Madura Foot (Mycetoma).—This disease, which attacks particularly the foot and ankle and occasionally the hands and other parts, is common in India and East Africa and is occasionally met with in the West Indies and some other tropical regions. It is due to streptothrices, the filaments of which resemble but are not identical with those of actinomyces (Streptothrix maduræ). Swellings form, soften, and rupture. Sinuses with indurated walls result. The sinuses finally reach and may involve the bone. The disease is of very slow progress, never becomes generalized, and does not seem to cause death directly. Portions of streptothrices can often be discovered in the fluid from the sinuses and in the granules found in this fluid.

Treatment.—Iodid of potassium is valueless. Incision and excision are alike useless. The best plan is to amputate if possible (C. W. Daniels in "A System of Surgery," edited by C. C. Choyce).

Yaws (Frambœsia Tropica).—This disease is due to a spirochete resembling nearly the spirochete of syphilis. It occurs endemically in certain tropical regions (Africa, India, Islands of the Southern Seas, Ceylon, Malacca, and particularly in the West Indies). Now and then we see a case in Philadelphia in a man who has come from the West Indies.

Caucasians may get it, but are not very apt to if they retain European dress and customs. Native children are particularly liable. The disease spreads by the discharges from a victim. In some cases it is carried by insects. The first lesion arises where there is a breech of continuity and in very many cases this happens to be about the mouth. The first lesion is an elevated infective granuloma of the subcutaneous tissue which softens and forms a yellowish crust. Crops of granulomata soon form, especially on the face, neck, and elbows. Finally granulomata cease to appear. Any granuloma may ulcerate and such an ulceration is persistent.

At the onset of the eruption there may be fever and severe backache, hence the condition has been mistaken for smallpox. Like smallpox it protects from another attack. It has been mistaken for syphilis, but the crust does not resemble the blackened crust of rupia and when it is pulled off it does not disclose the deep rupial ulcer, but, instead, humped-up granulation tissue. Again, as Daniels points out, the eruption is not polymorphic as syphilitic eruptions characteristically are. The disease is not fatal except perhaps to young children.

Treatment.—Isolate the patient. Administer salvarsan and subsequently mercury and iodid of potassium. Cleanse and disinfect ulcers and administer tonics and nourishing food. (See C. W. Daniels in "A System of Surgery," edited by C. C. Choyce.)

Blastomycosis.—May, in 1894, called attention to the disease. In 1894 Busse described a fatal infection due to a pathogenic yeast. The very existence of this disease has been denied, but numerous cases have been reported and most observers regard it as an entity. Many cases have been reported from Chicago and its neighborhood by Bevan, Hektoen, Hyde, and others. It may be a local infection (cutaneous blastomycosis), but in some cases the disease is generalized (systemic blastomycosis). The disease is found in North America, South America, Europe, and the East. The organism usually enters through the skin and is disseminated by the lymph. The course of the disease is slow. Multiple abscesses form (subcutaneous tissues, lungs, liver, spleen, kidneys). Anemia and emaciation develop and progress and the urine is albuminous. In generalized blastomycosis the lungs are usually the first organs infected. Generalized blastomycosis is fatal as a rule. The yeasts when found in the tissues are in the budding stage (Powers in "Surgery, Gynecology, and Obstetrics," 1914, lx; Stoddard and Cutler on Torula Infection in "Monographs of Rockefeller Institute for Med. Research," Jan. 31, 1916).

Cutaneous blastomycosis (blastomycetic dermatitis or oïdiomycosis) was first described by Gilchrist in 1894. It is due to infection with a variety of yeast fungus. In the skin it begins as a papule or an indurated pustule, which becomes crusted and finally warty, enlarges at the periphery, and becomes surrounded by more recently developed lesions. The area becomes studded with minute abscesses, crusted foci, and bleeding granulations. Here and there healing may occur.

The disease may arise on any portion of the body, but the hands and face are most liable to it. It is slow in progress and lasts for many months. If it progresses, it will finally produce systemic blastomycosis, or secondary infection will produce fatal septicemia. Bevan (Lexer's "General Surgery," edited by Arthur Dean Bevan) says the evidences of general infection are: "irregular temperature, loss of appetite,

general weakness, emaciation, cough, rapid, feeble pulse, acceleration of the respiration, at times albumin in the urine, multiple subcutaneous nodules and abscesses resulting in superficial, irregular ulcers, abnormal physical findings in the lungs, edema of the extremities, and various grades of anemia." Coccidial disease is caused by an organism strongly resembling the yeast of blastomycosis. Bevan places the two diseases in the same group. Some observers regard them as identical. The symptoms are indistinguishable. Montgomery regards iodid of potassium as a test agent—it is without effect on coccidial disease, but acts strongly and favorably upon blastomycosis.

Treatment.—In some cases excision, in others the *x*-rays. Potassium iodid in very large doses is given. It greatly benefits most cases and cures many. Its employment in this disease is due to Bevan. He also gives copper sulphate internally ($\frac{1}{4}$ gr. three times a day), and applies a 1 per cent. solution of that chemical to local lesions.

XIV. BURNS AND SCALDS; EFFECTS OF COLD

Burns and scalds are injuries due to the action of caloric. Scalds are due to heated fluids or vapors. There is no true pathologic difference between burns and scalds. Dupuytren classified burns into six degrees, as follows: (1) Characterized by erythema; (2) characterized by dermatitis with the formation of vesicles; (3) characterized by



FIG. 127.—Dorrance's case of burn of axilla.

partial destruction of the skin, which is not, however, entirely burned through; (4) characterized by destruction of the skin to the subcutaneous tissue; (5) characterized by destruction of all superficial structures and of part of the muscular layer; (6) characterized by "carbonization" of the whole thickness of the muscles.

The **symptoms** of a severe burn are local and constitutional. *Local symptoms* are pain and inflammation, which vary in nature, in intensity, or in degree according to the extent of tissue damage. *Constitutional symptoms* are very weak pulse, shallow respiration, and subnormal temperature—in other words, the condition of shock exists. The patient may die without reacting from shock, but in most cases there is reaction, followed by a severe reactionary fever, with a strong tendency to congestion of internal parts. During the existence of fever there may be vomiting, diarrhea, hemoglobinuria, albuminuria and enlargement of the liver, spleen, lymph-glands, and tonsils. Marked blood changes follow burns (see "Clinical Hematology" by J. C. DaCosta, Jr.). During the early days there is a marked and rapid increase in red blood-cells (polycythemia). This is due in part to venous stasis and in part to loss of blood-plasma. Leukocytosis is rapid and pronounced and there is a notable increase in blood-plaques.

The blood has a marked disposition to clot, and clots may damage various structures or organs. Further, the altered blood damages the organs of excretion, and the liver and kidneys may cease to perform their functions properly. After a severe burn there

are imperfect oxygenation and a tendency to universal fatty degeneration. The symptomatic stages are often designated as *prostration*, *reaction*, and *suppuration*. During the first forty-eight hours after a burn there are congestion in and about the burned area, severe pain, and in some cases internal congestions. There may be shock and possibly toxic delirium or convulsions. From the end of the second to the end of the eighth or ninth day there are severe inflammation of the burned area, formation of sloughs, and a strong tendency to inflammation of the brain in head burns, of the lungs in chest burns, of the abdominal organs in abdominal burns. Duodenal inflammation may arise after any burn. Septic emboli in very unusual cases cause *Curling's ulcer* of the duodenum (see page 88). Duodenitis and Curling's ulcer are possibly due, as Wm. Hunter suggested, to the bile having become irritant by the excretion in it of toxic matter. After the eighth or ninth day the sloughs separate from the burned area and healing begins. The raw surface is slow to heal, hemorrhages may occur, the granulations are apt to be exuberant and edematous, and the scars are very contractile and often produce hideous or disabling deformity. If over one-half of the body surface is badly burned, death will almost certainly occur, and probably within two days. The danger of a burn depends upon its extent, its depth, and its situation. Burning of a large area superficially is much more dangerous than burning a small area deeply. Burns of the extremities are not so dangerous as are burns of the head, chest, or abdomen. Death after severe burns is positively not due to loss of body heat in the burned area. Some think it is produced by auto-intoxication with retained body secretions. High temperature produces blood changes—viz., disintegration of red corpuscles. Thrombosis may occur, and irritation of the kidneys and other organs is produced by "products of corpuscular degeneration."[1]

The blood of burned animals contains toxins (Kijanitzen), and so does the urine (Reis). It seems probable that the constitutional symptoms are due to the absorption of toxic matter from the seat of injury, this matter having been formed by the action of heat on the body cells and fluids. The toxin acts particularly upon the red cells, and disorganizes them. The blood-serum and the fluid of blisters are not toxic. Burned tissue contains toxins. Chemically the toxin is composed of proteoses. Death during the first twenty-four hours is due to primary shock, death at a later period to toxemia (Robertson and Boyd in "Jour. of Laboratory and Clinical Med.," Oct., 1923). Sepsis is not infrequent. Death may be directly due to shock, to sepsis, to exhaustion, to tetanus, to embolism or thrombosis, to congestion of the brain, lungs or kidneys, or, in very rare cases, to Curling's ulcer of the duodenum.

Treatment.—The *local treatment* of slight superficial burns is to moisten the parts frequently with a warm, saturated solution of bicarbonate of sodium or with warm normal salt solution.

If a large surface is burned, remove the clothing with great care, and before applying dressings give a hypodermic injection of morphin, administer stimulants, and if the patient has a chill, place him in a warm bath. Use all ordinary means to secure reaction from shock. Waterhouse makes a recommendation which I have frequently used with advantage, viz., dress the burn with a 1 per cent. solution of acetate of aluminum, wrap the patient in blankets, hold up the other bedclothes with a cradle, and put under the bedclothes an electric light of 32 candlepower. This will make the temperature under the clothes from 100° to 105° F. ("Brit. Med. Jour.," July 9, 1910). Tetanus antitoxin should be given. The custom in the Jefferson Medical College Hospital has long been to give morphin and stimulants, to cut away the clothing, to wrap the unburned parts with blankets, and place about them cans or bags of hot water. The burned region is sprayed with boric acid solution, and is irrigated with salt solution. Portions of epidermis which remain are retained. Any blisters are opened with a sterile needle, but are not cut away, and the part is dressed for two days with several layers of sterile lint or tarlatan soaked in a warm solution of bicarbonate of sodium or in warm, normal salt solution, and the dressing is kept moist. During the second or inflammatory stage use Dakin's oil (1 per cent.) or apply an ointment consisting of equal parts of zinc oxid and cold cream, use stimulants and concentrated food, allay pain by opium or morphin, favor elimination by the skin, bowels and kidneys, and combat any tendency to internal congestion or inflammation. The urine should be examined daily for acetone and diacetic acid. Acidosis calls for active treatment (page 107). In very extensive burns complete and continuous immersion of the part in warm salt solution is an excellent treatment. Some patients are kept immersed in a bath of warm salt solution. If a burn becomes septic

[1] Bardeen in "Johns Hopkins Hospital Bulletin," April, 1897.

it is dressed with Dakin's oil or boric acid solution. If dressings stick they can be removed easily after moistening with diluted peroxid of hydrogen.

The *picric acid treatment*, first suggested by Thiery, has many advocates. It greatly mitigates the pain. It is used early only in limited burns of the first and second degrees, but it can be employed in late stages of deep burns to stimulate the formation of epidermis. If used early in a large or a deep burn, it may poison the patient. It may poison a child when used upon a burn of the second degree. A case was reported by Dr. J. Stuart Rose ("Scottish Med. and Surg. Jour.," Dec., 1903), occurring in a boy of nine, who was treated with picric acid for a scald of the first degree, there being only one or two small blisters in addition to the redness. Ointment of picric acid was used (½ dr. to 1 oz. of vaselin). Symptoms were noted three days after beginning the treatment. The symptoms of poisoning are dark colored urine (carboluria), albuminuria, marked yellowness of the skin, yellowness perhaps of hair at the scalp margins, diarrhea, and elevated temperature. Picric acid when absorbed enters the blood-serum and cerebrospinal fluid. It colors the skin yellow and the urine pink. If much is absorbed it makes the urine dark. It damages the liver cells and may cause genuine jaundice the discoloration of which is then added to the yellow hue caused by the drug ("Jour. Amer. Med. Assoc.," March 24, 1917). Rose considers a 1 per cent. solution safe. It is applied as follows: The part should be cleansed, gauze saturated with a 1 per cent. watery solution of picric acid should be laid upon the burned area, and be covered with absorbent cotton and a bandage. If there is no odor, picric acid dressings are not changed for three to five days. Odor is one of the first evident signs of infection and calls for change of dressing. Severe pain too calls for change of dressing. It may mean blisters under tension, and if they exist they should be opened. After a picric-acid dressing has been removed substitute ointment. It will be found more comfortable. (Vaselin alone softens too much at body temperature and boric acid ointment alone forms hardened masses. A mixture of the two is excellent.) D'Arcy Power has carefully studied the real status of picric acid as a remedy for burns, and some of his conclusions have been set forth above.

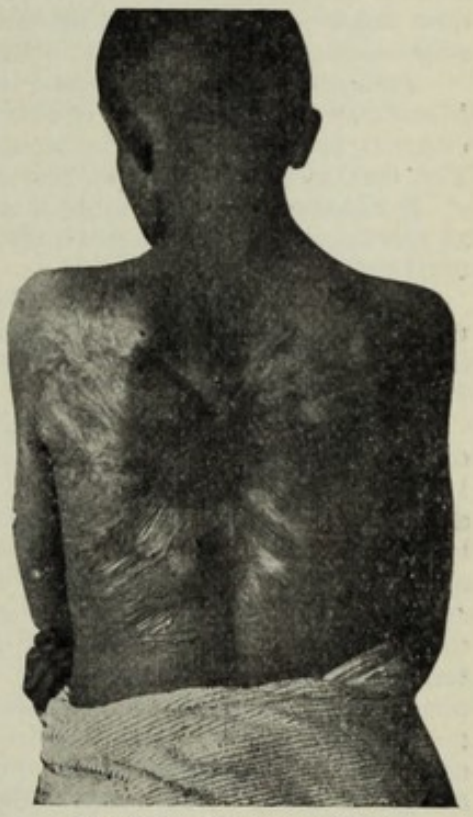


FIG. 128.—Cicatrix of burn.

Paraffin Treatment of Burns.—In the recent war paraffin was warmly advocated in the treatment of burns. Dr. Barthe de Sandfort, of the St. Nicholas Hospital, Issy-les-Moulineaux, devised a combination of paraffin and 5 per cent. oil of amber which he used successfully in treating burns, especially tar and gas burns. The trade name is ambrine. Unfortunately the formula is held by a commercial company. It is a great pity it was not given to his countrymen and to the world in accordance with the principles of American medical ethics. Lt.-Col. Hull makes a paraffin preparation which some consider superior to ambrine. It is as follows:

	Per cent.
Resorcin	1
Oil of eucalyptus	2
Olive oil	5
Soft paraffin	25
Hard paraffin	67

If resorcin is unobtainable substitute 0.25 per cent. of betanaphthol and increase the hard paraffin to 67.75 per cent. Melt the hard paraffin, add the soft paraffin and olive oil, dissolve resorcin in absolute alcohol, and add oil of eucalyptus. The burn is to be washed with sterile water and dried by fanning. Blisters are not opened. The mixture is to be heated to a temperature of 122° F. (at this point the surface wax will show a film of solidification). A layer of paraffin is applied to the wound as a spray by means of an atomizer or is painted on by a camel's-hair brush. Over this is

placed a thin layer of cotton wool. Then another stratum of paraffin is applied. A wool bandage completes the dressing. Dress the burn every day, and later every other day. At the second dressing blisters are opened and dead skin is cut away.

Sollmann and Beitler (both in the "Jour. Amer. Med. Assoc.," June 1, 1917) call attention to the severe pain caused by applying paraffin preparations to recent burns and advise cleansing the burn and applying as a first dressing liquid petrolatum. It is sprayed or painted upon the part, the cotton wool layer being applied and then the paraffin.

All agree that burns of the surface heal more quickly under paraffin treatment than by any other method. As to results in deeper burns there is disagreement. I do not believe in sealing a severe burn. Drainage is necessary. As Moorhead has well said, "a burn is an infected wound due to heat" and an infected wound requires drainage ("Jour. Amer. Med. Assoc.," June 11, 1921). Some hold that the scar which follows healing under paraffin is soft and little liable to cause contractures. Others maintain that the scar acts like the scar which follows healing under any other treatment.

The So-called Antiseptic Treatment of Burns.—This treatment was found to be painful and highly irritant. As De Tarnowsky says ("Jour. Cutan. Dis.," 1916, xxxiv), the treatment of burns by active antiseptics has been abandoned. The surgeon now cleanses the surrounding parts and washes the burn with some mild fluid (boric acid solution or normal salt solution). Only gross dirt is removed from the burn.

Treatment by Horse-serum.—(See Edward Percy Robinson in "Annals of Surgery," March, 1917.) The object of this treatment is to hasten epidermization by giving nourishment to the cells at the wound margins and so to stimulate them to proliferate. The treatment is begun at the stage of a burn when epidermization should begin.

Normal serum containing a small percentage of tricresol is sprayed upon the cells at the margin several times a day for ten days. After spraying the parts are covered with rubber tissue.

"Périer dresses a burn with a tarlatan compress, folded six times and soaked in the following solution: boric acid, 2½ dr.; antipyrin, 1½ dr.; sterile water, 8 oz. The following ointment is used by Reclus: iodoform, 15 gr.; antipyrin, 75 gr.; boric acid, 75 gr.; vaselin, 1½ oz.

Carron oil consists of equal parts of linseed oil and lime-water. It allays the pain of a burn, but it is a filthy preparation, and its use is followed by much pus formation. It is named from the Carron Iron Works near Stirling, Scotland, where the mixture was devised. Cosmolin gives comfort as a dressing, but should not be used on the face, lest it cause pigmentation. If used alone it becomes too liquid at the body temperature and should be mixed with boric acid ointment. The elder Gross used lead paint. A solution of nitrate of potassium allays the pain. Bismuth paste is a satisfactory dressing. In a burn of the face a mask is applied, and if there is conjunctivitis it is treated by appropriate methods. Members of the fire department are not unusually scorched and the conjunctiva may be much irritated by hot smoke. If they are to go into the smoke again the fire surgeon does not instil cocain. It gives temporary ease at the expense of early congestion and worse pain. Again during the stage of analgesia many cinders may lodge within the lids and not be felt. In every burn of the fingers and toes keep the burnt digits separated by gauze, lint, or rubber tissue during healing, otherwise adjacent fingers will adhere and "*webbing*" will result. In a burn of the axilla keep the arm from adhering to the side (see Fig. 127). When extensive destruction of tissue has taken place and healing has begun, use splints and extension to limit contractures, and skin-graft as soon as possible. Amniotic grafts are useful. If granulation is slow, stimulate with copper sulphate or mild silver nitrate solutions. Exuberant granulations require burning down. Flabby granulations require pressure. If healing is slow, or if the burn is extensive, skin-graft. Skin-grafting should be done early in an extensive burn. If performed before much cicatricial tissue has formed, the graft will be more apt to adhere, and if the graft does adhere, further formation of scar tissue will be greatly limited. When an extremity has been carbonized, amputation must be performed. The *constitutional treatment* of a severe burn is to bring about reaction; combat pain with opium, and keep the bowels and kidneys active. Examine the urine daily and note daily the amount passed. Let the patient drink boiled water in large quantities. Be on the watch for acidosis. If suppuration occurs, give tonics, stimulants, and concentrated foods. Complications are treated according to general rules.

Burns and Scalds of the Tongue, Pharynx, Glottis, and Epiglottis.—A child or lunatic may drink boiling fluid or inhale steam from a tea-kettle. Firemen

occasionally suffer from scalds of the tongue and pharynx after having been suddenly enveloped in a cloud of hot steam, and from burns by the inhalation of hot vapor or flame. Caustic may be taken into the mouth or swallowed. The tongue and pharyngeal mucous membrane swell greatly, large vesicles form, there are shock, severe pain, dysphagia, and dyspnea. Edema of the glottis may arise.

Treatment.—Combat shock; give morphin for pain; puncture vesicles, and have the patient almost constantly suck bits of ice. If great swelling occurs, make multiple longitudinal incisions through the mucous membrane of the dorsum of the tongue. If edema of the glottis begins, scarify it. If this fails, perform intubation or tracheotomy.

Burns of the Esophagus.—The esophagus is seldom scalded, as a boiling fluid seldom gets below the pharynx. The swallowing of an acid or alkali produces severe burns, particularly at the constricted portions of the gullet (see page 920). Such an accident produces shock, dyspnea, violent pain, vomiting of blood, and thirst. Death may occur from shock or perforation of the stomach. In many cases severe gastritis follows a burn of the esophagus. As the acute symptoms of a burn of the gullet gradually abate sloughs are cast off, ulcers form, cicatrization begins, and the signs of stricture develop (see page 920).

Treatment.—Give a remedy to neutralize the caustic. Administer several large drafts of water and wash out the stomach. Combat shock. Give morphin for pain. Feed by the rectum as long as the patient's strength does not begin to fail. On beginning mouth-feeding, use at first milk and later olive oil, beef-juice, jelly, and ice-cream. In from two to four weeks after the infliction of the burn begin the use of bougies to limit contraction.

Effects of Cold.—*Local Effects.*—Cold produces numbness, pricking, a feeling of weight, redness of the surface followed by stiffness, local insensibility, and mottling or pallor. Sudden intense cold causes the formation of blebs, the coagulation of blood in the superficial veins, and violent pain in the part. Cold locally produces frost-bite (see page 109). Trench foot is considered on page 240.

The *constitutional effects* of cold are at first stimulating, then depressing, and are exhibited by uneasiness, pain, and an intense drowsiness which, if yielded to, is the road to death by way of internal congestion. Death from prolonged cold resembles in appearance death from apoplexy. Death from sudden and overwhelming cold is caused by anemia of the brain from weak circulation and capillary embolism. To bring a partly frozen person into a warm room may cause death by embolism.

Treatment.—Frost-bite is treated as outlined on page 110. When a person is nearly frozen to death place him in a *cool* room, but under no circumstance in a cold bath; make artificial respiration, rub him briskly with flannel soaked in alcohol or in whisky, and follow this by rubbing with dry hands. After a time wrap the patient in warm blankets and give an enema of brandy. Mustard plasters are to be applied over the heart and spine. As soon as swallowing is possible brandy is administered by the mouth. As the condition improves gradually raise the temperature of the room and give *hot* drinks.

Chilblain, or **pernio,** is a secondary effect of cold. It is really an area of local asphyxia (see page 109). It usually appears as a local congestion upon the toes, the ears, the fingers, or the nose, and now and then inflames and ulcerates. A chilblain is apt to become congested on the victim approaching a fire or on taking exercise, and when congested it itches, tingles, and stings. Frequent attacks of congestion produce crops of vesicles; these vesicles rupture and expose ulcers, which in rare instances slough.

Treatment.—If chilblain affects the toes, prevent congestion of the legs and feet. Order large, low shoes and woolen stockings and forbid tight garters. The patient with pernio must take regular outdoor exercise and must not loiter around a hot stove, a heater, a hot radiator, or an open fire. Every morning and evening he should take a general cold sponge-bath, followed by rubbing with alcohol and friction by a coarse towel, and in winter he should sleep wearing warm stockings or with his feet upon a warm-water bag. When a chilblain is only a congested spot it should be washed twice a day in cold salt water, rubbed dry with flannel, and subjected to applications of tincture of iodin and soap liniment (1 : 2), tincture of cantharides and soap liniment (1 : 6), or equal parts of turpentine and olive oil (W. H. A. Jacobson). Davidson advises for a congested spot the following plan: Paint several times a day with the following mixture:

℞. Thymolis iodid ..... ℥j
Flexible collodion ..... ℥j

Relief is due to exclusion of air. Jacobson says itching is relieved by painting belladonna liniment upon the part and allowing it to dry. Tincture of iodin may relieve it, and so may a mustard foot-bath. A valuable preparation for itching is composed of 1 dr. of powdered camphor and 4 oz. of cosmolin. A little of this ointment is rubbed in twice a day. The following prescription, the source of which I do not remember, is very valuable for itching: 1 dr. of powdered camphor, 1½ dr. of ichthyol, ½ dr. of lanolin, and 4 oz. of cosmolin, rubbed into the part and covered with cotton-wool. Itching is much relieved by soaking the feet several times a day in very hot water containing 1 tablespoonful of powdered alum (Davidson). If vesicles form, paint with contractile collodion. Ulcers may be dressed with the following ointment:

℞. Phenolis ..... gr. x
Camphor ..... gr. xx
Adipis lamar ..... ʒiv
(Davidson.)

If ulcers are sluggish, use equal parts of resin cerate and spirits of turpentine. A good antiseptic and protective is the following: oxid of zinc, 6 gr.; chlorid of zinc, 20 gr.; gelatin, 2 oz.; distilled water, 1 oz.

XV. SYPHILIS, OR POX

(Dr. Thomas C. Stellwagen, Associate Professor of Genito-urinary Surgery in the Jefferson Medical College, did me the favor to give me valuable aid in the revision of this article.)

The name comes from the title of a poem which was published in Venice in 1530, "Syphilis sive Morbus Gallicus," by Girolamo Frâcâstoro. For centuries there has been fierce dispute as to the origin of syphilis. Many assert that Europe was free of it until the discovery of America and that the sailors of Columbus brought it from Hayti. Others claim that the disease has always existed in Europe and the East. We know there was a violent outbreak of it in 1495 among the 90,000 soldiers who were invading the kingdom of Naples, under King Charles VIII of France, and that it soon spread through Europe. Hence the old name of French disease. The French resented the term and called it the Neapolitan disease. The confusion is like that between the two Dromios. The offense of each points to the other. The spread of the disease was rapid and disastrous, in fact, syphilis became epidemic. At this time the pox was often fatal.

Definition.—Syphilis is a chronic contagious, and sometimes hereditary, constitutional disease, due to an organism known as the Treponema pallidum. It is one of the most common of diseases and were facts known would rank high as a cause of death. Lassar states that in Berlin, of men over twenty-five years of age who come to autopsy, 9 per cent. are syphilitic. "There are at least a million and a half syphilitics in the United States" (J. Howard Beard, "Pop. Science Monthly," Feb., 1917). The report of the "Royal Commission on Venereal Diseases," 1916, indicates that in England from 8 to 10 per cent. of the civil population are syphilitic. In the United States it is twice as frequent among negroes as compared with whites, although in the black race the disease is apt to be more curable and less disastrous.

Etiology.—The disease has been definitely established as due to the Treponema pallidum; discovered jointly by Fritz Schaudinn, a protozoölogist, and Erich Hoffmann, a syphilologist, on March 3, 1905.

The organism consists of a series of small spirals from 4 to 14 microns in length and ¼ micron in diameter. There are usually from 6 to 14 spirals in each organism. There may be more or less. It is very motile and can be easily confounded with other spirals by the uninitiated. It can be found by a specially constructed microscope in the juice from an untreated chancre, from the lymph-nodes, and in many other structures of the body. A so-called dark field study should be made of the serum of all suspicious sores, either genital or extragenital. Spirochæta pallida, or Treponema pallidum, as it should be called, can often be found before the Wassermann test is positive. This fact is of the greatest clinical importance, as it enables the surgeon to institute treatment before the disease gains a strong foothold in the blood-stream. The older method was to wait for the appearance of the eruption before starting treatment. If the dark field study is definitely positive and confirmed by successive studies it is often advisable to place the patient under treatment at once. Some oppose this on the ground that it prevents the development of vital resistance.

Life History.—Nothing is definitely known of its life-cycle. It is believed by some, notably McDonagle, that it passes through a series of changes and the organism as we know it is the male gamete of a sporozoan. This, however, has not been confirmed by cultural studies and is not generally accepted. It multiplies by transverse fission.

Animal Inoculations.—Syphilis was thought incapable of transmission by inoculation to animals other than man until Metchnikoff and Roux in 1903 succeeded in producing the disease in a chimpanzee from a chancre of one month's duration upon a man. The anthropoid apes present symptoms resembling those in man, excepting that they do not reach the tertiary stage. The disease can be transmitted by inoculation from monkey to monkey. Treponema pallidum has been recovered from the lesions in the lower animals. Thibierge and Rovant succeeded in every case by inoculating the eyelid. Fenger and Landsteiner demonstrated the infectivity of the sperm of man.

Neisser produced syphilis in monkeys from tertiary lesions in man. The old idea that tertiary syphilitic lesions were not potent as inoculating sources was proved wrong. Tertiary lesions do furnish the organisms, but are not so virulent as the primary or secondary lesions. This may be because they do not contain so many treponemata or because the organisms are of mitigated virulence.

Bertarelli has given the disease to rabbits and transmitted it to other rabbits and monkeys from the original animals. He further produced corneal lesions in dogs, sheep, and guinea-pigs. The original animal inoculations were upon the cornea. The latter inoculations have been upon the testicle of the rabbit. Sowade claims to have produced constitutional syphilis in rabbits by inoculation with artificially grown spirochetes. Noguchi, Sowade, Schereschewsky, Hoffmann, and Nakano claim to be able to grow the organism upon artificial media. Noguchi was probably the first to accomplish this feat.

Generalized syphilis will develop in rabbits, if the local primary tissue reactions be suppressed by means of subcurative doses of spirocheticidal drugs (Brown and Pearce from J. W. Klauder).

Viability.—Fortunately for humanity the organism loses its vitality very soon after removal from a viable host. It may maintain its motility for twenty-four hours when isolated if maintained at body temperature. The majority of the organisms soon die. Infected body tissue will show viable treponemata for forty-eight to seventy-two hours when kept at room temperature. Thus, the surgeon must exercise great care in the study of tissues. In fact, the doctor should consider every patient a potential syphilitic and early in his career learn to guard himself against infection. Especially so is this the case with the obstetrician, the laryngologist, and the dentist. The reason there are not more syphilitics than there are is probably because drying promptly kills the organism.

At first the causative protozoöns are localized. Metchnikoff in 1906 inoculated a student and a monkey with syphilitic virus. An hour after inoculating the man the seat of inoculation was rubbed for five minutes with mercurial ointment and the man escaped syphilis. The ointment was not used on the monkey and a chancre developed. The first lesion of syphilis is an infecting area or chancre, which is followed by lymphatic enlargements, eruptions upon the skin and mucous membranes, affections of the appendages of the skin (hair and nails), "chronic inflammation and infiltration of the cellulovascular tissue, bones, and periosteum" (White), and, later, often by gummata. The Spirochæta pallida is demonstrated in recent scrapings from specific lesions. The more contagious the lesion, the more of the organisms are found. The later the lesion, the fewer the organisms found. Spirochetes are always discoverable in the chancre. They can usually be found in the secondary lesions and sometimes in the blood during the secondary stage. Spirochetes are present in tertiary lesions, although in less number than in secondary lesions. The presence of a great number of spirochetes means a malignant case. They tend to disappear under mercurial treatment (see pages 281–283). Syphilitic fever is due to absorption of toxins. Skin eruptions and eruptions on the mucous membranes in the secondary stage arise from local deposit and multiplication of the spirochetes. The spirochetes continue to exist in the body after the cessation of secondary symptoms, and may die out or may awaken into activity, producing *reminders*.

Infection and Reinfection.—Up to about twelve days after the appearance of a chancre a person can still be infected by a fresh exposure to inoculation. After twelve days he cannot be inoculated even with a very large amount of virus (Pinard).

In other words, after twelve days there is immunity to fresh inoculation, but the immunity is not powerful enough to kill the spirochetes already in the body. During the primary stage, from the twelfth day after the appearance of the chancre, and during the secondary stage fresh poison cannot infect, and this is true for a long time after the disappearance of secondary symptoms. As a matter of fact, the immunity generally lasts for life and reinfection is one of the rarest of occurrences. Most supposed cases of reinfection were really instances of a fresh outbreak of an old disease, but a few undoubted cases of reinfection have been reported. Immunity in the primary stage is due to products absorbed from the infected area. Colles's immunity is that acquired by mothers who have borne syphilitic children, but who themselves show no sign of the disease. Profeta's immunity is the immunity against infection possessed by children born of syphilitic parents. Some of these children have never shown signs of disease, but nevertheless they are immune. It is claimed that a person long free from active syphilis, but still immune, can transmit immunity to his children. Tertiary syphilis is not nearly as readily transmissible as secondary syphilis, but it secures immunity.

Transmission of Syphilis.—This disease can be transmitted: (1) by contact with the virus—*acquired* syphilis, and (2) by hereditary transmission—*hereditary* or *congenital* syphilis. The virus cannot enter through an intact epidermis or epithelial layer, and abrasion or solution of continuity is requisite for infection. Syphilis is usually, but not always, a venereal disease. It may be caught by infection of the genitals during coition, by infection of the tongue or lips in kissing, by smoking poisoned pipes, by drinking out of infected vessels, or by beastly practices. Syphilis not due to sexual relation is called *syphilis of the innocent* (*syphilis insontium*). The barber is a danger, and cases have been reported as following razor cuts and particularly the application of the alum stick to arrest bleeding. This stick is used over and over again and dried blood is often to be found upon it. I was consulted by a man who had been thus infected. I have treated two young girls infected by dentists' instruments, a policeman infected by a pipe, a glassblower infected from the blowpipe, a street car driver who got the disease from a borrowed whistle, a police officer who got it striking a prisoner on the mouth and cutting his own knuckle on the teeth, a hospital orderly who infected his nose picking it by a contaminated finger, and 3 physicians who caught it from patients. Schamberg makes a valuable contribution to the accumulation of facts which demonstrate the danger of promiscuous osculations ("Jour. Amer. Med. Assoc.," Sept. 2, 1911). A party of young men and women indulged in a kissing game. One of the young men had a sore lip. As a result of the party 1 man and 6 women developed labial chancres. A girl kissed at another party by the contaminator of the first party got a chancre. The solitary male victim of the first party evidently got the disease by kissing a girl recently kissed by the syphilitic man. Bulkley (Ibid., March 4, 1905) collected 1863 cases following vaccination; 179 following circumcision; 82 following tattooing, and 745 following cupping or venesection. The initial lesion of syphilis may be found on the finger, penis, eyelid, lip, tongue, cheek, palate, tonsil, labium, vagina, anus, nipple, etc. A person may be a host for syphilis, carry it, give it to another, and yet escape it himself (a surgeon may carry it under his nails and a woman may have it lodged in her vagina). Syphilis can be transmitted by vaccination with human lymph which contains treponemata. Vaccine lymph, even after passage through a person with pox, will not convey syphilis if it is free from treponemata. It is not the lymph that poisons, but organisms which the lymph may carry. When syphilis is caught from one of a different race the disease is apt to run a peculiarly severe course. The apprehensions of the sailor regarding "Chinese pox" are probably well founded. John Knott says ("New York Med. Jour.," Oct. 31, 1908): "The Swan Alley sore of the days of Benjamin Travers was immeasurably more severe and more rapidly destructive in its progress than any average London chancre; for it was the fruit of the continuous patronizing culture of the foreign sailors and refugees who were derived from the veriest social and moral dregs of the population of all foreign countries."

Effect of Syphilis Upon Longevity.—This is a difficult matter to determine. Many deaths result from diseases caused by syphilis and yet they are not certified as due to syphilis. My own belief is that the mortality directly due to active syphilis is very small indeed (except in cases of congenital syphilis), but that the mortality due to the results of syphilis is very large. I think that the life insurance companies are justified in requiring those who have had syphilis to pay higher premiums than those who have never had the disease. J. Howard Beard ("Popular Science Monthly," Feb., 1917) says that in 1913 syphilis was directly responsible for 7200 deaths (4600

due to paresis and 2600 due to locomotor ataxia)—that syphilis tends strongly to produce cardiovascular disease—that it kills many infants during the first year of life—that it causes more than one-fourth of all still births—that it is responsible for one-fifth of the admissions to hospitals for the insane—and that "there is an increased mortality rate among syphilitics of 70 per cent., which means a reduction of the average expectancy of life of five and one-half years."

According to the reports of the census statistics this disease causes only 3000 deaths per year in the United States, but these figures are not to be accepted, since many deaths due to syphilis are not reported as such. Brockbank's statistics indicate that the mortality rate in syphilitics is 33½ per cent. above expectation. Many of the following causes of death could probably be directly traced to the ravages of syphilis. Encephalitis, early apoplexy, cerebral softening, angina, heart disease, kidney disease, arterial degeneration, paralysis, tabes, paresis, etc., etc.

It is more common in the negro race. Hazen, Fox and Boas believe it one and a half times more frequent in the hospital cases in the negro than in the white.

Sir William Osler stated that in the British Islands 60,000 persons die each year of syphilis or its sequelæ. Early diagnosis and thorough treatment would prevent most of the mortality. One-fifth of hospital patients who deny syphilis and who exhibited no signs of the disease show a positive Wassermann. As Burke says, they "recruit the ranks of locomotor ataxia, aneurysm, and general paralysis of the insane" ("Lancet," Oct. 11, 1919).

Syphilis and Tuberculosis.—These diseases may often coexist. The syphilis may be severe and the tuberculosis mild, or vice versa. In some cases neither is severe and in some cases both are. As a rule, they have an unfavorable influence on each other. Tuberculosis is not very unusual in the course of secondary syphilis. It is apt to run a rapid course because of the patient's debility and worry and because of the treatment employed for the syphilis. Old syphilitics may develop tuberculosis, but do not seem particularly prone to do so. A child born syphilitic is very apt to become tuberculous, more apt even than is a child born of tuberculous parents. If a patient who is thought to be well of syphilis becomes tuberculous the syphilis may crop out again. If a tuberculous patient becomes syphilitic the tuberculosis usually gets worse. It is well known that syphilitic ulcers may become tuberculous. This sometimes occurs in the larynx. (See chapter on Syphilis in Bonney's treatise on "Pulmonary Tuberculosis.") Bronfenbrenner ("Arch. Int. Med.," 1914, xiv) maintains that tuberculosis is very apt to arise in syphilitics. He found that the sera of 43 per cent. of syphilitics respond to Besredka's tuberculous antigen. Much over one-half of them showed clinical signs of tuberculosis. Letulle found that 19 per cent. of tuberculous patients give a positive Wassermann reaction ("Bull. de l'Acad. de Méd. Paris," 1914, vol. lxxi). Bowman reaches different conclusions and does not think that the incidence of positive Wassermann reaction is greater among the tuberculous than among the general population (A. K. Bowman in "Lancet," Oct. 15, 1923).

Syphilitic Stages.—Syphilis was divided by Ricord into three stages: (1) The *primary* stage—chancre and indolent bubo; (2) the *secondary* stage—disease of the upper layer of the skin and mucous membranes; and (3) the *tertiary* stage—affections of connective tissues, bones, fibrous and serous membranes, and parenchymatous organs. This division, which is useful clinically, is still largely employed, but it is not so sharp and distinct as was believed by Ricord; it is only artificial. For instance, ozena may develop during a secondary eruption, and bone disease may appear early in the case.

Syphilitic Periods.—White divides the pox into the following periods: (1) Period of *primary incubation*—the time between exposure and the appearance of the chancre, from ten to ninety days, the average being twenty-five days; (2) period of *primary symptoms*—chancre and bubo of adjacent lymph-glands; (3) period of *secondary incubation*—the time between the appearance of the chancre and the advent of secondary symptoms, about six weeks as a rule; (4) period of *secondary symptoms*—lasting from one to three years; (5) *intermediate* period—there may be no symptoms or there may be light symptoms which are less symmetric and more general than those of the secondary period: it lasts from two to four years, and ends in recovery or tertiary syphilis; (6) period of *tertiary symptoms*—indefinite in duration. The fifth and sixth periods may never occur, the disease having been cured.

Primary Syphilis.—The primary stage comprises the chancre or infecting sore and bubo. A chancre or initial lesion is an infective granuloma resulting from the epidermic reaction to the virus of syphilis, and is most usually met with upon the genital organs. In men the genital chancre is most commonly seen on the inner layer of the

prepuce in or back of the sulcus. The next most usual sites are upon the glans penis, about the frenum or near the margin of the opening of the foreskin. "The primary sore is found at times at the meatus urinarius, in the skin of the penis, on the groin or the scrotum, or in the urethra" (White and Martin's "Genito-urinary Surgery and Venereal Disease").

In women chancres are most common upon the labia majora and labia minora, are not unusual about the fourchet and clitoris, but are seldom seen in the vagina. A chancre may occur about the os uteri.

Whereas chancre is particularly common in the genital region, it may be met with in other regions, and when it is in another region we speak of it as an *extragenital chancre*.

Extragenital chancre may be found upon the lip, tongue, tonsil, the mucous membrane of the mouth or pharynx, anus, nipple, finger, hand, eyelid, and other regions.

A chancre may be derived from the discharges of another chancre, from the secretion of mucous patches and moist papules, from syphilitic blood, or from the pus or secretion of any secondary lesion. Tertiary lesions may, but seldom do, cause chancre. A chancre appears at the point of inoculation, and is the first lesion of the disease. During the three weeks or more requisite to develop a chancre the virus is continuously entering the system, and when the chancre develops the system already contains a large amount of virus. A chancre is not a local lesion from which syphilis springs, but is a local manifestation of an existing constitutional disease, hence excision is entirely useless. If twelve days or more after the appearance of a chancre we take some of the discharge and insert it at some indifferent point into the person from whom we took it, a new indurated chancre will not be formed. This means that the subject has become immune to inoculation, but the immunity is not a sufficiently powerful factor to kill the spirochetes already in the body. If a syphilitic is inoculated with the discharge of a chancre twelve days or more after the chancre began, no indurated sore develops, but if the chancre furnishing the virus was *irritated*, a *non-indurated* sore may arise at the point of inoculation. If the discharge of a chancre be introduced by inoculation into a healthy person, an indurated chancre follows. Hence we say that primary syphilis is not auto-inoculable, but is hetero-inoculable. In some cases a second infection with another initial lesion has been seen between the twelfth and twentieth day from the appearance of the first chancre. After this period it has not been seen. Some observers, notably Kaposi, of Vienna, advocated the *unity theory*. This theory maintained that both hard and soft sores are due to the same virus, the infective power of the soft chancre simply being less than that of the hard sore, and the possibility of constitutional infection depending not upon differences in the poison, but rather upon differences in the soil and in the local processes. The unicists advocated excision of chancres, soft or hard, to prevent, if possible, constitutional involvement. Syphilographers of today believe in the *duality theory*, which we have previously set forth. This theory took origin from the classical investigations of Basserau and Rollet. The duality theory maintains that the soft sore is caused by a poison different from the one which originates the hard sore, and that a true soft sore never infects the system. The discovery of the micro-organism causing syphilis proves the dualists to be correct.

Syphilis without chancre (*syphilis d'emblee* of the French) is extremely rare. A woman infected through the fetus has no chancre. It is claimed that chancre may be absent in a woman who contracts syphilis by tainted intercourse. In most of these cases there was probably a concealed chancre, although Gaucher says there are positive cases of syphilis in women not preceded by chancres ("Lancet," Feb. 10, 1917). Fournier stated that a deep puncture with an infected needle or knife may be followed by syphilis without chancre. Fordyce and Hazen believe there are 25 proved cases on record.

Initial Lesions.—An initial lesion, hard chancre, or infecting sore never appears until at least ten days after exposure; it may not appear for many weeks, but it usually arises in about twenty-five days. There are three chief forms of initial lesion: (1) A purple patch exposed by peeling epidermis, without induration and ulceration—a rare form; (2) an indurated area under the epidermis, without ulceration—a very common form; and (3) a round, indurated, cartilaginous area with an elevated edge, the area ulcerates, exposing a velvety surface looking like raw ham; it bleeds easily, rarely suppurates, does not spread, and the discharge is thin and watery. This is the *Hunterian chancre*, which is rarer than the second variety, but commoner than the first, and which ulcerates because of dirt, caustic applications, or friction.

Multiple primary chancres are rare, but if they arise, all the sores usually appear to-

gether as a result of the primary inoculation; they seldom follow one another because of auto-infection, although during the first twelve days such a result is possible. A hard sore does not suppurate unless irritated by caustics, friction, or dirt, or unless there be mixed infection with chancroid, pus cocci, or with another form of treponema. Its nature is not to suppurate. The hardness may affect only the base and margins of an ulcer or it may affect considerable areas, but the induration has well-defined margins and feels like cartilage encapsuled, so that it can be picked up between the fingers. This hardness or sclerosis is due to gradual inflammatory exudation into "the tissue at the base of the ulcer and to growth of the nodule" (von Zeissl). It feels distinct from the surrounding tissues, like a foreign body lying in the part. The very characteristic, circumscribed induration which is so common in the male is seldom noted in women. In them there is apt to be softer and less definitely circumscribed induration. A chancre untreated may last many months. An untreated chancre is apt to heal more quickly in a woman than in a man. The induration usually disappears soon after the appearance of secondary symptoms. A copper-colored spot remains, and does not disappear until the disease is cured. Induration may again appear before the outbreak of some distant lesion.

Mixed Infection of Chancre and Chancroid.—Von Zeissl says: "If syphilitic contagion is mixed with pus, a chancre begins as a circumscribed area of hyperemia and swelling, which undergoes ulceration, and does not develop hardness for a period of from ten days to several weeks, and may develop a nodule after the first ulcer has entirely healed." This condition is seen when mixed infection occurs, the chancroid poison being quick, and the syphilitic poison being slow. If chancroid poison is deposited some time after the syphilitic poison has been absorbed, the induration may appear in a few days after the chancroid begins. A soft chancre may arise upon an existing syphilitic nodule and may eat out the induration.

Diagnosis of Chancre.—It is necessary to distinguish a chancre from a chancroid and from ulcerated herpes. A chancroid appears in from two to five days after contact with the poison (always less than ten days); it may be multiple from the start, but, even if beginning as one sore, other sores appear by auto-inoculation; it begins as a pustule, which bursts and exposes an ulcer; the ulcer is circular, has thin, sharp-cut, or undermined edges, a sloughy, non-granulating base, and gives origin to a thin, purulent, offensive discharge which is both auto- and hetero-inoculable. These soft sores have no true sclerotic area, do not bleed, produce no constitutional symptoms, and are apt to be followed by acute inflammatory buboes which tend to suppurate. A chancroid causes pain, and the original ulcer enlarges greatly. A chancre appears in about twenty-five days after inoculation (never before ten days); it is generally single, but if multiple sores exist they usually all appear together, for their discharge is not auto-inoculable after the twelfth day if the sore is not irritated; an auto-inoculation of the products of an irritated chancre may produce a soft purulent ulcer. A chancre begins as a desquamating area, an excoriation, or a nodule; if an ulcer forms, its floor is covered with granulations and it is red and smooth; the discharge is thin and scanty and not offensive; the edges are thick and sloping; it is surrounded by an area of induration, and bleeds when touched; there appear about the same time with the induration or very soon after it indolent multiple, unfused enlargements of the adjacent glands, which rarely suppurate, and it is followed by secondary symptoms. A chancre causes little pain, and after it has existed for a few days rarely shows any tendency to spread. For the first few days after the appearance of a chancre the Wassermann reaction is negative, then, in nearly three-fourths of the cases, it becomes positive. There is, however, dispute as to the value of the reaction in the diagnosis of primary syphilis. Finding the treponemata in the discharge of the sore is proof that the lesion is a chancre. Dark-field studies by an expert are imperative. Puncture of adjacent lymph may obtain fluid containing treponemata. Brown and Pearce found that in rabbits the lymph-nodes harbor treponemata before the appearance of the chancre. A urethral chancre appears in accordance with the usual period of incubation; it is situated near the meatus, one lip of which is usually indurated; the discharge is slight, often bloody, seldom purulent; indurated multiple buboes arise; the sore can be seen, and constitutional symptoms follow.

Herpetic ulceration has no period of incubation; it may follow fever, but usually arises from friction or irritation due to dirt or acrid discharges. It appears as a group of vesicles, all of which may dry up, or some may dry up and others ulcerate, or they may run together and ulcerate. The edges of a herpetic ulcer are in segments of circles; the ulcer is superficial, has but little discharge, and does not have much tendency to

spread; it has no induration; it is painful; it is not accompanied by bubo unless suppuration is marked. Herpes is not followed by constitutional involvement.

A chancre may be mistaken for cancer of the tongue. "A chancre of this region is brownish red, a cancer being bright red. A chancre is soft in the center; a cancer presents uniformity of induration. A chancre gives origin to a thin, purulent discharge, free from blood; a cancer furnishes a non-purulent, bloody discharge. A chancre is soon followed by indolent lymphatic enlargements under the jaw; a cancer is followed by painful enlargements." A cancer is slower in evolution, is not followed by constitutional symptoms, and the lymphatic enlargements are much later in appearing than in chancre. In doubtful cases seek for the organisms or even remove a portion of the edge of the sore and have it studied in the laboratory.

Phagedena.—A chancre or a chancroid may be attacked by phagedena, a destructive form of ulceration which was once common, but at present is rare. The ulceration often spreads on all sides and also deeply into the tissues. In some cases it spreads at the edge in one direction (*serpiginous ulceration*), in some cases sloughing occurs. Phagedena occurs only in the debilitated (anemics, drunkards, strumous subjects, sufferers from diabetes, Bright's disease, etc.; salivation can cause it). The phagedenic ulcer is irregular, with congested and edematous edges, and a foul, sloughy floor.

Chancre Redux.—Some observers believe that reinfection with syphilis is not very unusual. Most authorities maintain that it is very rare. The latter school maintains that the region once occupied by a chancre may, after months or several or even many years, become indurated anew. Occasionally such a relapse occurs during full treatment. Fournier pointed out this fact many years ago. Such a reinduration is called *chancre redux*, or relapsing chancre.

If syphilitic manifestations follow such an induration, we must conclude that reinfection has truly occurred. If they do not follow, and this is the rule, the lesion is not really a chancre, but is probably a gumma in an early stage of development. Mauriac in 1896 made the above statements.[1]

In **syphilitic bubo** anatomically related lymphatic glands enlarge about the same time as or at least very soon after induration of the initial lesion begins. In the very beginning these glands may be a little painful, but the pain is slight and of temporary duration. These enlargements are called "indolent buboes"; they may be as small as peas or as large as walnuts, are freely movable, and very rarely suppurate. The lesion of the glands is hyperplasia of all the gland elements and of their capsules, due to absorption of the virus. If the patient is tuberculous, the bubo is apt to become enormous, lobulated, and persistent. If the chancre appears on the penis, the superficial inguinal and femoral glands enlarge, usually on the same side of the body as the sore. If the sore is on the frenum, both groins are involved. If a chancre appears on the lip or tongue, the bubo is beneath the jaw. Chancre above the lower third of the vagina does not cause primary bubo of the inguinal glands. These buboes may remain for many months; they do not break down unless the sore suppurates or unless the patient is of the tuberculous type; and they finally disappear by absorption or fatty degeneration. About six weeks after buboes have formed in the glands related to the lesion all the lymphatics of the body usually enlarge about the time the secondary eruption appears. The enlargement of the postcervical and epitrochlear glands is diagnostically important. Glandular enlargements persist until after the eruptions have disappeared. In 10 per cent. of cases general adenopathy does not arise.

Glandular enlargement always occurs in syphilis, but the bubo exists in only one-third of the chancroid cases. The bubo of syphilis is multiple, consisting of a chain of movable glands (the glandulæ Pleiades of Ricord); the bubo of chancroid is one inflamed and immovable mass. The bubo of syphilis is indurated, painless, small, and slow in growth; the bubo of chancroid shows inflammatory hardness, is painful, large, and rapid in growth; the first rarely suppurates, the second often does. The skin over a syphilitic bubo is normal; that over a chancroidal bubo may become red and adherent. A syphilitic bubo is not cured by local treatment, but is cured by antisyphilitic treatment and is followed by secondary symptoms. A chancroidal bubo requires local treatment, is not cured by mercury, and is not followed by secondaries. Herpes, balanitis, and gonorrhea rarely cause bubo, but when they do the bubo in each case is similar to that caused by chancroid. A positive diagnosis of syphilis can be made when an indurated sore on the penis is followed by multiple indolent buboes in the groin and by enlargement of distant glands.

[1] H. G. Antony in "Chicago Medical Recorder," April, 1899.

General Syphilis.—As the general lymphatic enlargement becomes manifest a group of symptoms known as *syphilitic fever* may appear. In many mild cases, however, fever is absent and the eruption is the first sign of constitutional involvement. When fever arises the patient usually thinks he has a severe cold, is feverish and restless; complains of headache, lassitude, sleeplessness, and anorexia; his face is pale; he has intermitting rheumatoid pains in the joints and muscles, especially of the shoulders, arms, chest, and back, and these pains change their location constantly and prevent sleep; night-sweats occur and the pulse is quite frequent. The fever usually reaches its height in forty-eight hours, and falls as the eruption develops. The eruption develops usually in from forty-eight to seventy-two hours after the onset of the fever, but may not do so for one week or even more. The fever and the discomfort are worse at night. In type the fever may be intermittent, remittent, or continued. It is usually intermittent. There may or may not be chills, and chills may occur every day or irregularly. Prolonged syphilitic fever with delay in the appearance of the eruption gives rise sometimes to great errors in diagnosis. Prolonged and irregular fever is apt to arise in visceral syphilis, especially syphilis of the liver. In syphilitic fever there are anemia, trivial leukocytosis, and a marked fall in hemoglobin. Syphilitic fever may reappear during the progress of the disease.

Secondary Syphilis.—The phenomena of secondary syphilis are due to treponema virus. They are "local reactions against the spirochetes which have now become disseminated by the blood-stream" (H. G. Adamson in "Lancet," April 6, 1912). During untreated active secondary syphilis the Wassermann reaction is practically always positive. Fluid from a lesion may show the causal protozoans provided the juice has been obtained from the deeper regions of the sore, and that no local or constitutional treatment has been employed. Secondary syphilis is characterized by plastic inflammation, by collection of round cells about the blood-vessels, by the formation of fibrous tissue, and by thickening of tissue. Superficial ulcerations may occur. Structural overgrowths appear (for instance, warts).

Syphilitic Skin Diseases.—*Syphilodermata* (*syphilids*) are due to circumscribed inflammation, and may be dry or purulent. There is no one eruption characteristic of syphilis. This disease may counterfeit any skin disease, but it is an imitation which is not perfect and is never a counterpart. Syphilitic eruptions are often circumscribed; they terminate suddenly at their edges, and do not gradually shade into the sound skin. In color they are apt to be brownish red, like tarnished copper, or ham colored, especially is this the case in late syphilids. Hutchinson cautions us to remember that an ordinary non-specific eruption may be copper colored, especially in people with dark complexions and when it occurs on the legs. Syphilitic eruptions are apt to leave a brownish stain. Early syphilitic eruptions are symmetric. Specific eruptions have an affection for particular regions, such as the forehead, the abdomen and chest, the neck and scalp, about the lips and the alæ of the nose, the navel, anus, groins, between the toes, upon the palms and soles, and the flexor surfaces of the arms and legs. Early secondary eruptions rarely appear on the face or hands. Specific eruptions are polymorphous, various forms of eruption being often present at the same time, so that roseola is seen here, papules there, etc. These syphilids do not cause as much itching as do non-specific eruptions except when they occur upon the scalp, about the anus, or between the toes. The late secondary eruptions tend to an arrangement in curved lines.

Forms of Eruption.—The chief forms of eruption are: (1) erythema, (2) papular syphilids, (3) pustular syphilids, and (4) tubercular syphilids. Besides these eruptions pigmentation may occur (pigmentary syphilid) and blood may extravasate (purpuric syphilid).

Prince A. Morrow does not believe in erecting the vesicular syphilids into a special group. He tells us that vesicles sometimes form on erythematopapular lesions, but their presence is an accident and not a regular phenomenon. So, too, the bullous syphilid is a rare accident in a case, and even when it occurs soon becomes pustular. The pemphigoid syphilid is found almost exclusively in hereditary disease.[1]

1. **Erythema** (*Maculæ*, *Roseola*, or *Spots*).—This eruption usually comes on gradually, crop after crop of spots appearing, and many days passing before an extensive area is covered. Occasionally, however, it arises suddenly (after a hot bath, after taking violent exercise, or after eating an indigestible meal). This eruption consists of circumscribed, irregularly round, hyperemic spots, about ½ inch in diameter, whose color does not entirely disappear on pressure in an old eruption, but does in a recent

[1] Morrow's "System of Genito-urinary Diseases, Syphilology, and Dermatology."

one. The color is at first light pink, but it becomes red, purple, or even brown. In the papular form of erythema the spots are slightly elevated. Erythema is rare upon the face and the dorsum of the hands and feet. It attacks especially the chest and belly, but appears often on the forehead, the bend of the elbow, and the inner portion of the thigh, the neck, and the flexor surface of the forearms and arms. It appears first on the abdomen and last on the legs. Usually erythema follows syphilitic fever, about six weeks after the chancre appears, and the number and distinctness of the spots are in proportion to the violence of the fever. No fever or slight fever means there will be but few spots and they will soon disappear. In rare cases the eruption is very transitory, lasting but a few hours, but it usually continues for several weeks if untreated. It may pass away or may be converted into a papular eruption. Mercury will cause it to disappear in a couple of weeks. In examining for this form of eruption in a doubtful case, let cold air blow upon the chest and belly; this blanches the sound skin and makes clear any discoloration. No desquamation attends the macular eruption, but a brownish stain remains for a variable time after the eruption fades. Erythema means, as a rule, a mild and curable attack. Maculæ may be combined with the next form, constituting a maculopapular eruption.



FIG. 129.—Condylomata (Horwitz).

The maculopapular syphilids are evolved from the macular syphilids. They are slightly elevated, are situated upon hyperemic bases, and the summits of some of them may undergo slight desquamation. A roseolar area may show one or several of these macular papules. They are apt to arrange themselves in segments of circles and are symmetrically distributed. This eruption usually appears early, but may appear late. It may fade and reappear several times in the same patient. The eruption lasts a few weeks.

2. **Papular syphilids,** which are papules or elevations covered with dry skin, may or may not desquamate. If they do desquamate, the process begins over the center. They usually appear from the third to the sixth month of the disease. They may be preceded by fever, and often reappear again and again. They are at first small and red, but become larger and brownish. They are firm in feel and vary in size from the head of a pin to a 5-cent piece or larger. Large, flat papules constitute nummular syphilids. Papules tend to scale. The epiderm becomes thin, red, and glistening, splits in the center and desquamates, and a fringe of epidermis surrounds the desquamated area. This process may be repeated once or oftener. When lenticular papules recur in the late secondary stage they are apt to group themselves in circles limited to particular regions (annular or circinate syphiloderms). They may be present as miliary papules, lenticular papules, moist papules, and papules with marked epidermic proliferation resembling psoriasis (papulosquamous eruption). Papules on fading leave very persistent coppery-looking stains. Papules upon the palms and soles constitute the so-called "palmar and plantar *psoriasis*," which appears from three months to one year after the appearance of the chancre. Papules just below the line of the hair on the forehead constitute the *corona veneris*. Papular syphilids appear especially upon the forehead, the neck, the abdomen, and the extremities. The papular or squamous syphilid of the palms and soles begins as a red spot, which becomes elevated and brownish; the epidermis thickens and is cast off, and there then remains a central red spot surrounded by undermined epidermis. If papules are in regions where they are kept moist (as about the anus), they become covered with a sodden gray film, which after a time is cast off and leaves the papule without epidermis. The

sodden papules are called *flat condylomata*, moist or humid papules or plates (Fig. 129). Papules which are at first small may become large. The small or miliary papules constitute *syphilitic lichen*. The lenticular papules are most common, and strongly tend to scale off. The papular syphilids give a worse prognosis for the constitutional disease than do spots. The syphilitic negro is particularly apt to develop the annular syphiloderm.

3. **Pustular syphilids** arise from papules. The condition is known as *acne* when the apex of the papule softens, *impetigo* when the whole papule suppurates, and *ecthyma* or *rupia* when the corium is also deeply involved. Vesicles occasionally precede pustules. The pustular eruption appears a number of months after infection and later than the papular. The pustular eruption gives a very bad prognosis for the constitutional disease. Rupia is formed by a pustule rupturing or a papule ulcerating, the secretion drying and forming a conical crust which continually increases in height and diameter, while the ulceration extends at the edges. When the crust is pulled off there is seen a foul ulcer with congested, jagged, and undermined edges. Rupia may be secondary or tertiary, and it invariably leaves scars. It appears only after at least six months have passed since the chancre began. Secondary rupia is symmetric. Tertiary rupia is asymmetric.

4. **Tubercular syphilids** are greatly enlarged papules intermediate between ordinary papules and gummata.

Diagnosis Between Secondary and Tertiary Syphilids.—A secondary eruption is distinguished from a tertiary eruption by the following: the first tends to disappear, the second tends to persist and to spread; the first is general and symmetric, the second is local and asymmetric; the first does not spread at its edge, the second tends to spread at its edge, and this tendency, which is designated *serpiginous*, produces an ulcer shaped like a horseshoe (Jonathan Hutchinson). Secondary lesions appear within certain limits of time, develop regularly, and are dispersed by mercurial treatment. Tertiary lesions appear at no fixed time, develop irregularly, and are not cleared up by mercury.

Affections of the Mucous Membranes.—The chief lesions in syphilitic affections of the mucous membranes are mucous patches, warts, and condylomata. The first phenomena of secondary syphilis are, as a rule, symmetric ulcers of the tonsils, painless, of temporary duration, and superficial (Hutchinson). The borders of the ulcers are gray and the areas are reniform in shape. Catarrhal inflammations often occur. Eruptions appear on the mucous membranes as upon the skin. *Mucous patches* are papules deprived of epithelium; they are gray in color, are moist, and give off an offensive and virulent discharge. They usually appear as areas of congestion, swelling, and abrasion of the epidermis upon the lips, palate, gums, tongue, cheeks, vagina, labia, vulva, scrotum, anus, and under the prepuce. A moist papule of the skin is really a mucous patch. These patches, which are always circular or oval, are among the most constant lesions of the secondary stage, appearing from time to time during many months. If a patch has the papillæ destroyed, it is called a *bald patch*. If the papules present hypertrophied papillæ fused together, there appear enlargements with flat tops, termed *condylomata* (Fig. 129); if the papillæ of the papules hypertrophy and do not fuse, the growths are called *warts*. Mucous lesions of the mouth are commonest in smokers and in those with bad or neglected teeth. Hutchinson says that persistence in smoking during syphilis may cause leukomata (leukoplakia) or persistent white patches. The vagina and lips of the vulva during the secondary stage are often covered with mucous patches. The uterus may contain mucous lesions which poison the uterine discharge. The larynx may suffer from inflammation, eruptions, and ulceration (hence the hoarse voice which is so usual). The nasal mucous membrane may also suffer. The rectal mucous membrane may be attacked by patches, and so may the glans penis, the inner surface of the prepuce, and the urethra. Early in the secondary stage in some very rare cases there is a slight mucopurulent urethral discharge, and examination with an endoscope shows redness of the mucous membrane of the anterior urethra. The discharge is contagious. The condition may be followed by constriction of the urethral caliber. Distinct ulceration may take place.

Affections of the Hair.—In syphilis the hair is usually shed to a great extent. This loss may be wide-spread (beard, mustache, hair of head, eyebrows, pubic hair, etc.) or it may be limited. The appearance is usually moth-eaten. Complete baldness sometimes ensues, but it is rarely permanent. The hairs of the head are first noticed to come out on the comb; on pulling them they are found loose in their sheaths—so loose that Ricord once said "a man would drown if a rescuer could pull only upon the

hair of the head." The falling out of the hair, which is known as *alopecia*, usually begins soon after the fever or about the time of the eruption, but it may be postponed until much later. The skin of a syphilitic bald spot is never smooth, but is scaly. The hair may thin generally, baldness may appear in twisting lines, or it may be complete only in limited areas. Alopecia results from shrinking of the hair-pulp, death of the hair, and casting off of the sheath.

Affections of the Nails.—*Paronychia* is inflammation and ulceration of the skin in contact with a nail and extending to the matrix. The nail is cast off partially or entirely. *Onychia* is inflammation of the matrix, and is manifested by white spots, brittleness or extended opacity, twisting, and breaking off of the nail. The parts around are not affected. The damaged nail drops off and another diseased nail appears.

Affections of the Ear.—Temporary impairment of hearing in one or both ears is not uncommon in syphilitic affections and is due to involvement of the eighth nerve. This nerve is probably involved more often than any other nerve. Rarely, permanent symmetric deafness is produced. Ménière's disease is sometimes caused by syphilis.

Affections of the Bones, Bursæ, and Joints.—In syphilis there may be slight and temporary periostitis. Pain racks various bones, the bones become tender, and the pain is worse at night (*osteocopic pains*). Osteoperiostitis usually arises with or after the onset of the secondary eruption, but in rare instances precedes the syphilids. The bones usually involved are the tibiæ, clavicles, and skull. Intense headache may be due to periostitis of the inner surface of a cranial bone. Local periostitis may form a *soft node*, which by ossification becomes a *hard node*. Pain like that of rheumatism may affect the joints. It is not increased by motion and is worse at night. Such pains are by no means uncommon and in some cases are very severe. The joints are not stiff except perhaps on rising. Paton reminds us that such arthralgia is an early symptom and may actually antedate the secondary eruption ("Brit. Med. Jour.," Nov. 28, 1903). More common than the above condition is synovitis, acute or chronic. It often comes on rapidly without other symptoms and is announced by swelling, tenderness, and pain. In some cases the pain is severe, and the patient is feverish or actually ill. Such cases constitute what is called *syphilitic rheumatism*, but the profuse sweats of acute rheumatism are absent, the heart is never attacked, the skin is not red, the fever is not high, and the condition is not migrating (Ibid.). Hydrarthrosis may arise in the knee as a sequence of either of the above conditions, or, late in the secondary stage, it may arise without such an antecedent trouble (Paton). Symmetric synovitis has been noted. Secondary syphilitic disease of bone, periosteum, and joint lasts only a short time and is never destructive. Secondary bursitis is mentioned on page 684.

Affections of the Eye.—*Iritis* is the commonest eye trouble which may arise during secondary syphilis. It appears from three to six months after the appearance of the chancre, and begins in one eye, the other eye soon becoming affected. The symptoms are a pink zone in the sclerotic, a congested, red or muddy iris, irregularity of the pupil accentuated by atropin, the existence of pain and photophobia, and sometimes hazy or even clouded pupil. Rheumatic iritis causes much pain and photophobia, syphilitic iritis comparatively little; there is less swelling in the first than in the second; the former tends to recur, the latter does not. Iritis is usually recovered from, good vision being retained. Diffuse retinitis and disseminated choroiditis never occur until a number of months have passed since the infection. The symptoms are failure of sight, muscæ volitantes, and very little photophobia. The diagnosis of retinitis and choroiditis is made by the ophthalmoscope.

Affections of the Testes.—Syphilitic Sarcocele.—This is a very common lesion. It occurs in over one-third of syphilitics. The testicle enlarges because of plastic inflammation. Both glands usually suffer, but not always. Fluid distends the tunica vaginalis. The epididymis escapes. The testicle is not the seat of pain, is troublesome because of its weight, and has very little of the proper sensation on squeezing. The plastic exudate is generally largely absorbed, but it may organize into fibrous tissue, the organ passing into atrophic cirrhosis (chronic interstitial orchitis). In some late cases a gumma adheres to the skin, opens, and forms a sinus. In such a case the testicle is destroyed.

Nervous System.—Syphilis of the nervous system may arise as early as the sixth month after infection, although the nervous system is far more apt to suffer in the intermediate period or in the tertiary stage. Actual deposits in the brain or cord do at times take place in the secondary stage. These deposits call for prompt and active treatment or they will cause permanent damage. Such lesions are particularly common

in untreated cases and in cases in which secondary manifestations were slight or perhaps even unobserved.

The Albuminuria of Secondary Syphilis.—It is not very unusual for nephritis with albuminuria to develop early in the secondary stage. There may be the ordinary symptoms of nephritis, but in many cases there is albuminuria and nothing more. Large amounts of albumin run away from the kidneys and the high percentage of albumin in the urine is a notable feature. Many of these cases recover completely, some become chronic, and in some death occurs. It seems probable that mercurial treatment is, in part at least, responsible for some of these cases. The syphilitic poison causes the others. Those in which there is albuminuria and nothing more are due to syphilis rather than to mercury. Those in which there is dropsy were aggravated and perhaps caused by mercury (Fleissinger in "Journal des Practicens," August 3, 1907, and Stokes in "Jour. Amer. Med. Assoc.," 1916, lxvi).

Intermediate Period.—Secondary lesions cease to appear in from eighteen months to three years. In the intermediate period no symptoms may appear, yet the disease may be still for some time latent and not cured. The Wassermann reaction may be negative. Symptoms may arise, from time to time. These symptoms, which are called *reminders*, are not so severe as tertiary symptoms, are apt to be symmetric, and do not closely resemble secondary lesions. Among the reminders we may name palmar psoriasis and sarcocele. Sarcocele in this stage is bilateral and rarely painful. Bilateral indolent epididymitis occasionally occurs. Sores on the tongue, a papular skin eruption, and choroiditis may arise. Gummata occasionally occur in this stage, but they are apt to be symmetric and non-persistent. Symmetric superficial dactylitis may occur. Arteritis may develop, beginning in the intima or adventitia, and causing, it may be, aneurysm, thrombosis, or embolism. Obliterative endarteritis may cause gangrene. Vascular changes are notably common in the vessels of the brain, and thrombosis may occur, in which case paralysis usually comes on gradually, preceded by numbness, although sudden paralysis may take place. The paralysis may be limited, extensive, transitory, or permanent. The nervous system often suffers in this stage (anesthetic areas and retinitis). The viscera are often congested and infiltrated (liver, spleen, kidneys, and lungs).

Tertiary Syphilis.—This stage is not often reached, the disease being cured before it has been attained. About 85 per cent. of syphilitics escape it entirely. In this stage there is greatly impaired nutrition the result of the prolonged disease. Until recently it was generally thought that tertiary lesions were not contagious. This opinion is now known to be false. They are not nearly so contagious as the primary lesion, as secondary lesions, or as blood of the secondary stage, but they are contagious, though feebly so. A tertiary lesion contains spirochetes, but not nearly so many as a lesion of the secondary stage. The primary lesion disappears, sooner or later, without treatment, the secondary stage tends ultimately to spontaneous disappearance, but tertiary lesions tend to persist and to recur. Tertiary lesions may be single or may be widely scattered; when multiple they are not symmetric except by accident. These lesions may attack any tissue, even after many years of apparent cure; they all tend to spread locally, they all leave permanent atrophy or thickening, they all tend to relapse, and a local influence is often an exciting cause. Tertiary syphilis may cause marked anemia and it is sometimes the cause of pernicious anemia (Dumas and Pirrot in "La Presse Médicale," xv, Nos. 39 and 40).

Tertiary skin eruptions are liable to ulcerate. Various eruptions may occur: papular syphilids, pustular syphilids, gummatous syphilids, serpiginous syphilids, and pigmentary syphilids. The characteristic syphilid is *rupia*, which is formed by a pustule rupturing or a papule ulcerating. A brown or black crust forms because of the drying of the discharge, ulceration continues under the crust, new crusts form, and, as the ulcer is constantly increasing peripherally, the new crusts are larger in diameter than the old ones and the mass assumes the form of a cone. An ulcer which has destroyed the deeper layers of the skin is exposed by tearing off the crust. On healing, a rupial ulcer always leaves a permanent scar.

Serpiginous ulcers (Fig. 130) are common in tertiary syphilis, and are especially common about the knees, nostrils, forehead, and lips. Serpiginous ulceration is spoken of as *syphilitic lupus*. It is preceded by a wide-spread, brown colored, nodular, cutaneous infiltration. The nodules suppurate, run together, crust, and produce an ulcer which spreads rapidly and assumes the shape of a horseshoe.

The **gumma** (Fig. 132) is the typical tertiary lesion. In some cases there is a solitary gumma; in others, there are two or three or even many gummata. A gumma

is a mass of granulation tissue, grayish-yellow in color, containing many cells and few fibers. Organization of the gumma fails to take place because of a want of sufficient blood-supply, the cellular mass is apt to undergo caseation, and when this occurs an ulcer forms. One portion of the mass may caseate, another portion may become fibrous. In some cases the entire gumma becomes fibrous. A gumma varies in diameter from 1/8 inch to 2 or 3 inches, presents a center of gummy degeneration, a surrounding area of immature fibrous tissue, and an outer zone of embryonic tissue and leukocytes. A gumma, when it is spontaneously evacuated, exhibits a small opening



FIG. 130.—Serpiginous ulcers.

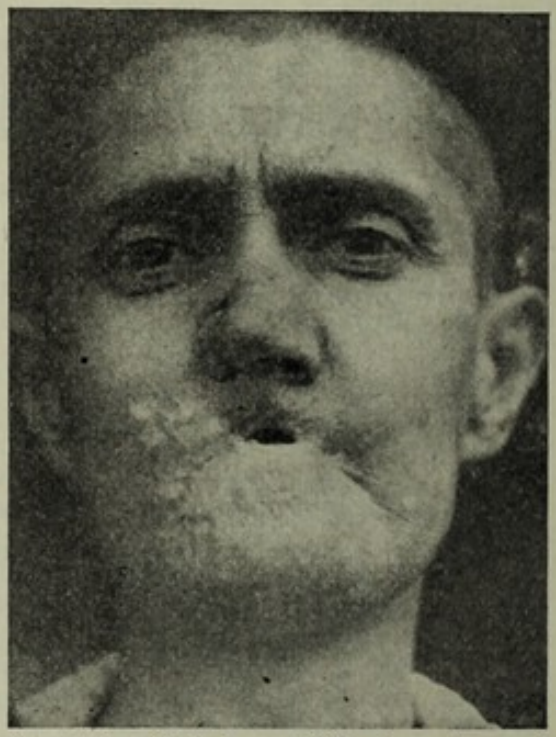


FIG. 131.—Healed syphilitic ulcers (case of Dr. Jos. J. Sweeney, Toledo, Ohio).

or many openings with very thin red and undermined edges; the ulcer is slow to heal, and forms a thin scar, white in the center, but pigmented at the margins and usually depressed (Jonathan Hutchinson. Jr.). The *gummatous ulcer* is deep, circular in outline, with undermined edges and an uneven floor, which is usually covered with a thick, white, adherent slough. Sometimes there is no slough, but an extensive area

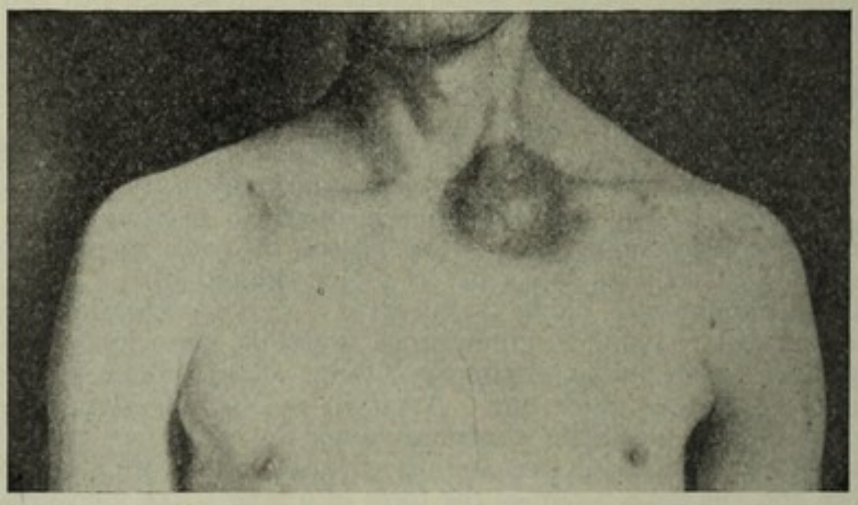


FIG. 132.—Gumma of the clavicle.

is infiltrated. A gummatous ulcer may coalesce with one or more adjacent ulcers. The discharge is scanty and tenacious. These ulcers are often seen upon the legs, and when once healed seldom recur. A gumma in the internal organs may become a fibrous mass. Gummata form in the skin, subcutaneous tissues, submucous structures, muscles, tongue, joints, bones, bursæ, testes, spinal cord, brain, and internal organs. In tertiary syphilis an inflammation may not form a circumscribed gumma, but, instead, may produce a diffuse degenerating mass. This type of inflammation,

which is seen in bones, is called "gummatous." In the nasal cavity a gumma is rapidly followed by an ulcer and there is a strong tendency to necrosis of the vomer and sometimes of the turbinated bones. This condition produces a foul discharge and is known as syphilitic *ozena*. Advanced intranasal necrosis causes the nose to "fall in," which is a hideous deformity (Fig. 133). The commonest laryngeal lesion is multiple ulceration following minute gummata. A healing gumma in a mucous canal such as the rectum or larynx causes thickening and stricture. Tertiary syphilis is a common cause of amyloid degeneration (page 171) and the most frequent cause of arterial and nervous sclerosis.

Various Lesions.—Hutchinson enumerates the lesions of tertiary syphilis as follows: *Periostitis*, forming nodes or causing sclerotic hypertrophy, suppuration, or necrosis; gummata in various parts; disease of the skin of the type of rupia or lupus; gumma or inflammation of the tongue, causing sclerosis; structural changes in the nervous system, causing ataxia, ophthalmoplegia externa and interna, general paresis, optic atrophy, and paralyses of cerebral nerves; amyloid degenerations; and chronic inflammation of certain mucous membranes (of the mouth, pharynx, vagina, rectum, etc.), with thickening and ulceration. Smoothness and hardening of the base of the tongue, due to fibrous changes in the lymphoid follicles, is a very valuable sign of late syphilis. It was called by Virchow *indurative atrophy*. Gummatous infiltration of the eyelid is sometimes observed. Gummatous osteoperiostitis of the vertebræ may arise, and this may be associated with disease of the membranes or cord. Syphilitic inflammation of vertebræ is called syphilitic spondylitis. Unilateral enlargement of the epididymis is sometimes noted, the mass feeling heavy, aching a little, but not being very tender. Unilateral sarcocele may be met with. Gummata may arise in the iris, the larynx, the rectum, and the nose.

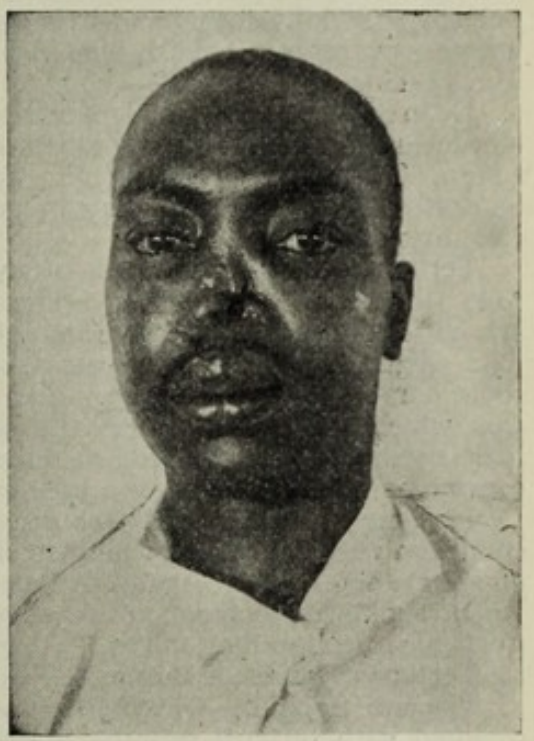


FIG. 133.—Destruction of the nose in tertiary syphilis.

Tertiary Syphilis of Bones.—The bones particularly liable to disease are the skull, sternum, clavicle, nasal septum, and tibia. There may be productive periostitis. This arises in the deeper layer of the periosteum. It may be one limited area, several, or many areas; may be circumferential, or may involve the length of the shaft of a long bone. In most cases the bone is also involved (osteoperiostitis). The bone thickens under the periosteum or toward the medullary cavity, or in both directions. The cortical or the spongy substance may be the seat of disease. The lesion may be small and circumscribed or extensive. The thick bone becomes dense (sclerosis). In a protracted case in a long bone overgrowth may occur. If growth occurs in the direction of the long axis, the bone will become bent. As a matter of fact, each of the above lesions is a gumma which undergoes resolution or organization. Syphilitic periostitis is a superficial gumma. Syphilitic osteitis is a deep gumma. Syphilitic osteomyelitis is a deep gumma which has not undergone resolution or organization. The bone about a deep gumma thickens. There is usually but one gumma in a bone, but there may be two or several. A large gumma weakens bone so that fracture may take place from slight force. Caries or necrosis may arise. A sequestrum seldom forms unless there is mixed infection. Periostitis affects particularly the superficial bones (tibia, clavicle, sternum, ulna, etc.). It begins in the deeper layer of the periosteum, swelling arises, gummy changes occur, and the bone beneath is more or less destroyed. In the skull the bone may be completely penetrated. Not unusually syphilitic periostitis arises at the seat of a trivial injury. Syphilitic osteomyelitis occurs particularly in the phalanges and skull. Syphilitic osteitis of the vertebræ is a source of confusion in diagnosis. It occurs particularly in adults. It causes pain and stiffness of the back, which, unlike what occurs in tuberculosis, are aggravated by rest in bed. The Wassermann test may suggest the diagnosis. If an abscess

forms and opens the discharge is scanty, either thick or gummy, and contains spirochetes. There are no large sequestra and the sinus soon heals (Editorial in "N. Y. Med. Jour.," Sept. 9, 1916). An area of syphilitic bone disease may undergo repair, osteosclerosis usually and osteoporosis sometimes resulting. After perforation of the skull there is no bony repair. Syphilis of the bones of the nose is necrosis resulting from gummatous ulceration. The *x*-ray picture is usually most valuable in reaching a diagnosis of tertiary syphilis of bone. A syphilitic lesion, if visible, usually has a distinct outline. A pure periosteal mass may not show at all. The bone lesion shows the deep shadow of thickening throughout or, as in the gumma, thickening around a much lighter region. Tuberculosis produces absorption of bone and light areas in the plate. Sarcoma of the periosteum is always evident. Sarcoma has not a distinct margin like syphilis. If a syphilitic breaks a bone he will not obtain sound repair unless given specific treatment.

Tertiary Dactylitis (see Fig. 134).—This condition is a gummatous formation in a finger or toe. There is a superficial form in which the deposit begins in the subcutaneous tissue and subsequently involves the joint ligaments. In a toe the entire digit is usually involved, in a finger the condition is usually limited to the proximal phalanx. Superficial dactylitis is a very early tertiary phenomenon. A painless swelling gradually forms and it is most distinct on the dorsal surface. The swelling becomes purplish or reddish-blue in color and the joint becomes preternaturally mobile. The swelling may ulcerate.

Deep dactylitis is a very late tertiary manifestation and is osteomyelitis or periostitis of the fingers or perhaps of the toes. One or more proximal phalanges are apt to suffer. The skin seldom suffers. Caries and necrosis may occur and the joint may be destroyed, or the bone may be partially absorbed and shortened from dry caries. Ulceration of the skin is rare.

Tertiary Syphilis of Joints.—(See the careful study of E. Percy Paton in "Brit. Med. Jour.," Nov. 28, 1903.) The knee-joint is most commonly affected. Chronic synovitis may arise with considerable or even great swelling (hydrarthrosis), trivial pain, slight functional impairment, some thickening of the synovial membrane, and some harshness or grating on movement. Gummatous synovitis may arise, a condition which sometimes follows the ordinary synovitis, but more often causes very little swelling. The synovial membrane exhibits irregular areas of thickening and the symptoms resemble those of a tuberculous joint (Paton).

In some syphilitic joints the disease begins in the bone and cartilage. In such a condition there is rigidity, marked limitation of movement, pains, not often severe, and some deformity. Again, as Paton points out, a joint may be involved by an adjacent syphilitic area, synovitis arising, or, if a gumma breaks into a joint, secondary pyogenic infection may follow. Ankylosis may follow joint syphilis.

Tertiary Syphilis of Bursæ.—(See page 684.)

Visceral Syphilis.—Amyloid changes may occur in any of the viscera of an individual with tertiary syphilis, and such changes may be found in people in whom suppuration never occurred. The lungs may contain gummata or may undergo fibroid induration (*syphilitic phthisis*). The commonest condition is unilateral and fibroid in character. It involves a portion of one lobe, or, more rarely, portions of several lobes (Landis and Lewis in "Amer. Jour. Med. Sciences," August, 1915). An area of consolidation may arise at one apex, but it is rare in this situation.

This latent pulmonary syphilis is readily mistaken for tuberculosis. There may or may not be blood-streaked expectoration. Syphilitic phthisis is often a non-febrile malady, but there may be slight rises of temperature. The expectoration may or may not be blood-streaked, but it does not contain the bacilli of tuberculosis. Night-sweats and diarrhea are unusual, and emaciation and exhaustion are less decided than in tuberculosis. Nodes may perhaps be found on ribs, clavicle, or tibia or nodules in the epididymis. Specific treatment cures the case. Gummata may form in the heart, liver, spleen, or kidneys. Disease of the aorta is quite common. It is the rule in cardiac syphilis to find a diastolic murmur in the aortic area. The capsule and fibrous septa of the liver may thicken, the organ being puckered by contraction. The liver may enlarge greatly and be the seat of pain. In such cases prolonged elevation of temperature may be noted. Ascites is common and jaundice may arise. Albuminuria may occur in tertiary syphilis. It may be caused by fibroid changes in the kidneys, by the formation of gummata, or by amyloid degeneration. Its occurrence should be watched for. Mercury and iodid of potassium have been regarded as causative of albuminuria in some cases. When albuminuria is associated with arterial disease and

elevated tension, the condition is to be regarded as parasyphilitic rather than syphilitic. Nephritis in early life is not uncommonly syphilitic.

Syphilis may cause disease of the stomach, and probably does so more frequently than was formerly supposed, because it is difficult to distinguish from more common diseases. The condition may be gummatous infiltration of the walls of the stomach, multiple and minute gummata, ulcerations resulting from breaking down of gummata, or syphilitic endarteritis of the gastric vessels. When ulcers heal, cicatricial contraction results. Sometimes a large mass can be palpated. The symptoms last for years. There is pain after eating, but hemorrhage does not occur unless ulcer forms. Syphilitic ulcers and gummata of the stomach may be cured by efficient antisyphilitic treatment. Like lesions may form in the intestines. Flexner, Fränkel, Fournier, and others have discussed this subject.[1]

Nervous syphilis may be manifested by disorders of the brain, cord, or nerves. It is rare after severe secondaries, and is most common when secondaries were light or so trivial as to have escaped observation. Severe secondaries seem to cast off, mitigate, or exhaust the poison. Nervous syphilis may result directly from the specific disease, and such lesions are truly syphilitic. Paresis, locomotor ataxia, myelitis, meningitis, neuritis, and arteritis may be directly due to the presence of spirochetes causing the formation of syphilitic tissue. Nervous syphilis may result indirectly from the specific disease, but not be directly caused by spirochetes having formed syphilitic tissue. Such lesions are called *parasyphilitic*. For instance, a gumma of the brain is a true syphilitic lesion, but locomotor ataxia following syphilis is often a parasyphilitic lesion. As a matter of fact, the spirochetes may act directly on nerve matter without forming syphilitic tissue. Such a condition, though degenerative, is syphilitic, not parasyphilitic. Syphilitic lesions are improved or cured by antisyphilitic treatment, parasyphilitic conditions are not. The diagnosis between syphilitic and parasyphilitic lesions is often impossible without the therapeutic test (mercury, salvarsan). The former are far more apt to show positive Wassermann reactions than the latter. We must remember that brain syphilis is usually a late phenomenon (from one to thirty years after infection). The lesion may be gumma of the membranes (tumor), gummatous meningitis, arterial atheroma, or obliterative endarteritis. A gumma may eventuate in a scar, a cyst, or a calcareous mass. The symptoms of brain syphilis depend on the nature, seat, and rate of development of the lesions. It is to be noted that syphilitic palsy is apt to be limited, progressive, and incomplete. Epilepsy appearing after the thirtieth year is very probably specific if alcohol as a cause can be ruled out. Persistent headache, tremor, insomnia or somnolence, transitory, limited, and erratic palsies, unnatural slowness of utterance, amnesia, vertigo, and epilepsy are very suggestive of syphilis. Sudden ptosis is very significant; so is sudden palsy of one or more of the extrinsic eye muscles. In syphilitic insomnia the patient cannot get to sleep at night for a long while, but when he once gets to sleep he reposes well. The type of insanity which is most apt to arise is general paralysis, and it is not curable. Most paretics have a syphilitic history and practically all will show a Wassermann reaction. Spinal syphilis may cause sclerosis (a condition like Landry's paralysis), softening, and tumor. Neuritis is not uncommon in syphilis.

The Serum Diagnosis of Syphilis.—Syphilis causes changes in the blood-serum. Various colloidal materials cause floccules to form in syphilitic blood. Unfortunately this test is unreliable. It may fail to occur in syphilitic blood and may at times be noted in non-syphilitic blood. The most valuable test is the *complement-fixation test* known as *Wassermann's test*. This test can only be employed in institutions possessed of the best laboratory facilities. It is technical in the extreme. In order to understand it certain facts must be known.

Every normal serum contains an activating material known as *complement*, and complement is destroyed by heat. When bacteria or alien corpuscles are injected into a living animal, the tissues of that animal react and *amboceptor* is formed. Amboceptor includes all antibodies. Amboceptor brings together complement and the bacterial cell and it is not destroyed by heat. If we inject the corpuscles of sheep's blood into a rabbit, amboceptor forms and appears in the rabbit's serum. Amboceptor unites with the complement and with alien corpuscles and the sheep's corpuscles are dissolved, and the blood of the rabbit now contains a distinct excess of amboceptor. If some of this blood is drawn and the serum is placed in a test-tube, it will dissolve in the tube corpuscles of sheep's blood if they are added to it. If, however, the rabbit serum

[1] See editorial in "Jour. Amer. Med. Assoc.," March 24, 1900, and Roudnitzky, quoted in "Progressive Medicine," June, 1908, from "Prakt. Vratch," August and September, 1907.

is heated for one-half hour to 50° C. before being placed in a test-tube, the heat destroys the complement, and then the rabbit serum will be unable to dissolve the corpuscles of sheep's blood if they are added, because amboceptor without complement is incapable of effecting the solution.

If, however, after destroying the complement by heat, any other serum is added, the added serum furnishes the necessary complement and the mixture is now able to dissolve sheep's corpuscles.

On these facts the serum diagnosis of syphilis depends.

Wassermann proved that if an extract made of a syphilitic organ is placed in the serum of a syphilitic individual, the amboceptor or antibody will unite with the complement and the organ extract, although the union cannot be recognized by inspection. In order to be able to identify the occurrence of such a union a process must be gone through.

The serum of the patient thought to be syphilitic is heated and complement is thus destroyed. It is then mixed with the organ extract, which unites with the amboceptor of the serum, one arm of the amboceptor being still unsaturated and open for union. Guinea-pig serum is now added to furnish complement. If the patient is syphilitic, the serum complement just added will unite with the unsaturated arm of the antibody or amboceptor. To find out if this has taken place we add the heated serum of a rabbit, which will destroy sheep's corpuscles if fresh serum is added to it.

"Sheep's corpuscles are also added. If the complement contained in the guinea-pig serum that was added was taken up or united with by the syphilitic antibody, there will be none left over, and consequently the added sheep's corpuscles will not be dissolved. If, however, the serum was not syphilitic, the complement will not have been taken up, but will be left over for union with the hemolytic amboceptor of the inactivated rabbit serum, which later unites with the blood-corpuscles, and the combination causes the solution of the latter" (Wm. J. Butler, "N. Y. Med. Journal," Jan. 30, 1909).

The test is usually made with blood of the suspected individual, but may be made with cerebrospinal fluid withdrawn by lumbar puncture. The test can be made with milk taken from the breast of a lactating syphilitic.

Major Harrison (quoted by D'Arcy Power in "Brit. Med. Jour.," Dec. 7, 1912) applied the test in 489 cases. It was positive in 71.8 per cent. of cases of primary syphilis, in 90 per cent. of cases of secondary syphilis, and in 83.5 per cent. of cases of tertiary syphilis. It was present in 50 per cent. of those in a stage of latency. In paretics it was found in over 80 per cent. of cases; in tabetics in over 50 per cent. of cases. It does not prove active syphilis and may only mean that a person has had syphilis.

If the test indicates syphilis we say it is positive. If it does not indicate the disease we say it is negative. We indicate the emphasis of the positive reaction by saying it is plus 1, 2, 3, or 4 as the case may be. The test is extremely valuable, but is not infallible. A strong positive test twice obtained indicates the existence of syphilis unless the patient has yaws, leprosy, rat-bite fever, scarlatina, noma, relapsing fever, sleeping sickness, diabetes with acidosis, malaria in the febrile stage, or perhaps pellagra. In each of the above-named conditions a positive reaction can be obtained. A positive reaction can be obtained in blood taken from a non-syphilitic patient under ether or chloroform (Boas). Early in the stage of initial lesion the test is negative. Sometimes the test is negative in persons obviously and even violently syphilitic. In about one-fifth of cases the test becomes negative after the secondary stage. A test may be negative for a time and then become positive; hence one negative test cannot be taken as proof that syphilis is absent. A negative Wassermann does not prove that syphilis is absent, unless it is constantly negative and the patient is not taking mercury. In latent stages of syphilis the reaction often becomes negative for a considerable time. Active mercurial treatment or injections of salvarsan should cause a positive reaction to become negative. The earlier mercury is given in a case of syphilis, the sooner is a negative reaction obtained.

Wassermann's test may enable us to be sure of the diagnosis before the appearance of secondaries. A positive reaction indicates that the poison is active and calls upon the physician to apply active treatment. This should be the rule no matter how long it has been since there were any external manifestations of the disease. Wet nurses should be tested by this method before being allowed to assume charge of an infant.

Noguchi's Cutaneous Reaction ("Jour. of Exper. Med.," 1911).—Noguchi gives the name luetin to an emulsion of the dead cells of a pure culture of Spirochæta pallida.

Rubbed or injected into the skin it produces a marked reaction in tertiary and hereditary syphilis, but seldom gives a reaction in primary or secondary syphilis (Noguchi in "Jour. Amer. Med. Assoc.," 1912, vol. lviii). The reaction is manifested by the formation of a pustule. The value of the test is not as great as was hoped. It is of use only in late syphilis—positive results are sometimes obtained when syphilis is not present—and a negative test does not prove that syphilis is absent ("The Third Great Plague," by John H. Stokes).

Diagnosis by Finding the Treponema Pallidum.—This method is of the greatest value. The organism, if carefully searched for, is found in chancre, in all the lesions of early secondary syphilis, and in lesions of congenital syphilis. Spirochetes, though comparatively few, are found in tertiary lesions. Hence, the old idea that tertiary lesions are not contagious must be cast aside. They are not found in lesions other than syphilis. Spirochetes can be detected in a few minutes in material from a syphilitic papule or sore. Williams ("Archives of Diagnosis," Jan., 1910) scrapes the papule or sore lightly with a scalpel, drops a little warm salt solution on it, withdraws some of the salt solution and examines it at once.

Prevention of Syphilis.—Various plans have been proposed for the diminution or extinction of syphilis in communities. As yet no method has been decided upon as certain. Serious bars to intelligent action are the criminal prudery of many and the unnatural stupidity of many others. The facts about syphilis should be known, not hidden. People should be educated in order that they may employ proper safeguards. The professional moralist would undertake to club out of existence ideas, habits, occupations which seem to breed the disease, but to succeed in this he must begin by abolishing certain fundamentals of human nature. Desirable as it would be to prevent syphilis entirely, that is at present impossible. Promiscuous sexual intercourse and prostitution are still with us, and destined, for some time at least, to remain. Compulsory notification and detention are advocated by many. Certainly the system could be applied only to those in active stages of the disease. To lock up everybody with a positive Wassermann reaction would shrink the producing population to a dangerous degree. Mere notification could not accomplish much good. The adoption of the above suggestions of well-meaning individuals would cause victims to conceal the disease and go for relief to quacks who would destroy them. If a man is formally registered as a syphilitic he will all of his life be threatened by the trailing curse of blackmail. Certain things seem clear. A person who deliberately or by heartless indifference gives syphilis to another should be punished as a criminal.

There should be many free dispensaries and hospitals for the treatment of venereal diseases and there should be special beds for such sufferers in all general hospitals.

Men who persist in wickedness should learn that the common results of a contaminated intercourse may usually be prevented by the adoption of certain precautions. This has been practised with great success in the army and navy. Some rigid doctrinaires insist that this plan is merely conniving at vice. But we should reflect if we save a bad man from getting syphilis we may prevent him from spreading it through the community and infecting the innocent. We try to save the one bad man in order to protect the hundred who are innocent. Firemen could not stand by and let a house, however notorious, burn to the ground. The worst of evil houses, if in flames, might burn a city. So I believe not only in all precautions to avoid coming in contact with the virus but I also believe in teaching preventive treatment.

The individual in endeavoring to avoid syphilis should avoid, as far as possible, all the acts spoken of on pages 263 and 264, which may be responsible for infection. Metchnikoff discovered that if within twenty-four hours of inoculation calomel ointment is rubbed in the exposed area syphilis can usually be prevented. He used 1 part of calomel and 2 of lanolin. This fact is widely utilized. In the United States Navy the custom was, when a sailor returned from shore leave and admitted to a suspicious connection, to rub the penis and foreskin with a mixture containing 33 parts of calomel, 10 parts of vaselin, and 67 parts of lanolin. This useful procedure was forbidden by a highly moral official, but was re-established on his return to private life.

If before connection the glans and prepuce are smeared with soap or calomel ointment, the liability to tearing and abrasion is lessened and crypts and follicles are blocked up. If this plan is followed, and if after connection the parts are washed and bathed with a warm solution of corrosive sublimate (1 : 2000) or permanganate of potash (1 : 3000), the danger of infection is greatly lessened. To apply also the calomel ointment gives additional assurances of safety.

Abortive Treatment.—I do not believe that syphilis can be aborted by cauterization, by excision, or by the administration of mercury, luetin, or arsphenamin. Several observers, even during recent years, have claimed that ablation of the chancre will sometimes prevent the disease. In the reported cases there is some doubt as to the diagnosis. Neisser's experiments upon apes demonstrate the futility of excision. He found treponemata in adjacent glands before the sore had indurated. Injection of another ape with material from these glands was followed by the development of syphilis. Excision causes pain and diagnostic uncertainty and I believe it to be invariably useless.

Treatment of the Primary Stage.—It has long been taught that a chancre should not be excised because the disease is constitutional when the chancre appears, and excision and cauterization inflict needless pain and do no good. The initial lesion should never be cauterized unless it is phagedenic or becoming so. Order the patient to soak the penis for five minutes twice daily in warm salt water (a teaspoonful of salt to a cupful of water), and then to spray the sore with peroxid of hydrogen diluted with an equal bulk of water, and dress it with black wash or with calomel ointment. The buboes in the groin require no local treatment unless they tend to suppurate. If they persist or become large, paint them with iodin or rub ichthyol ointment or mercurial ointment into them, and apply a spica bandage to the groin. Some authorities give mercury in this stage in order to prevent secondaries. The younger Gross opposed this strongly, and affirmed a wish to see the secondary eruption —first, because it proves the diagnosis; and, second, because it affords valuable prognostic indications (an erythematous eruption means a light case, an early pustular eruption means a grave case with serious complications); I long followed the plan of my old master, and did not order mercury until constitutional symptoms developed. We now know that the development of a positive Wassermann reaction may be regarded as confirmatory of the diagnosis, the finding of treponemata proves it, and early treatment may prevent disastrous lesions. We make the diagnosis early and at once begin constitutional treatment (see page 262). If phagedena arises, place the patient promptly upon stimulants and nutritious diet, secure sleep, and destroy the ulcer by the use of nitric acid or the cautery while the patient is anesthetized. After cauterization dust the sore with iodoform and dress with wet antiseptic gauze. Several times a day change the dressings, and at each change spray the sore with peroxid of hydrogen, irrigate with bichlorid of mercury solution, and dust with iodoform. It may be necessary to cauterize several times. In some cases it will be necessary to employ continuous irrigation by an antiseptic fluid. These cases are sometimes fatal and usually produce great destruction of tissue. In chancre redux watch carefully for the symptoms in order to determine if the condition is really one of reinfection or if we are dealing with a gumma which resembles a chancre in appearance.

A chancre usually heals promptly after the administration of salvarsan, and rapidly when the patient is placed on mercury. It is not wise to give iodid of potash during the primary stage, and it is not probable that it is helpful at all. Some teach that iodid of potash helps the absorption of granulation tissue and so lessens induration and promotes healing. It certainly is not as efficient as mercury for this purpose; it does not kill spirochetes, the tissues of the patient soon become "habituated to its presence and excrete it as rapidly as it is ingested" (D'Arcy Power in "Brit. Med. Jour.," Dec. 7, 1912).

Treatment of the Secondary Stage.—The chance of cure in most cases is excellent if the patient follows advice. The prognosis is much worse if the patient is a hard drinker or is the victim of Bright's disease, diabetes, tuberculosis, or other chronic exhausting malady. In the secondary stage the aim is to cure the disease. That it can be cured is known, because reinfection occurs in some persons. The old axiom, "Syphilis once, syphilis ever," is not true.

Diet and General Care.—In the beginning of treatment the patient must see his physician every day or two until the proper dose of mercury has been ascertained. For the following six months he should see his physician once a week, and during the next six months once every other week. During the second year he needs to see him once every month. Of course, if complications arise at any period the visits must be more frequent. At the beginning of the attack he must have his teeth put in perfect order. Tobacco is absolutely forbidden because its use favors the development of mucous patches in the mouth. Alcohol as a beverage is prohibited. It is used only as a medicine. The teeth should be gently scrubbed with a soft brush in the morning, in the evening, and after each meal, and a mild astringent or antiseptic mouth-wash

and gargle is to be used several times a day. If the gums become red and tender, chlorate of potash is used as a gargle and mouth-wash (1 oz. of the drug to 1 pint of water). The patient should wear flannel in winter. The author believes Guiteras's rules are sound, and in accordance with them directs the patient to refrain from kissing any one on the lips and from using a common towel, wash-rag, cup, glass, pipe, or razor. He is told to sleep alone in bed, to wash his hands often, to wear gloves, and to keep his fingers out of his mouth. Every morning he should take a warm bath, being especially careful to cleanse the anus, perineum, axillæ, groins, and between the toes; and after the bath these parts should be dusted with borated talc powder. A Turkish bath once a week is ordered by Guiteras when no skin eruption exists. The patient must avoid drafts, cold, and wet; must take a moderate amount of gentle outdoor exercise, and must sleep eight hours out of the twenty-four. The diet is of importance, and in this, too, the author follows Guiteras and orders the patient to avoid eating anything fried, or any meat or fish which has been canned, salted, or preserved. Fruits, pickles, tea, condiments, alcoholic beverages, clams, pork, veal, and pastry are not to be taken. (See article by Luke Beggs in "Phila. Med. Jour.," June 7, 1901.)

Medical Treatment by Mercury.—Mercury cures syphilis. We no longer give it only to remove symptoms, we give it to produce cure. It is given in small doses for a long period. We were taught this by Fournier, Lang, and Sir Jonathan Hutchinson (D'Arcy Power in "Brit. Med. Jour.," Dec. 7, 1912). Mercury kills the spirochetes. This is proved by the experiments upon apes made by Metchnikoff and Roux. Iodid of potash is seldom used in the secondary stage for the same reasons that it is avoided in the primary stage. Mercury must be used, the form being a matter of choice. Fournier advocated intermittent treatment. In this plan give 1/3 gr. of protiodid of mercury daily for six months, then stop for a month; then give mercury for three months, then stop two months. During the first year the patient is under treatment nine months, and during the second year eight months. Some prefer the intermittent and others the continuous plan of treatment. The author prefers the continuous plan. In following the continuous plan find the patient's tolerance to mercury, and keep him for two years on daily doses below the amount he will tolerate. Gross's rule for continuous treatment is to order pills of green iodid of mercury, each pill containing 1/5 gr. The patient is ordered one pill after each meal to begin with; the next day the after-breakfast dose is increased to two pills; the following day the after-dinner dose is two pills, and so on, one pill being added every day. This advance is continued until there is slight diarrhea, griping, a metallic taste, or tenderness on snapping the teeth together, whereupon one pill is taken off each day until all unfavorable symptoms disappear. Then the dose is reduced one-half and this amount is called the tonic dose. This experimentation finds a dose on which the patient can be kept with entire safety for a long time; but if it is found that colic or diarrhea is apt to recur, there must be added to each pill 1/12 gr. of opium. The patient is given mercury in this way for two years. Every time new symptoms appear the dose is raised, and as soon as they disappear it is lowered to the standard. If the protiodid is not tolerated, give the bichlorid:

℞. Hydrag. chlor. corros. ..... gr. j;
Syr. sarsaparillæ comp. ..... f℥iij.—M.
Sig.—One fluidram, in water, after meals.

Mercury with chalk in 1- or 2-gr. doses four times a day, with or without Dover's powder in 1-gr. doses, may be used. Mercurial inunctions produce a rapid effect, but irritate the skin. The drug should be rubbed in with a gloved hand. There can be used once a day ½ dr. of oleate of mercury (10 per cent.) or 1 dr. of mercurial ointment, rubbed into the skin. The first day it is rubbed into the inside of one thigh; the second day into the inside of the other thigh; the third day into the inside of one arm; the fourth day into the other arm; next, into one groin and then into the other groin, and then inunction is again made at the point of original application, and so on. After the rubbing the patient puts on underclothes and goes to bed, and in the morning takes a bath. The ointment may be smeared on a rag, which is then worn between the stocking and sole of the foot during the day.

Fumigation is performed by volatilizing each night 1 dr. of calomel. The patient sits naked on a cane-seat chair, and is wrapped up to the neck in a blanket which drops tent-like to the floor; the calomel is put upon an iron plate under the chair, and is heated by an alcohol lamp beneath the plate. The skin becomes coated with calomel, and the subject, after putting on woolen drawers and an undershirt, gets into

bed. Hypodermic injections of mercury are used by some physicians. They cause an eruption to disappear rapidly, but may produce abscesses, and relapses are prone to occur. The injection method will not abort the disease; should never be a routine treatment; in suitable cases it is very valuable for symptomatic use, as when lesions on the face or in important structures make a rapid impression desirable or necessary; in cases which obstinately relapse under other treatment, and in syphilis of the nervous system. J. William White, after a large experience with this method, says that hypodermic injections of corrosive sublimate are painful and are strongly objected to by many patients; that this method of treatment is occasionally dangerous and even fatal; that it is liable to be followed by local complications (erythema, nodosities, cellulitis, abscess, sloughing); that it cannot be carried out by the patient, but requires the surgeon's constant intervention. This syphilographer concludes that hypodermic medication does not offer advantages justifying its use as a systematic method of treatment, and that it encourages insufficient treatment—those "short heroic courses" which Hutchinson shows are followed by the gravest tertiary lesions. "The claim that by a few injections the time of treatment can be measured by months or even by weeks, instead of by years, would seem, as Mauriac has said, to involve the idea that mercury given hypodermically acquires some new and powerful curative property which, given in other ways, it does not possess."[1] A usual plan is to give daily a hypodermic injection of corrosive sublimate deep into the back or buttock, the dose being $\frac{1}{4}$ gr. of the drug. Thirty such injections are used unless some contraindication demands their discontinuance sooner. The treatment is then stopped. If the symptoms recur, however, the patient is given another course, the daily dosage being 1/6 gr., the treatment being again stopped after thirty injections, but being continued anew in 1/8-gr. doses if the symptoms recur. At present the most popular preparation for hypodermic use consists of salicylate of mercury suspended in albolene. The strength of the mixture is 10 per cent. The early doses are 10 minims each, given every third to seventh day. The dose may be pushed up to 30 or even to 40 minims. After from six to twelve doses the administration is discontinued for several weeks or several months. The following preparation is used by some syphilographers: 0.5 part of corrosive sublimate, 3 parts of guaiacol, and 97 parts of sterile olive oil. Thirty minims contain 1/16 gr. of corrosive sublimate. This mixture should be thrown deeply into the buttock and it causes no pain. The use of gray oil hypodermically has warm advocates. It is claimed that it provokes little pain and irritation, and that it is a very efficient remedy. The oil should not be thick like an ointment, because such a preparation could not be used without warming, and heat causes the mercury to aggregate in lumps. Olive oil should not be used, as it becomes rancid. Dumesnil's formula is the best ("Brit. Med. Jour.," Jan. 18, 1908):

"The ingredients must be sterilized before they are incorporated, as it is impossible to sterilize the product. If the directions given below are carefully followed no risk of septic poisoning is to be apprehended. The formula proposed by M. Dumesnil has been accepted by a committee especially appointed by the Société de Pharmacie of Paris, to investigate the methods of preparing gray oil. Twenty-six gm. of anhydrous wool-fat and 60 gm. of pure liquid paraffin (*huile de vaselin médicinale*) are sterilized separately in glass flasks at 120° C. for twenty minutes. A pestle and mortar are sterilized by means of burning alcohol and placed therein are 40 gm. of mercury and then the wool-fat. The metallic particles are triturated until they are sufficiently minute when examined under a magnification of 480 diameters, and then the liquid paraffin is added in small portions. The product should weigh 126 gm. and measure 100 c.c. and should be transferred immediately to phials of 2-, 5-, and 10-c.c. capacity, previously sterilized at 180° C."

An injection is given twice during the first week, once during the second week, and after this once a week or once every other week for an indefinite period of time. It may be given oftener if symptoms arise or persist.

Taylor believes that gray oil may give rise to unpleasant and sometimes even dangerous symptoms, and that it should be used with extreme care and only in selected cases in which other remedies are contraindicated. He says that in reading about the hypodermic method he has been struck with the fact that "the most serious results have almost invariably followed injections in which fatty matters have been the vehicle of suspension."[2]

[1] J. William White, in Morrow's "System of Genito-urinary Diseases, Syphilology, and Dermatology."

[2] "Venereal Diseases," by Robert W. Taylor.

Some surgeons employ intravenous injections of mercury. Lane injects, at first every other day and later daily, 20 min. of a 1 per cent. solution of cyanid of mercury. The skin in front of the elbow is rendered aseptic, a fillet is tied around the arm, the needle is inserted into a vein, the fillet is loosened, the fluid is injected, and the needle is withdrawn. This method of using mercury is painless and produces a rapid effect. It may be used in nervous syphilis, but should not be used as a routine. In whatever way mercury is given, do not allow it to produce salivation (hydrargyrism or ptyalism). Always remember that mercury may cause albuminuria and examine the urine at regular intervals during a course of the drug. In the beginning of a case of syphilis, if the kidneys are found to be diseased, give the mercury cautiously, and never fail to examine the urine at regular intervals. An individual can take more mercury in summer than in winter because during the warm weather perspiration favors elimination.

A drug used largely is the salicylate of mercury. The dose is 1 gr. in 2 or 3 c.c. of sterile water. An injection is given once a week and the series consists of sixteen injections. At any time that the Wassermann is found positive the injections are repeated. The drug is best given in association with arsphenamin (see page 286).

Sometimes, when a patient has a secondary eruption, the eruption grows temporarily worse when mercury is administered. This is called the *Jarisch-Herxheimer reaction*. It is due, according to Adamson, to having killed some spirochetes and thus caused the liberation of more endotoxins, the endotoxins causing "a further local defensive reaction" ("Lancet," April 6, 1922).

In order to cure syphilis mercury should be given for two years, and the mercurial course must be followed by at least a six months' course of iodid of potash. Reminders require both iodid of potash and mercury (mixed treatment). Throughout the mercurial course the patient should be weighed once a week, and if it is at any time found that the weight is decreasing, tonics, concentrated food, and cod-liver oil are ordered. If the weight continues to grow less and the health begins obviously to fail, stop the mercury for a time, continue the cod-liver oil, tonics, and nourishing food, and order hot baths, fresh air, iron, and chlorid of gold and sodium. If during the mercurial course albumin appears in the urine and some edema is noted, the mercury should be stopped for several or a number of weeks and the patient should be given a milk diet. If marked albuminuria is noted, but no other symptoms exist, mercury need not be discontinued, but the patient is watched most carefully for the advent of any other symptom (Fiessinger in "Journal des Practiciens," August 3, 1907).

Acute Ptyalism, or Salivation.—In acute ptyalism the saliva becomes thick and excessive in amount; the gums become spongy and tender and liable to bleed. Tenderness can be detected early by snapping the teeth. A metallic taste is complained of; the breath becomes fetid; the oral structures swell; the teeth loosen; the saliva is produced in great quantity; and there are purging, colic, and exhaustion. Sometimes there are fever and a diffuse scarlatiniform eruption upon the skin. A chronic hydrargyrism may be shown by salivation, gastro-intestinal disorder, emaciation, mental depression, weakness, albuminuria, and tremor. To avoid salivation advance the dose with great caution and instruct the patient as to the first sign of the trouble. He should use a soft tooth-brush and an astringent mouth-wash (48 gr. of boric acid to 4 oz., each, of listerin and water). When ptyalism is noted, discontinue the administration of the drug. Employ the above mouth-wash or one composed of a saturated solution of chlorate of potassium. Order 1/120 gr. of atropin twice a day, and in bad cases spray the mouth with peroxid of hydrogen and use silver nitrate locally (20 gr. to 1 oz.). Give stimulants (iron, quinin, and strychnin) and nutritious food. A weekly Turkish bath is of great service. In chronic hydrargyrism stop the administration of the drug, use tonics, stimulants, open-air exercise, Turkish baths, and nutritious food. The chlorid of gold and sodium may be used as a substitute for mercury. The use of iodid of potassium is of questionable value in ptyalism.

Treatment of Complications in the Secondary Stage.—The complications of the secondary stage usually require local applications in addition to general remedies. Mucous patches in the mouth should be touched with bluestone every day, an astringent mouth-wash being employed several times daily. If the patches ulcerate, they should be touched once a day with lunar caustic; if these areas proliferate, they should be excised and cauterized. Vegetations or growing papules on the skin must, if calomel powder fails to remove them, be cut away with scissors and be cauterized with chromic acid or with the Paquelin cautery. Condylomata demand washing with ethereal soap

several times daily, thorough drying, dusting with equal parts of calomel and subnitrate of bismuth or with borated talcum, and covering with dry bichlorid gauze. If these simple procedures fail, excise and cauterize.

For psoriasis of the palms and soles diachylon ointment, mercurial plaster, or painting with tincture of iodin should be employed. Ulcers of paronychia are dressed with corrosive sublimate gauze. Deep cutaneous ulcers are cleaned once a day with ethereal soap, sprayed with peroxid of hydrogen, dressed with corrosive sublimate gauze, and bandaged. When the process of granulation is well established dress with 1 part of unguent. hydrarg. nitratis to 7 parts of cosmolin. In sarcocele mercurial ointment should be rubbed into the skin of the scrotum or the testicle be strapped. In alopecia the hair should be kept short, and every night the scalp should be cleaned with equal parts of green soap and alcohol rubbed into a lather with water. After the soap has been washed out some hair tonic should be rubbed into the scalp with a sponge. A favorite preparation of Erasmus Wilson consisted of the following ingredients:

℞. Ol. amygd. dil. }
Liq. ammoniæ } ..... āā f℥j;
Sp. rosemarini }
Aquæ mellis } ..... āā f℥iij.—M.
Ft. lotio.

One part of tincture of cantharides to 8 parts of castor oil may be rubbed into the scalp. Solutions of quinin are esteemed by some. A useful wash for the scalp is the following: 1 dr. of borate of sodium, 1 dr. of spirits of camphor, 2 dr. of glycerin, and sufficient orange-flower water to make 4 fl.oz.

In treating persistent skin lesions, inunctions, injections, fumigations, or mercurial baths may be used. Baths are suited to patients with delicate skins, to those whose digestion fails when mercury is given by the mouth, and to those whose lungs will not tolerate fumigations. Corrosive sublimate, ½ oz., and 4 scruples of sal ammoniac are mixed in about 4 oz. of water; this is added to a bath at a temperature of 95° F. The patient gets into this bath, covers the tub with a blanket, leaving only his head exposed, and remains in the bath an hour or so. Mercurial baths may rapidly cause salivation.

Tertiary Stage.—If at any time during the case there appear tertiary symptoms, the patient should be put on mixed treatment, that is, mercury and an iodid. In any case, after two years of mercury add iodid of potassium to the treatment. If any tertiary symptoms appear, the rule is to use mixed treatment and to continue it for at least six months after all symptoms disappear, the six months' course dating from their disappearance. This emphasizes the fact that the iodids alone will not cure tertiary syphilis. Iodid of potash does not cure, but is very valuable in removing symptoms. In late syphilis both iodid and mercury are given. It is the mercury that cures. The mercury is given in small or tonic doses. Since the days of Ricord iodid of potash has been held in high esteem. In obstinate tertiary lesions and in nervous syphilis the iodids should be run up to an enormous amount (from 30 to 250 gr. per day). Sometimes people can take large doses of iodid when small doses produce iodism. Cyon explains this curious fact as follows: small doses combine with some products of the thyroid gland and form toxic iodothyrin. Large doses are diuretic, form soluble salts, and are rapidly eliminated. An easy way to give iodid is to order a saturated solution each drop of which equals about 1 gr. of the drug. Each dose of the iodid is given one hour after meals and in at least half a glass of water. If the iodid disagrees, it may be given in water containing 1 dr. of aromatic spirit of ammonia, or 5 drops of fluidextract of ergot, or may be given in milk. The iodid of sodium may be tolerated better than the potassium salt, as it is less depressing to the circulation, or the iodids of sodium, potassium, and ammonium may be combined. Gottheil sometimes gives tincture of iodin in 10-drop doses, well diluted. Iodid may be given as an enema in milk. In giving the iodids, begin with a small dose. During a course of the iodids always give tonics and insist on plenty of fresh air. Arsenic given daily tends to prevent skin eruptions. The iodids may disagree for a time, but tolerance may be established as the administration is continued. The value of the newer organic iodin preparations is as yet uncertain. Some of them are given hypodermically. An iodized oil, known as iodipin, can be given by the mouth or by intramuscular injection. If given by the stomach it may be taken in capsules, in tablets, or in milk (Coates

in "Brit. Med. Jour.," May 7, 1910). The iodids when they radically disagree produce *iodism*—a condition which is made manifest by a flow of mucus from the nose, conjunctival irritation, a bad taste in the mouth, exhaustion, anorexia, nausea, and tremor. In some subjects there are outbreaks of acne, vesicular eruptions, or even bullæ or hemorrhages. Iodism calls for the abandonment of the drug, and the administration of increasing doses of Fowler's solution of arsenic, of laxatives, of diuretic waters, or, if there is great exhaustion, of stimulants. In some cases belladonna is of service. Some patients who cannot take the alkaline iodids may take syrup of hydriodic acid. After the patient has been for six months under mixed treatment without a symptom, stop all treatment and await developments. If during one year no symptoms recur, the patient is probably cured; if symptoms do recur, there must be six months more of mixed treatment and another year of watching. It would be wise were every person who has had syphilis to take a six weeks' course of mercury and iodid twice a year for the balance of life. It is probable that such a plan would save many from visceral syphilis and late nervous syphilis. Syphilitic ulcers are treated locally by cleanliness, antiseptic applications, and, if the situation admits of it, by the daily use of the hot-air apparatus or by the induction of hyperemia by means of the rubber bandage or the cupping-glass. If albuminuria arises during the tertiary stage and there is arterial disease with high tension, mercury will do harm. In albuminuria without high tension it may be given (see pages 276 and 283).

The Question of Marriage.—Fournier has insisted that it is a great wrong to tell a syphilitic that he can never marry. He must not marry until he is cured, and he is not cured until, after the cessation of the use of mercury and iodid, he goes one year without treatment and without symptoms.

Treatment of Syphilis by Salvarsan or "606" (Dioxydiaminoarsenobenzol Dihydrochlorid).—Various arsenic compounds have been tried in syphilis (atoxyl, cacodylate of sodium, arsacetin, soamin), but salvarsan and neosalvarsan are the most important. Ehrlich introduced "606" (salvarsan) in 1909 and later he introduced neosalvarsan. Salvarsan and neosalvarsan in the United States are known as arsphenamin and neoarsphenamin. There are various new combinations of arsenic (sulpharsphenamin, tryparsamide, etc.). We greatly prefer arsphenamin or neoarsphenamin. It was hoped that a single intravenous injection would kill all the treponemata and immediately cure the disease. This hope has not been realized, though the remedy has great power for good. It kills multitudes of treponemata by directly poisoning them, not by causing the tissues to form antibodies. It causes symptoms to pass away rapidly, but if the administration is not continued at intervals or if mercury is not given, relapse, and probably disastrous relapse, is almost certain to occur. In many cases, but not in all, the Wassermann reaction becomes negative after the injection. The test is rendered negative more quickly than by mercury, but it may soon become positive again. The beneficial effects of these arsenic preparations are particularly manifest in early syphilis, but are very evident in tertiary syphilis. The drugs are of little or no use in parasyphilitic lesions.

In some cases "a spirochete infection which has been in abeyance" can be roused by arsphenamin "into sufficient activity to cause the Wassermann reaction to become positive," when it was before negative. Hence arsphenamin may be used as a test for syphilis and as a test to determine if syphilis has been cured (D'Arcy Power in "Brit. Med. Jour.," Dec. 7, 1912). This reaction is known as the *Jarisch-Herxheimer reaction.* It is marked by edematous swelling of a local lesion.

Neurorecidive.—The problem of dosage of arsphenamin in syphilis is one of great importance both as to the amount given in each injection and the number of injections that should be given. When salvarsan was introduced by Ehrlich there were those who arrayed themselves in favor of it and those who contended it was too dangerous a drug to use. Today the profession has practically accepted it as a great heritage to humanity. It is still a question whether it alone will cure syphilis. When first used there were fatalities, and are today, but with a better understanding of its use they are becoming rarer. In view of these fatal issues there was a strong tendency to reduce the amount of the drug given at injection and also the number of injections. This, of course, led to insufficient medication which, in its turn, aggravated certain cases of syphilis. It is believed today that insufficient dosage is often more dangerous than no drug at all. The production of generalized syphilis in rabbits after insufficient dosage has been shown by Plant and Mueger and Bronfenbrenner and Fiessinger. Inadequate dosage in low concentration exerts a stimulating effect upon treponemata and causes a more rapid growth. Noguchi and Bronfenbrenner found that in inoculated rabbits

where insufficient dosage was employed that generalized syphilis was most prone to develop, while in those treated by proper dosage and in those without any treatment generalized syphilis did not develop. Thus we are led to believe that neurosyphilis is possibly most likely to develop after insufficient treatment because the organisms are stimulated to rapid growth.[1]

Arsphenamin may fail to cure. It is not a substitute for mercury. Even when arsphenamin is given, mercury and iodid should be given in the same doses and for the same time as they would have been given had salvarsan not been administered. Arsphenamin should always be given when the patient is intolerant to mercury or when mercury fails to control the disease; when an important structure is threatened with damage or destruction; when the sore becomes phagedenic; for malignant syphilis; for persistent or spreading ulcerations; for laryngeal syphilis; for tertiary syphilis; for glossitis and ulceration of the tongue with leukoplakia, and for periostitis and osteitis in congenital or acquired syphilis. It does no good to syphilitic necrosis, probably because pyogenic organisms are active in such cases, and it is useless for symmetric synovitis of the knees, possibly because the child victims usually have also tuberculosis.

A man with persistent mucous patches in the mouth and every prostitute with syphilis should be given salvarsan because of the danger to the community of such syphilitics. A characteristic and disfiguring eruption calls for it. A married man with a chancre should receive it promptly. Salvarsan is contraindicated when there is advanced disease of the heart and arteries; in degenerative conditions of the brain and cord, when there is optic atrophy; in diabetes; in diseases of the liver or kidneys (even if syphilitic), and in pulmonary tuberculosis. Until recently it was thought to be contraindicated in children before the age of three, but John Adams shows that "syphilitic children can be safely treated immediately after birth" ("Brit. Med. Jour.," Nov. 16, 1918). Neither arsenic nor mercury seems to enter the cerebrospinal fluid, which fact probably explains the failure of these drugs to produce distinct benefit in cerebrospinal syphilis (Gilpin and Earley, "Jour. Amer. Med. Assoc.," 1916, lxvi). The position of arsphenamin may be summed up as follows: The fundamental problem in the treatment is first an early positive diagnosis, and then immediate adequate treatment. The old custom of waiting for the appearance of secondaries is wrong and dangerous. When arsphenamin was introduced it was by many believed that it accomplished cure by sterilization of the blood and lymph circulations. Today we know the arsenicals and mercurials may and do cure syphilis when used properly. We know that bismuth is a very powerful antisyphilitic. The modern syphilologist does not rely upon any one of these drugs, but on combinations of treatment carefully checked up upon from time to time. We know that these drugs when improperly used fail. We know that sterilizans magna was a myth, and in the past much harm was done to both doctor and patient because belief in the supposed cure permitted the disease to become deeply rooted and consequent nervous or visceral symptoms of a tertiary character developed. It is wise to explain to the patient the necessity of full co-operation upon his part and also to impress upon him the importance of a continued course of observation over a period of years. The disease is often difficult to stamp out, and it is only by continuous and persistent application to the rule of thoroughness in treatment and study that a cure will be accomplished.

Beginning Treatment.—When the diagnosis is made by the dark-field study or the Wassermann test, institute treatment at once.

Arsphenamin was introduced by Ehrlich after a long series of experiments eventuating in the famous "606."

The use of arsenic in treating syphilis is, according to Herzfeld, ancient history dating to the time of Fallopius. Atoxyl, soamin, arsacetin, hectin, and other preparations have been used with some success and considerable danger. They are no longer in use.

Administration of Arsphenamin and Neo-arsphenamin.—The preparations generally used are the old "606" and the new or neo-arsphenamin. They are usually given by injection, but have been introduced by mouth and rectum. They are injected intravenously, intramuscularly, and rarely subcutaneously. Most clinicians prefer the intravenous route.

Subcutaneous injections are always painful, and may cause sloughing.

Intramuscular injections have practically been discontinued except in young children.

For intravenous use the following things are requisite: Freshly double distilled water made in a glass still free from contamination, a 15 per cent. solution of sodium

[1] Perhaps the organisms are mitigated to a degree which bars the formation of antibodies, but are not killed in great numbers.

hydroxid, a sterile funnel and gauze or filter-paper for filtering the mixed product. A graduate to measure the amount of fluid. A tourniquet for the arm—ample rubber tubing of proper caliber. Iodin, sponges, and last, and most important, a proper needle.

The contents of an ampule of arsphenamin is dissolved in 30 c.c. of distilled sterile water at about 70° to 80° F. Into this solution the 15 per cent. sodium hydroxid is placed a drop at a time; a heavy white precipitate forms in the solution, more sodium hydroxid is added a drop at a time, and the solution agitated. By dropping more alkali into the solution the white precipitate clears up. The fluid is then filtered through several layers of fine surgical gauze into a container which should be of at least 100 c.c. capacity. Freshly distilled sterile water from another flask is now added until the desired amount is present. The tourniquet is then placed on the arm above the elbow-joint and proper tension made to distend the veins in front of the elbow. This can be facilitated by opening and closing the hand or by rubbing upward. A suitable vein is selected and the skin sterilized over it by iodin or 70 per cent. alcohol. Sterile water to the amount of an ounce or so is then placed in the bottle of the injection apparatus and air bubbles exhausted from the tube by raising and lowering the reservoir. A suitable needle is then inserted within the vein and blood allowed to flow. While the blood is flowing the adapter on the end of the tubing is inserted into the base of the needle and the arsphenamin permitted to flow slowly into the blood-stream. The bottle and tubing may have the last drops washed into the blood-stream by running normal salt solution or distilled water through. A thermometer may be used in the tubing to regulate the temperature of the injection.

Don'ts in Arsphenamin Injection.—1. Always study the urine before giving the drug, and if a contraindication exists, weigh the situation carefully.

2. Have an eye examination made.
3. Don't give it when the stomach contains food.
4. Don't hurry the injection.
5. Don't allow any solution to pass into the tissues around the vein. If this happens, stop and try another vein or cease the injection altogether.
6. Never use a solution that is not clear.
7. Don't allow air to enter the vein.
8. Use only the very best of sterile doubly distilled water.
9. Insist upon the patient remaining quiet after injection, preferably in bed.

Dosage and contraindications will be treated of later. In using neo-arsphenamin it can be given by means of a large hypodermic syringe (20 to 40 c.c.). It is mixed with the proper distilled water and drawn into the syringe at once. It does not need the alkalinization. The needle is then entered into the vein and blood allowed to flow back into the syringe, insuring the presence of the needle within the lumen of the vein. Inject slowly, and if the patient does not sense the odor of ether, or if the vein swells, stop at once and look over the situation, especially if he complains of pain or burning at the seat of injection.

Neo-arsphenamin is not as powerful an antisyphilitic as the older "606."

Contraindications.—Arsphenamin and neo-arsphenamin possess about the same contraindications. A list of some of the more prominent is appended:

1. Fetid bronchitis.
2. Extreme debility not due to syphilis.
3. Certain optic nerve complications.
4. Rashes, particularly purpuric or erythematous.
5. Acute nephritis with blood in the urine.
6. Individuals who have severe reactions.

The whole aspect of contraindication has very materially changed during recent years. Many of the so-called dangers are not feared today. The surgeon should bear in mind that the drug can cause death, and when in doubt he should start with very small dosage and keep a careful check upon the case. In eye complications the ophthalmologist should always be consulted.

In my own experience I most fear the advent of a dermatitis exfoliativa, or an encephalitis, which is usually fatal.

Fever after injection is seen more and more rarely. It was thought to be due to liberation of endotoxin from destruction of the organisms. Today we believe it due more to faulty technic. We lay particular stress upon the purity of the distilled water used. Wichselmann[1] pointed out the fact that distilled water may contain the remains of numerous dead organisms that will make trouble by entering the blood-stream. For

[1] Deutsch. med. Wchnschr., 1911, xxxvii, 778.

other reactions the student should consult special works; space does not permit an exhaustive explanation here.

It is desirable to give twelve to fifteen doses of arsphenamin at weekly intervals. Toward the end of the arsenic séances the administration of mercury intravenously should be begun (see page 283) and sixteen injections should be given. At the end of the mercury course there should be a variable rest period, the condition being checked up by a Wassermann test now and then. Whenever the Wassermann shows positive, give another course of arsenic, followed by another course of mercury. The number of injections of each depends upon the judgment of the surgeon.

If the Wassermann shows negative at the end of the first rest period (two months), repeat the arsenical and mercurial courses, giving smaller doses and fewer injections. If after any course a positive reaction appears, give another series of injections. If after the second course the Wassermann remains negative, do not repeat the injections. A positive reaction at any time, except in Wassermann-fast blood, calls for more arsenic and mercury.

The final tests of the cure of syphilis are the absence of symptoms and a persistent negative Wassermann in the blood and spinal fluid.

It is estimated by some that salvarsan is responsible for 1 death in every 1000 cases treated. Others set the rate at a much higher figure. Major French ("Lancet," Nov. 18, 1911) refers to 41 deaths as having occurred in less than one year. Levy-Bing, of Paris, says that the deaths number 70 or 80 and that death may occur in a healthy person. Hallopeau, Gaucher, and Ravant reported 3 deaths ("Bull. de l'Acad. de Med.," Oct. and Nov., 1911). A man of nineteen developed arsenical poisoning and died of uremia on the sixth day after the injection. A girl of eighteen died in a similar manner. Géronne, Finger, and others seem to prove that the symptoms which may follow the administration of salvarsan are manifestations of acute intoxication by arsenic, and are not, as Neisser claims, produced by endotoxins from destroyed spirochetes. Finger had a fatal case due to arsenical poisoning ("Brit. Med. Jour.," Jan. 27, 1912). Auditory and ocular complications may occur. In 9 per cent. of patients to whom Finger gave salvarsan nerve complications developed. Most of the deaths followed a second injection, hence the claim that anaphylaxis was the cause. Deaths are now much less common than the figures cited above would indicate.

The drug may be given by intramuscular injection. It causes pain which is often severe, and prolonged inflammation. This method is employed in children from three to seven years of age because the veins are small and hard to find. In adults the intravenous method is always to be preferred.

Several hours after the injection of salvarsan symptoms may arise (chills, elevation of temperature, diarrhea, vomiting, headache). In a few hours, as a rule, the symptoms pass away. One must be on the watch for dangerous symptoms (cardiac depression, dyspnea, great restlessness, excitement, edema of the face, cyanosis of the face, persistent vomiting, diarrhea, albuminuria, spasm of the limb muscles, and collapse). Since the discovery that fresh distilled sterile water should be used as solvent, and if it is used that the chill, vomiting, and day's depression which used to be expected need not occur, the safety of the method has been much enhanced. In cerebrospinal syphilis Swift and others suggested giving salvarsan as usual, draining 40 c.c. of blood from the patient's vein after an hour or so, separating the serum, making a spinal puncture, withdrawing some of the fluid, and introducing a like amount of the salvarsanized serum. The serum is diluted with normal salt solution and subjected to a temperature of 56° C. before being injected. It is of little avail in advanced tabes, but may do good in an early case in which the cerebrospinal fluid contains the spirochetes. This serum given by spinal puncture does no good in paresis, but Gordon claims it is useful if injected beneath the cerebral dura.

The effect of salvarsan on the Wassermann reaction has been much discussed. Theoretically, it should always make a positive reaction negative. Practically it often does not. It may require a second injection to do it. After the administration of salvarsan the reaction may become negative, remain so for several months, and again become positive. Neisser claims that in only 10 per cent. of latent cases is a negative reaction converted into a positive one. It was stated above that in latent syphilis with a negative reaction salvarsan may actually cause a positive reaction. Evidently a negative Wassermann is not to be regarded as absolute and unassailable proof that a patient is cured.

Inherited Syphilis.—Transmitted congenital syphilis is hereditary syphilis manifest at birth. Acquired syphilis (except in the case of a woman who obtains the

disease from a fetus) nearly always presents the chancre as an initial lesion (page 266); hereditary syphilis never does. Hereditary syphilis may present itself at birth, and usually shows itself within, at most, the first six months of extra-uterine life. In rare cases (tardy hereditary syphilis) the disease does not become manifest until puberty. A woman may have syphilis when she conceived. She may acquire syphilis during pregnancy. Some women bear a syphilitic child, but show no evidence of syphilis. Such a woman may perhaps exhibit a negative Wassermann reaction during pregnancy and show a positive reaction afterward. Treatment of a pregnant woman by salvarsan and mercury is of great value, and may result in the birth of child free from signs of syphilis and with a negative Wassermann reaction (see Meeting of the Section of Obstetrics and Gynecology of the Royal Society of Medicine in "Brit. Med. Jour.," Nov. 16, 1918). John Adams gives the mother a weekly dose of a salvarsan substitute intravenously and at the same time intramuscular injections of gray oil. These injections can be given up to the time of confinement ("Brit. Med. Jour.," Nov. 16, 1918).

Rules of Inheritance.—According to von Zeissl,[1] the rules of inheritance are as follows:

1. If one parent is syphilitic at the time of procreation, the child may be syphilitic.
2. Syphilitic parents may bring forth healthy children.
3. If a mother, healthy at procreation, bears a child syphilitic from the father, the mother must have latent pox, having become infected through the placental circulation, or must be immune. She often shows no symptoms, having received the poison gradually in the blood, and having thus received, it may be said, preventive inoculations. Certain it is that mothers are almost never infected by suckling their syphilitic children (Colles's law).
4. If both parents were healthy at the time of procreation, and the mother afterward contracts syphilis, the child may become syphilitic, and the earlier in the pregnancy the mother is diseased, the more certain is the child to be tainted. This is known as "infection *in utero*."
5. The more recent the parental syphilis, the more certain is infection of the offspring. The children are often stillborn.
6. When the disease is latent in the parents it is apt to be tardy in the children.
7. The longer the time which has passed since the disappearance of parental symptoms, the more improbable is infection of the children.
8. In most instances parental syphilis grows weaker, and after the parents beget some tainted children they bring forth healthy ones.

Syphilis in the mother is more dangerous to the offspring than syphilis in the father. The frequent immunity of the mother is said to be due to the fact that her tissues produce antitoxins under the influence of the slowly absorbed virus. The milk of a syphilitic mother contains quantities of antibodies (Bab, "Zeitschrift f. Geb. und Gynäkologie," vol. x, No. 2).

Of late years grave doubt has been thrown upon some of the long-accepted supposed laws of inheritance. It does not seem possible that the spermatic fluid can convey the spirochetes. If it cannot, the mother must be infected before the child. When we reflect that most stillbirths are in the sixth month of pregnancy, we would assume that the fetus becomes infected by way of the placenta. We doubt the possibility of a truly healthy child being born of a syphilitic mother. An apparently healthy child may have latent syphilis and exhibit no lesion for some years or for a number of years.

Many women affected with hereditary syphilis are sterile. Many syphilitic women abort before the eighth month, most commonly in the fifth or sixth month. The fetus sometimes dies at an early period of gestation. This may be due to a gummatous placenta or to a degeneration of placental follicles. Thirty per cent. of stillbirths are said to be due to pox. Bab (Ibid.) reports that out of 33 infants, victims of congenital syphilis, 16 were born alive, and 7 of these died within a few days. Hyde says that about 90 per cent. of those born living subsequently die of the disease.

Children born of syphilitic mothers in some cases exhibit a negative Wassermann reaction which may become positive after some weeks.

Evidences of Hereditary Syphilis Manifest at or, Oftener, Soon After Birth.—Hutchinson says that at birth the skin is almost invariably clear. In from six to eight weeks "snuffles" begin, which are soon followed by a skin eruption, by body wasting, and by a chain of secondary symptoms (iritis, mucous patches, pains, condylomata, etc.). The child looks like a withered-up old man. Eruptions are met with on the palms and soles. Intertrigo is usual. Cracks occur at the angles of the mouth and

[1] "Pathology and Treatment of Syphilis."

leave radiating scars. The abdomen is tumid and there is apt to be exhausting diarrhea. The secreting and absorbing glands of the intestinal tract atrophy.[1] It is very seldom that distinct gummata form in hereditary syphilis. The type of disease induced is a diffuse interstitial cellular change in the viscera, and the viscera are much more apt to suffer than in acquired syphilis. The liver, spleen, and pancreas often enlarge from interstitial changes, and the lungs sometimes are attacked in the same manner. Synovitis or arthritis may arise, the condition being similar to that met with in acquired syphilis. A form encountered between the third month and end of the second year, according to Paton, is characterized by growth into the joint of fungating granulation tissue, the joint is useless, and the parts about are swollen and edematous. Atrophic lesions may appear in the bones. In the skull the bone may be softened by removal of its lime salts or be thinned by the pressure of the brain. In a long bone the epiphyseal line suffers, the attachment of the epiphysis to the shaft is weak, and separation is easily induced. Epiphysitis is common, seldom causes pain, and rarely leads to suppuration, except in children who are old enough to walk (Coutts). Osteophytic lesions of the skull are shown by symmetric spots of thickening upon the parietal and frontal bones (*natiform skulls*). In the long bones osteophytes are frequently formed. In some cases osteophytes grow from the epiphysis, and in consequence deformity and impaired function are noted and a certain amount of ankylosis may occur. This condition of osteophytic growth from an epiphysis was called by Fournier *arthropathie deformant*. A child with precocious hereditary syphilis is apt to die, but if it lives from six months to one year the symptoms for a time disappear, and for years the disease may be latent. Diagnosis is difficult after the third or fourth year, especially if the disease be associated with rickets or tuberculosis. When later symptoms arise they may be various, namely: noises in the ears; often followed by deafness; interstitial keratitis; bursitis, synovitis in any joint, particularly painless but marked symmetric effusion in the knee-joints, with trivial functional disturbance; ossifying nodes; developmental osseous defects; suppurative periostitis; ulcerations; death of bone; falling in of the nose; nervous maladies; occasionally sarcocele, dactylitis, etc. Syphilitic children are rather prone to contract tuberculosis. Ricord used to speak of the scrofula of pox. Bones, joints, or viscera may become tuberculous. The Wassermann test is of great value in diagnosis and prognosis.



FIG. 134.—Dactylitis.

Dactylitis (Fig. 134) is common in hereditary syphilis. There is a superficial and a deep form (see page 276). Commonly, a swelling gradually forms. It is fusiform in shape and becomes purple in color. It lasts for months. One or more fingers may be involved and the fingers are more apt to suffer than the toes. The proximal phalanx is most liable to the lesion. The superficial form is apt to soften and ulcerate. Sinuses seldom form. The deep form not infrequently causes tissue destruction and shortening of the digit from rarefying osteitis or dry caries. Some cases of superficial dactylitis are symmetric and of short duration, and are to be regarded as late secondary lesions.

In hereditary syphilis the eye symptoms are of great diagnostic importance. In 212 cases of congenital syphilis Fournier found eye trouble in 101. Keratitis and choroiditis are the most usual forms. Bone trouble occurs in almost half of the cases, but is not usually severe enough to cause symptoms. The tongue often shows a smooth base (Virchow's sign). It is due to lymphoid atrophy and fibrosis (Symmers in "Amer. Jour. Med. Sci.," Dec., 1910). Hirschberg believed choroiditis to be pathognomonic. The descendants of syphilitic parents may exhibit certain pathologic conditions which are not directly syphilitic. Fournier calls such phenomena parasyphilitic. Among these phenomena are arrest of development of the body at large or of special structures, weakness of constitution, and other stigmata of degeneration.

[1] Coutts in "Brit. Med. Jour.," 1894, p. 1643.

In the **diagnosis** of hereditary syphilis the condition of the teeth is of considerable importance: the temporary teeth decay soon, but present no characteristic defect. If the upper permanent central incisors are examined, they are often, but by no means always, found defective. Other teeth may show defects, but in these alone are characteristic defects likely to appear. In hereditary syphilis they may present an appearance of marked deviation from health, and are then called *Hutchinson teeth* (Fig. 135). Hutchinson stated that if they are dwarfed, too short and too narrow, and if they display a single central cleft in their free edge, then the diagnosis of syphilis is probable. If the cleft is present and the dwarfing absent, or if the peculiar form of dwarfing be present without any conspicuous cleft, the diagnosis may still be made. The view that teeth of this nature *prove* the existence of hereditary syphilis and that they occur only in syphilis has been abandoned by Hutchinson himself. In fact, only one-fifth of congenital syphilitics have these teeth, and one-third of the cases of Hutchinson teeth are in individuals free from syphilis. In early infancy the diagnosis of syphilis is made by the snuffles, the broad nose, the skin eruptions, the wasted appearance, the sores at the mouth angles, the tenderness over bones, condylomata, and the history of the parents. The diagnosis at a later period is made by the existence of symmetric interstitial keratitis, choroiditis, the smooth base of the tongue, deafness, which comes on without pain or running from the ear, ossifying nodes, white radiating scars about the mouth-angles, sunken nose, natiform skull, deformity of long bones, painless inflammation of epiphyses, and Hutchinson teeth. It must be remembered that a child born apparently healthy and presenting no secondary symptoms may show bone disease, keratitis, or syphilitic deafness at puberty. A positive Wassermann reaction is highly significant. Finding the spirochetes is of conclusive importance in arriving at a diagnosis. (See article by Wm. S. Gottheil, "Progressive Medicine," Sept., 1908.)



FIG. 135.—Hutchinson teeth.

Treatment.—In infants it has long been the custom to use mercurial inunctions until the symptoms disappear, but mercury must not be forced or be continued too long after the symptoms have gone. There must be rubbed into the sole of each foot or the palm of each hand 5 gr. of mercurial ointment every morning and night. Brodie advised spreading the ointment (in the strength of 1 dr. to the ounce) upon flannel and fastening it around the child's belly. If the skin is so tender that mercury must be administered by the mouth, order that 1/12 to 1/3 gr. of mercury with chalk, with 1 gr. of sugar, be taken three times a day after nursing. If tertiary symptoms appear, and in any case when the secondaries have passed away, give ½ to 1 gr. or more of iodid of potassium several times a day in syrup. The mixed treatment should be continued intermittently until puberty. Local lesions require local treatment, as in the adult. A syphilitic child should, if possible, be nursed by its mother, as it will poison a healthy nurse, and also because the mother's milk contains antibodies. The mother is given salvarsan. If the baby has a sore mouth, it must be fed from a bottle, and if the mother cannot nurse the child, it must be brought up on the bottle. For the cachexia use cod-liver oil, iodid of iron, arsenic, and the phosphates. Adams ("Brit. Med. Jour.," Nov. 16, 1918) gives babies intramuscular injections of galyl in glucose and seems to prove that salvarsan may be given safely immediately after birth, but I would not give it intravenously. To a child over seven salvarsan may be given intravenously. The dose for a child of seven is 0.2 gm. If salvarsan is used mercury must also be given.

XVI. TUMORS OR MORBID GROWTHS

Division.—Morbid growths are divided into (1) neoplasms and (2) cysts.

Neoplasms.—A neoplasm is a pathologic new growth which tends to persist independently of the structures in which it lies, and which performs no physiologic function. We say that a tumor performs no physiologic function in order to make clear that it is never a useful addition to the economy, but we must not imagine that the cells of every tumor are devoid of functional activity. As Fütterer ("Medicine," March, 1902) has shown, the cells of a carcinoma of the liver may secrete bile, and even the cells of a secondary focus developing in the course of hepatic carcinoma may also secrete bile. The cells of a tumor may be active, but this activity is not useful and does not constitute physiologic function. A hypertrophy is differentiated

from a tumor by the facts that it is a result of increased physiologic demands or of local nutritive changes, and that it tends to subside after the withdrawal of the exciting stimulus. Further, a hypertrophy does not destroy the natural contour of a part, while a tumor does. Inflammation has marked symptoms: its swelling does not tend to persist, it terminates in resolution, organization, or suppuration, and examination of a section of tissue under the microscope differentiates it from tumor. Inflammation, too, has an assignable exciting cause. A new growth is a mass of newly formed *tissue;* hence it is improper to designate as tumors those swellings due to extravasation of blood (as in hematocle), or of urine (as in ruptured urethra), to displacement of parts (as in hernia, floating kidney, or dislocation of the liver), or to fluid distention of a natural cavity (as in hydrocele or bursitis).

Classes of Tumors.—There are two classes of tumors: the first class includes those derived from or composed of ordinary connective tissue or of higher structures. These all originate from cells which are developed from the mesoblast. There are two groups of connective-tissue tumors: (*a*) the typical, innocent, or benign, which mimic or imitate some connective tissue of the healthy adult human body; and (*b*) the atypical or malignant, which find no counterpart in the healthy adult human body or make but a poor attempt at imitation. It may find a counterpart in the immature connective tissues of the embryo.

The second class of tumors includes those which are derived from or composed of epithelium: (*a*) the typical or innocent, composed of adult epithelium, and which imitates a normal epithelial structure of the adult, glandular or surface; and (*b*) the atypical, or malignant, which finds no counterpart in the healthy adult body or which constitutes a poor and partial imitation. It may exhibit embryonic epithelium.

Müller's law is that the constituent elements of neoplasms always have their types, counterparts, or close imitations in the tissues, either embryonic or mature, of the human body.

Virchow's law is that the cells of a tumor spring from pre-existing body cells. There is no special tumor-cell or cancer-cell.

The starting-point of a tumor is a focus of embryonal cells, which focus may have originated before the person was born or may have resulted after birth from some disease or injury. The nature of the tumor depends, first, upon the embryonal layer from which it took origin. Connective-tissue tumors spring from the mesoblast; epithelial tumors spring from the epiblast or the hypoblast. The nature of the tumor depends also upon the stage in which the growth of its cells is arrested. If the cells remain embryonal, the growth is regarded as malignant; if they become fully developed, it is regarded as innocent.

The term "heterologous" is no longer used to signify that the cellular elements of a tumor have no counterpart in the healthy organism, but is employed to signify that a tumor deviates from the type of the structure from which it takes its origin (as a chondroma arising from the parotid gland). Tumors when once formed almost invariably increase and persist, though occasionally warts, exostoses, and fatty tumors disappear spontaneously. Tumors may ulcerate, inflame, slough, be infiltrated with blood, or undergo mucoid, colloid, calcareous, or fatty degeneration.

The **causes** of tumors are not positively recognized, those alleged being but theories varying in probability and ingenuity.

The *inclusion theory of Cohnheim* supposes that more embryonic cells exist than are needful to construct the fetal tissues, that masses of them remain in the tissues, and that these embryonic cells, later in life, are stimulated into active growth perhaps by injury or irritations or hereditary tendency. In other words, Cohnheim believes that all tumors arise from embryonal cells which were included or imprisoned by adult cells during fetal life and were not used during development; or from cells which were "displaced from their proper relations during the process of cell differentiation in the embryo" (Henry Morris, "Lancet," Dec. 12, 1903). The embryonic hypothesis seems to receive a certain force from the facts that exostoses do sometimes develop from portions of unossified epiphyseal cartilage, and that tumors often arise in regions where there was a suppression of a fetal part, closure of a cleft, or an involution of epithelium (epithelioma is usual at mucocutaneous junctions). This theory does not explain the origin of malignant tumors in scars, in recent callus or in parts subjected to injury or operation, etc.

Durante's addition to Cohnheim's theory does explain them. Cohnheim taught that the matrix from which a tumor springs is always an antenatal embryonic area. Durante says a tumor may also spring from a postnatal embryonic area resulting from

injury of the mature tissues, lessening their chemical and physiologic activities (Morris) and causing them to revert to an embryonic condition.

Objection has been made to the Cohnheim theory on the ground that an embryonal matrix could not remain quiescent, but, as Henry Morris says, certain teeth, the female mammary gland, the larynx, and certain appendages of the skin may not develop until puberty ("Bradshaw Lecture" in "Lancet," Dec. 12, 1903). Branchial cysts which are known to have such an origin are seldom seen until after puberty, and the same is true of many dermoids.

Morris shows that congenital matrices have been shown to exist in the brain, tongue, eye, testicle, ovary, broad ligament, line of coalescence in the trunk, and other places, and such matrices constitute *fetal rests* or *vestiges*. The same author shows that postnatal matrices may arise in the healing of a wound or ulcer, fistula, burns, etc. Portions of epithelium are separated, get placed deeply in the newly forming tissue, become surrounded by connective tissue, and may later take on active growth. As Ribbert points out, any fragment of isolated and imprisoned tissue may become a tumor.

Heredity is an extremely uncertain influence, though not an influence to be denied. A multitude of ignorant people have no idea what relatives or ancestors died of, and even intelligent persons may have erroneous ideas. The only certain statistical reports as to family liability would be shown by necropsies and microscopic studies, and it is evident that such reports are seldom obtainable. Clinical records obtained from members of a family may be suggestive, but do not prove anything. Bashford stated that out of 2932 histories of cancer cases, 2263 gave no definite statement as to family liability ("Proc. Royal Soc. Med.," 1909). I believe that there is such a thing as a more or less complete immunity to cancer and that there is such a thing as a predisposition to cancer, and the predisposition as well as the immunity may be hereditary or acquired. Youth constitues an almost though not quite certain immunity. Cancer is very rare in youth, and when it does occur in a young person it is always very malignant. Its occurrence means unnatural lack of tissue resistance or unusual vigor of cancer-cell. The retrogressive changes of age are predisposing causes. S. W. Gross believed direct hereditary influence to be by no means frequent in cancer of the breast. It is estimated that from 25 to 37 per cent. of cases of cancer of the breast have or had a cancerous relative or cancerous relatives (see below). Heredity in cancer is affirmed by some, denied by others, and doubted by a number. At most, hereditary influence may only predispose. Nevertheless, cases have occurred which cannot be explained by the term "coincidence." In the celebrated "Middlesex Hospital case," a woman and 5 daughters had cancer of the left breast. Sir A. Pearce Gould had charge of a woman for cancer of the left breast. The mother of this patient, the mother's 2 sisters, and 2 of the mother's cousins had died of cancer. Power reports a remarkable instance of family predisposition to cancer. A patient had his right breast removed for cancer in 1896. In 1897 cancerous glands were removed from the axilla. In 1898 he was seen again with an irremovable recurrent growth. His father died of cancer of the breast. He had 2 brothers, one of whom died of cancer of the throat when sixty-five years of age, the other having died of cancer of the axilla when he was only twenty-four years old. Of his 8 sisters, 4 died of cancer of the breast, and the 2 who are living both suffer from cancer of the breast. One sister died when an infant and one died after giving birth to a child.[1] The Emperor Napoleon, his father, his brother Lucien, and his sisters Pauline and Caroline died of gastric cancer. That there is such a thing as predisposition is rendered probable by the fact that out of many exposed under like conditions a single one may develop cancer. I believe, with Murphy, that there may be such a thing as absence of resistance to the cause of cancer on the part of certain tissues and that such impairment of resistance may be hereditary. (For a careful discussion of the question of the influence of heredity consult the article by H. Gideon Wells in the "Jour. Amer. Med. Assoc.," Sept. 22, 1923.)

Injury and *inflammation* may undoubtedly prove exciting causes. A blow is not infrequently followed by sarcoma; the irritation of a hot pipe-stem may excite cancer of the lip; the scratching of a jagged tooth may cause cancer of the tongue; chimmey-sweeps' cancer (which used to be seen in the old days when "the sweep" was an institution) arose from the irritation of dirt in the scrotal creases; and warts often arise from constant contact with acrid materials.

Physiologic activity favors the development of sarcoma, and *physiologic decline* favors the development of carcinoma.

[1] "Brit. Med. Jour.," July 16, 1898.

Parasitic Influences.—Many believe that parasites cause cancer. This theory does not maintain that the tumor is the parasite, but that it contains the parasite, although Pfeiffer and Adamkiewicz did at one time assert that a cancer-cell is not a body-cell, but a parasite resembling an epithelial cell. Butlin in 1905 asserted his belief that the cancer-cells are parasites and act independently like protozoa. Most observers deny this contention. Were it true, there would be only one variety of cancer, cases could only arise by direct contact, and it would leave unanswered how the original growth arose, as it could not have come from a pre-existing cancer-cell (Brand in "Lancet, " Jan. 11, 1908). Some facts render a parasitic origin of malignant growths not improbable; as, for instance, the likeness of some tumors to infective granulomata, the tendency to secondary development in distant parts of the body, the resemblance of the secondary to the primary growths, and the tenacity of their persistence. A parasitic origin of cancer is possibly suggested by its geographic distribution, the disease being very common in low and marshy districts, and Haviland ("Lancet," April 27, 1894) and others maintain that certain houses become infected, the disease appearing in these houses among successive families inhabiting them. They speak of such abodes as *cancer houses*.

Some surgeons believe that cancer is contagious, but most observers deny it. Hanau found a rat with a cancer and inoculated other rats from it. Moreau in 1894 inoculated mice from a mouse with cancer. Guelliott, of Rheims, believes that cancer is primarily a local infection. He believes this because Moreau and Hanau have inoculated it from one animal to another of the same species, and if this can be brought about experimentally he sees no reason why it cannot happen accidentally. This surgeon says that cancer is very unequally distributed, that genuine cancer centers and "cancer houses" exist, and that numerous cases of accidental infection have occurred.[1] Hahn apparently succeeded in grafting cancer from one part to another on the same individual. Jensen and Borrell have inoculated the disease in white mice. Mayet, of Lyons, holds that cancer can be reproduced by grafting or by injection of cancer fluid. Graf could not find cancer houses after a careful search.[2] Because several people, in the course of years, have died in the same house of cancer is not proof that the house was infected. If such a thing proves contagion there must be contagion in many things now thought free from it, and there must be broken-leg houses, and delirium-tremens houses, and heart-disease houses. Geissler claims to have produced the disease in a dog by planting fragments of cancer in the subcutaneous tissue and vaginal tissue, but Czerny, Rosenbach, and others dispute the claim. Plimmer tells us that an epidemic of cancer arose among the captive white rats in the Freiburg Pathological Institute, and in each case the growth was on the rear part of the body. Roswell Park believes that Gaylord has really produced adenocarcinoma in the lower animals. Hauser disputes the assertion that cancer must be an infectious disease because it is followed by secondary growths. Secondary growths in an infectious disease are caused by the bacterium; secondary growths in cancer are caused by the transference of cells from the primary growth.[3] Hauser says, with truth, that the close connection between innocent and malignant growths renders the parasitic view untenable, because to hold it we would be forced to believe that every tumor has a special parasite or that one parasite may cause many kinds of tumors.

There seems to be no doubt that autotransference of cancer can occur, although it rarely does so. Sippel has reported a case in which vaginal carcinoma developed at the point where the vagina was in contact with a pre-existing cancer of the portio.[4] Cornil has seen cancer transferred from one of the labia majora to the other, and from one lip to the other. Geissler was unable to transplant cancer, and Gratia also failed in his attempts. Duplay and Bazin say that transmissibility is possible, but only under conditions which are not practically realized. The facts that transplantation can be sometimes carried out, and that contagion is a possible occurrence under exceptional circumstances, do not prove that cancer is a parasitic disease, but simply prove that it can be transplanted. It is not that the cancer carries a parasite which will cause the disease in sound tissues, but rather that the cells of the cancer may themselves take root and grow in sound tissues. The parasitic theory arose from observation of the metastasis which occurs during the progress of the disease, and received support from the fact that inoculation of another part of an individual suffer-

[1] "Amer. Jour. of Med. Sciences," June, 1895.
[2] "Archiv. f. klin. Chir.," 1895, l, p. 144.
[3] Hauser in "Biolog. Centralbl.," Oct. 2, 1895.
[4] "Centralbl. f. Gynak.," No. 4, 1894.

ing from cancer may be followed by the development of a tumor like the original growth. For instance, if a cancer is growing upon the lower lip, the upper lip may be inoculated (*contact cancer*). The same is true of the labia. Mr. Harrison Cripps reported the occurrence of cancer of the skin of the arm from contact with an ulcerating scirrhus of the breast. It has also been pointed out that carcinoma is especially common in regions predisposed by their situation to injury and infection, and that, "among the lower animals at least, tumors resembling carcinomata have been transplanted from one to another" ("Recent Studies Upon the Etiology of Carcinoma," by Joseph Sailer, "Phila. Med. Jour.," June 7, 1902). But there is great doubt as to the cancerous nature of some of the tumors which have been successfully transplanted from one animal to another.

A transplanted mouse cancer may grow for a time and then completely disappear, and some observers (among them Gaylord) hold that when this occurs the mouse has become immune.

In 1908 the German Pathological Society met in Kiel and discussed various problems of cancer. In this meeting Sticker maintained that there is such a thing as natural immunity to tumors. He showed that a tumor arising spontaneously in an animal can never be transplanted into an animal of another species, and very seldom can a malignant tumor be transplanted into an animal of the same species. He quotes Metchnikoff's utter failure to transplant human tumors into anthropoid apes, and reports his own failure to transplant human tumors into various domestic animals. He made over 400 trials and failed every time ("Jour. Amer. Med. Assoc.," from Sticker, "Zeitschr. f. Krebsforschung," 1908, vii).

In successful transplanations there has been but slight effort to prove that epithelial cells were not transferred with the supposed parasites. If they were transferred the success of the experiment does not prove that cancer is due to parasites, but simply proves again what we knew before—that epithelial cells can be transplanted. Many parasites have been regarded as causative by different observers. Bacteria, yeast-cells, and protozoa have been found by different experimenters. It is not thought that bacteria are causative. Yeasts are regarded as causative by some. It is certain that they may exist in cancer, but it is highly improbable that they cause the disease. They may be only a contamination. Gaylord and others regard protozoa as causative, but this statement is not proved. Many of the supposed parasites of cancer have been shown to be cell degenerations or contaminations. Rous claims that a filterable virus, obtained from chicken sarcoma, reproduces the disease in other chickens ("Jour. Exper. Med.," 1914, xix). We are justified in concluding that the parasitic origin is not as yet proved, and we agree with the elder Senn that it is improbable.

Tillmanns elaborately discussed the subject of cancer in the Congress of 1895. His conclusions are still most sound and scientific. He says there is no evidence of a bacterial origin of cancer. The parasitic origin has not been proved, and protozoa have not certainly been found. Cancer can be transferred from one part to another of the same individual, or from one individual to another of the same species, but never to one of a different species. It is possible that cancer can spread by contagion; this is very rare, but can happen (as when penile cancer is followed by cervix cancer in a wife). Because it is sometimes possible to transfer cancer, this does not prove that the disease is parasitic or infectious; it simply shows that cells have been successfully transplanted.

Cancer à deux is cancer developing in people who live together. Such cases suggest, but do not prove, contagion. Behla collected 19 cases, and Gulliot 103 cases. *Conjugal cancer* is classified as cancer à deux. A wife, for instance, may have cancer of the womb and a husband may develop cancer of the penis, supposedly from contact. Conjugal cancer is probably due to irritation or implantation and not to microbic inoculation.

Actinomycosis, long thought to be a true tumor, is now known to arise from the ray fungus. Some think that psorosperms cause cancer. There can be no doubt that changes in the liver which practically constitute a new growth can arise from the growth of a cell called by Darier the "psorosperm." A disease due to psorosperms is called a "psorospermosis." It is affirmed by some that molluscum contagiosum, follicular keratosis, cancer, and Paget's disease are due to psorosperms. Some claim to find the parasite in all cases of cancer, while others can find it in only 4 or 5 per cent. of the cases.

Heneage Gibbes affirms[1] that dilatation of the bile-ducts of a rabbit's liver is caused

[1] "Amer. Jour. of Med. Sciences," July, 1893.

by the chronic irritation arising from multiplication of the Coccidium oviforme in them, and not in the columnar cells of the bile-ducts, as has been stated; and, further, that the large majority of glandular cancers show nothing that can be considered parasitic, the suspicious appearances noted in some few cases being due to endogenous cell formation. The Coccidium oviforme is a genus of the sporozoa, class protozoa, the lowest division of the animal kingdom. To this class belong the monera and infusoria.

Malignant and Innocent Tumors.—Malignant growths infiltrate the tissues as they grow; benign tumors only push the tissues away; hence malignant tumors are not thoroughly encapsuled, while innocent tumors are encapsuled. Malignant tumors grow rapidly; innocent tumors grow slowly. Malignant tumors become adherent to the skin and cause ulceration; innocent tumors rarely adhere and seldom cause ulceration. Many malignant tumors give rise to secondary growths in adjacent lymphatic glands (cancer, except in the esophagus and antrum of Highmore, always does so, and often does so in the esophagus; sarcoma rarely causes them, unless the growth be melanotic or lymphosarcoma, or unless it arises in the testicle, esophagus, or tonsil). Innocent tumors never cause secondary lymphatic involvement; although the glands near the tumor may enlarge from accidental inflammatory complications. The malignant tumors, especially certain sarcomata and soft cancers, may be followed by secondary growths (metastases) in distant parts and various structures (bones, viscera, brain, muscles, etc.); innocent tumors are not followed by these secondary reproductions, although multiple fatty tumors or multiple lymphomata may exist. Malignant tumors destroy the general health, inducing anemia and cachexia; innocent tumors do not unless by the accident of position. Malignant tumors tend to recur after removal; innocent tumors do not if operation has been thorough. The special histologic feature of a malignant growth is the possession by its cells of a power of reproduction which knows no limit, the cells of the tumor living among the body cells like a parasite and invading and destroying them.

The Cachexia of Malignant Disease.—This condition arises sooner or later in every uncured case of sarcoma and carcinoma.

In sarcoma there is advancing anemia and there are often episodes of elevated temperature due to the absorption of toxic materials from the tumor. The blood examination gives results similar to those found in cancer, but leukocytosis is more frequent. Pain is far less prominent than in cancer unless a nerve is involved or squeezed. Ulceration occurs much later in sarcoma than in carcinoma.

In carcinoma (see page 326) the emaciation is rapid and decided, the loss of strength is significant and notable, and the anemia is marked and progressive. It is due to pain, sleeplessness, ulceration, impaired appetite and digestion, repeated hemorrhages, and the absorption from the tumor of toxic products, which are probably enzymes (especially isohemolysins). Loss of hemoglobin is early and is followed by decrease in the number of red cells. In many cases considerable amounts of sugar exist in the blood. Irregular fever may occur. In both sarcoma and carcinoma the development of secondary growths aggravates the anemia.

Classification.—Tumors may be classified as follows:

I. Connective-tissue tumors (those derived from the mesoblast).

A. Innocent or typical tumors, or those composed of mature connective tissue, and which imitate some connective tissue of the healthy adult body. *Lipomata*, or fatty tumors; *fibromata*, or fibrous tumors; *chondromata*, or cartilaginous tumors; *osteomata*, or bony tumors; *odontomata*, or tooth-tumors; *myxomata*, or mucous tumors; *myomata*, or muscle-tumors; *neuromata*, tumors of or upon nerves; *gliomata*, or tumors composed of neuroglia; *angiomata*, or tumors formed of blood-vessels; *lymphangiomata*, or tumors formed of lymphatic vessels. The term *lymphoma*, meaning a tumor of a lymphatic gland, was formerly applied to hypertrophy and hyperplasia of a lymphatic gland, no matter whether caused by syphilis, tubercle, Hodgkin's disease, or any other morbid impression. The term has been largely abandoned except as expressing enlargement of a gland, and does not convey any suggestion as to the cause. It is doubtful if there is such a thing as a true lymphoma, understanding by the term a neoplasm arising from and composed of lymphoid cells and resembling lymphatic structure. In the described cases the possibility of infection as a cause has not been eliminated.

B. Malignant or atypical tumors in their structure find no true counterpart in any connective tissue of the healthy adult body, but rather resemble some embryonic structure. *Sarcomata* and adrenal tumors.

II. Endothelial tumors (those derived from and composed of endothelial cells). Some have regarded them as sarcomata.

III. Epithelial tumors (those derived from the epiblast or hypoblast).

A. Innocent, or typical, tumors or those composed of mature epithelial tissue and which find their structural model in the healthy adult body: *Adenomata*, or tumors whose type is a secreting gland; and *papillomata*, or tumors whose type is found in the papillæ of skin and mucous membranes.

B. Malignant, or atypical, tumors do not imitate or imitate but partially and poorly any structure in the healthy adult body. Their type is rather embryonic, and they are composed of embryonic epithelial tissue: *Carcinomata*, or cancers.

IV. Cystomata are cystic tumors, the cyst walls of which are new growths and the contents of which are produced by the cells of the newly formed cyst walls.

V. Teratomata and embryomata: A teratoma contains tissues or organs derived from two or all three of the embryonic layers. An embryoma is derived from all three layers, and its structures are arranged in imitation of a fetus.

Innocent Connective-tissue Tumors.—These growths mimic or imitate some connective tissue or higher tissue of the mature and healthy organism.

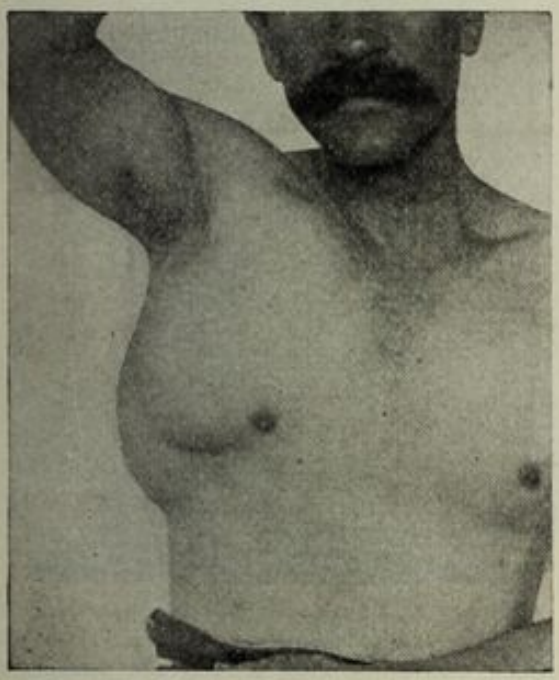


FIG. 136.—Lipoma, wandered from axilla.



FIG. 137.—Diffuse lipoma.

Lipomata are congenital or acquired tumors composed of fat contained in the cells of connective tissue, and these cells are bound together by fibers. If the fibers are excessively abundant, the growth is spoken of as a *fibrofatty tumor*. A fatty tumor has a distinct capsule, tightly adherent to surrounding parts, but loosely attached to the tumor; hence enucleation is easy. Fibrous trabeculæ run from the capsule of a subcutaneous lipoma to the skin; hence movement of the integument over the tumor or of the tumor itself causes dimpling of the skin. An ordinary circumscribed lipoma is of doughy softness, is lobulated, of uniform consistence, and on being tapped imparts to the finger a tremor known as pseudofluctuation. A fatty tumor is mobile, although it may be attached to the skin at points by trabeculæ. Sometimes a fatty tumor gradually shifts its position or wanders (Fig. 136). This is due to gravity. Lipomata are most frequent in middle life, and their commonest situations are in the subcutaneous tissues, especially of the back or of the dorsal surfaces of the limbs; they usually occur singly, but may be multiple and sometimes symmetric. Senn described the case of a woman who had a fatty tumor in each axilla. A lipoma may

grow to an enormous size (in Rhodius's case the tumor weighed 60 pounds), and the growth may be progressive or may be at times stationary and at other times active. The skin over a fatty tumor sometimes atrophies or even ulcerates; the tumor itself may inflame or partly calcify. When a lipoma has once inflamed, it becomes immovable. Subcutaneous lipoma of the palm of the hand or sole of the foot bears some resemblance clinically to a compound ganglion; it is apt to be congenital. Lipomata of the head and face are rare. In the subcutaneous tissues of the groins, neck, pubes, axillæ, or scrotum a mass of fat may form, unlimited by a capsule and known as a *diffuse lipoma* (Figs. 137 and 139). A diffuse lipoma may dip down among the muscles. Such masses attain large size. The typical diffuse lipoma is occasionally seen on the neck. It begins back of the mastoid process on one side or on both sides. When large, it completely surrounds the neck, a huge double chin forming in front, a great mass hanging on each side, and the posterior portion being divided into two halves by a median depression. A *nevolipoma* is a nevus with much fibrofatty tissue. A very vascular fatty tumor is called *lipoma telangiectodes*. If the tumor stroma contains large veins the growth is called a *cavernous lipoma*. A tumor containing much blood can be diminished in size by pressure. Fatty tumors may arise in the subserous tissue, and when such a growth arises in either the femoral or inguinal canal or the linea alba it resembles an omental hernia and is spoken of as a *fat hernia*. In the retroperitoneal tissues enormous fibrofatty tumors occasionally grow, and these neoplasms tend to become sarcomatous. In other regions lipomata very seldom become sarcomatous. Schiller reports 2 cases in which lipomata underwent sarcomatous transformation ("Surgery, Gynecology, and Obstetrics," August, 1918). Lipomata which arise from beneath synovial membranes project into the joints being still covered by synovial membrane. Fatty tumors occasionally arise in submucous tissues, between or in muscles, from periosteum, and from the meninges of the spinal cord (Sir J. Bland-Sutton). A fatty tumor may undergo metamorphosis. The stroma may be attacked by a myxomatous process or a calcareous degeneration. The fat cells themselves may become calcareous. Oil-cysts sometimes form. A *xanthoma* is a growth composed of fatty tissue in and about which there is marked infiltration with small cells. Such a tumor is flattened and slightly elevated. Several or many of these growths occur

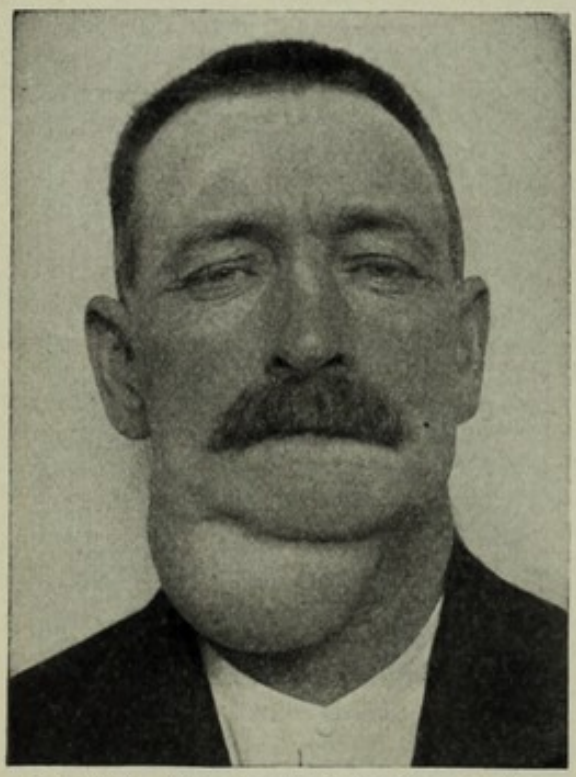


FIG. 138.—Lipoma of submaxillary region.

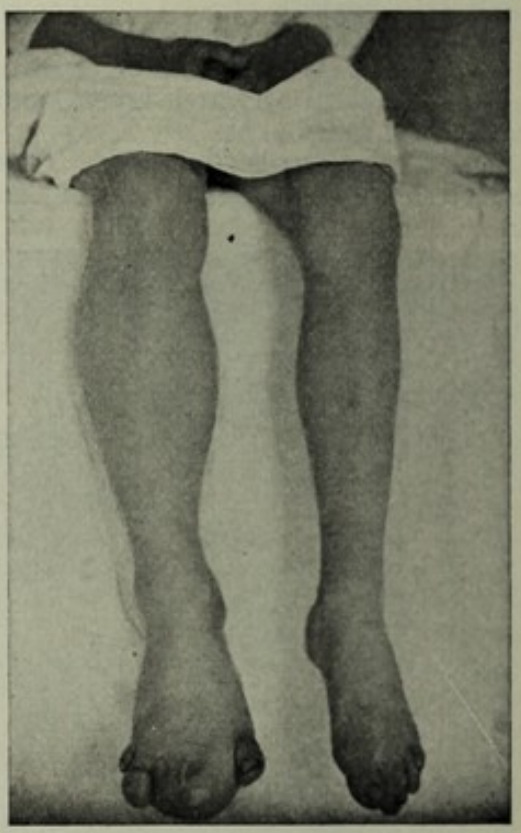


FIG. 139.—Congenital diffuse lipoma of foot and leg. Child seven years of age, second and third toes amputated at thirteen months and large mass moved from sole of foot. Later a large fatty mass moved from calf of leg, surrounding gastrocnemius and soleus muscles and between them (Rugh).

in the same person. The eyelids are the most common seat of xanthoma. The tumor may undergo involution or may become sarcomatous.

Diabetics are liable to develop xanthomata.

Treatment.—A single subcutaneous lipoma should be extirpated. The capsule must be incised, when the tumor is torn out forcibly or, better, is enucleated by dissection; drainage is always employed for twenty-four hours, as butyric fermentation will be apt to occur, and necrosis of small particles of fat predisposes to infection. Multiple subcutaneous lipomata, if very numerous, should not be interfered with unless troublesome because of their size or situation, when the growth or growths causing trouble should be removed. It is difficult to extirpate entirely a diffuse lipoma, and several operations may be needed to effect complete removal. Liquor potassæ, once recommended as possessing power, when taken internally, to limit the growth of multiple lipomata or diffuse lipoma, seems to be useless. Retroperitoneal lipomata are rarely dignosticated until the belly has been opened, sometimes not until the growth has been removed.

Fibromata are tumors composed of bundles of fibrous tissue. There are two forms, the hard and the soft. A *hard fibroma* consists of wavy fibrous bundles lying in close contact. Here and there connective-tissue corpuscles exist between the fibers.

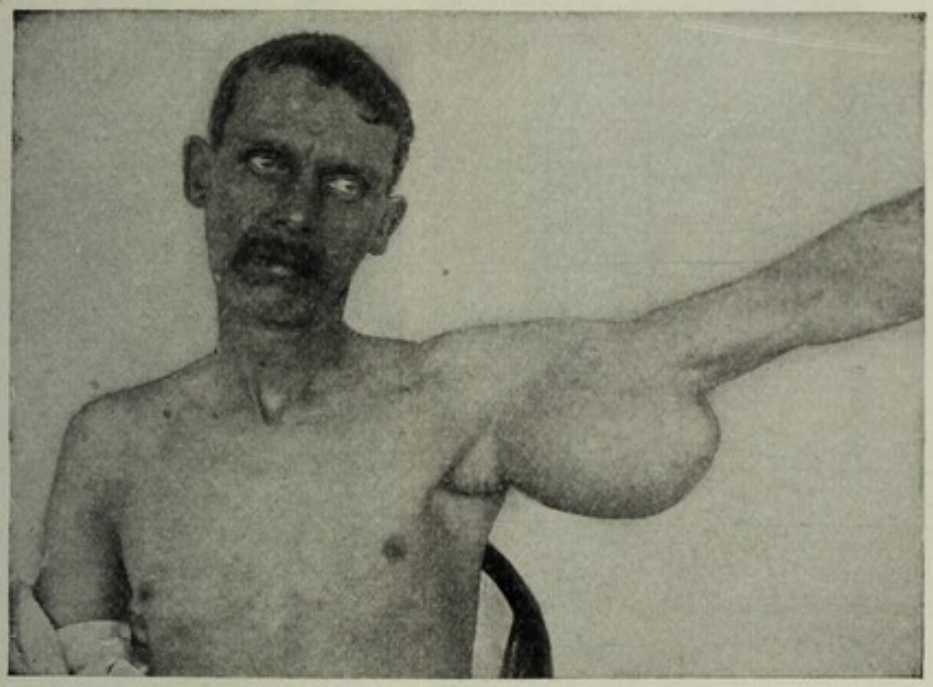


FIG. 140.—Fatty tumor.

A hard fibroma has no distinct capsule, though surrounding tissues are so compressed as to simulate a capsule. Fibromata are occasionally congenital, are most usual in young adults, but they may occur at any period of life, and in any part of the body containing connective tissue. Pure fibromata, which are rare, are generally solitary, grow slowly, are of uniform consistence, have not much circulation, and are hard and movable. Fibromata may form upon nerve-sheaths, may arise in the mammary gland, may develop in the lobe of the ear and from the stomach, and may spring from various fibrous membranes, from the periosteum of the base of the skull (*nasopharyngeal fibromata*), and from the gums (*fibrous epulides*). A *soft fibroma* contains much areolar tissue, the spaces of which are filled with fluid, so that the tissue seems edematous. Soft fibromata grow from the skin, mucous membrane, subcutaneous tissue, intermuscular planes, and periosteum. Soft fibromata possess distinct pedicles and are especially apt to arise from the skin of the scrotum, labia, inner surface of arm, the thigh, and from the belly wall of a pregnant woman. They are not unusually multiple, grow slowly, but more rapidly than the hard fibromata, and may become quite large. Fibromata may become cystic, calcareous, osseous, colloidal, or sarcomatous, and may inflame, ulcerate, or even become gangrenous.

A *painful subcutaneous tubercle*, which is a form of fibroma commonest in females, arises in the subcutaneous cellular tissue, usually of the extremities. It is firm, very

tender, movable, rarely larger than a pea, and the skin over it seems healthy. Violent pain occurs in paroxysms and radiates over a considerable area, of which the tubercle is the center. These paroxysms may occur only once in many days or many times in one day. Pain is always developed by pressure, and may be linked with spasm. Nerve-fibrillæ are now known to exist in these tubercles, a fact which was long denied.

A *mole* is a fibroma of the skin, though it arises from mesoblastic cells, its matrix arises from a special type of mesoblastic cell, but it also contains epithelial cells from the hair follicles and sweat glands. It involves the derm and epiderm. It is congenital or appears in the early weeks of life. It is rounded or flat, is usually pigmented and of a brown color, is slightly elevated above the cutaneous level, and has a few hairs or an abundant crop of hair growing from it, and varies in size from a pin's head to several inches in diameter, or may even occupy an extensive area of a limb or of the trunk. The tumor rarely grows after the thirteenth or fourteenth year. A mole may become malignant, melanotic carcinoma may arise from its epithelial structures, or melanotic sarcoma from its connective-tissue elements. A mole is an extremely vascular structure; it bleeds freely when cut or scratched, and it sometimes ulcerates. Occasionally several or many moles exist in the same individual. If a mole begins to increase rapidly in size, operation is imperative, as rapid growth probably indicates malignant change.

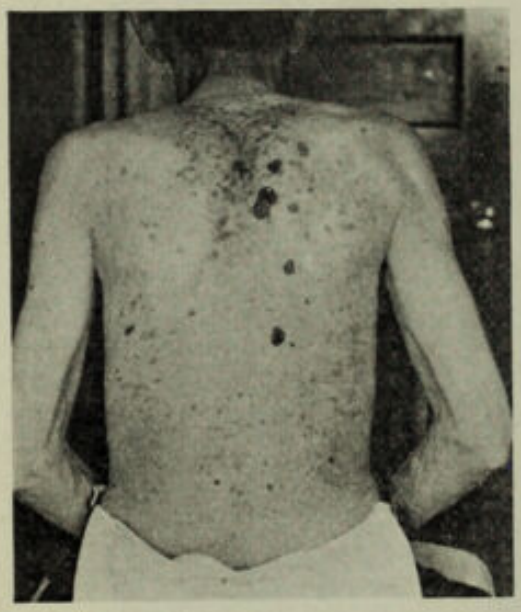


FIG. 141.—Multiple pigmented moles. Man about sixty (Dr. W. L. Clark).

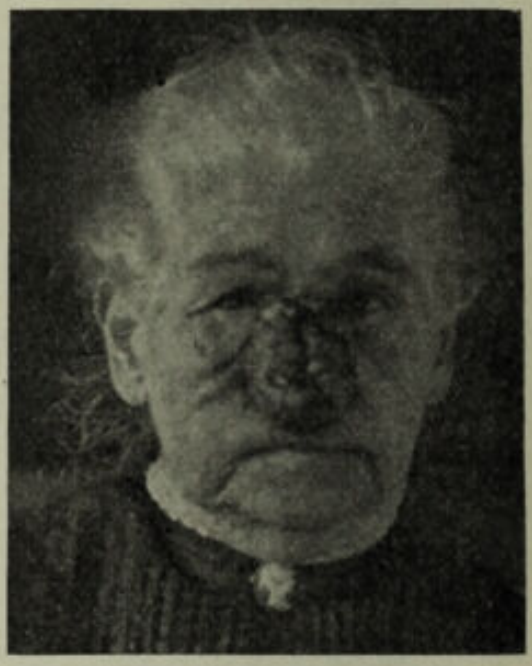


FIG. 142.—Carcinoma of nose arising from a neglected mole. The patient is seventy-five years of age (Dr. W. L. Clark).

Fibrous epulis is a fibroma arising from the gums or periodontal membrane (Sir J. Bland-Sutton) in connection with a carious tooth or retained snag; it is covered by mucous membrane, grows slowly, may attain a large size, and sometimes has a stem, but is more often sessile. It may undergo myxomatous change or may become sarcomatous.

Fibrous tumors may arise from the ovary, the intestine, the larynx, and the submucous tissues of the gastro-intestinal tract. Pure fibromata of the uterus are very rare, but fibromyomata are very common (see Myomata, page 308); hence the term "uterine fibroid" should be abandoned.

Desmoid tumors of the abdominal wall are cellular fibromata. A desmoid tumor has a strong disposition to become sarcoma. It has no real capsule. It takes origin from one of the abdominal muscles or muscular insertions or from fascia, particularly from the rectus muscle or its sheath. In most cases the growth is slow; in some it is rapid and the tumor may attain a great size. It may project either anteriorly or toward the abdomen. This form of tumor is vastly more common in women than in men and is especially common in women who have borne children. It may occur at any age, but is most frequent in those between twenty-five and thirty-five. It is a very rare tumor. (See Harvey B. Stone, "Annals of Surgery," August, 1908.)

Molluscum fibrosum is an overgrowth of the fibrous tissue of both the skin and subcutaneous structure. Senn excludes this form of growth from consideration with fibromata because of its supposed infective origin. It may be limited or widely extended; it may appear as an infinite number of nodules scattered over the entire body or as hanging folds of fibrous tissue in certain areas.

Keloid (Figs. 143, 144) is a fibroma of the true skin. It is a hard and fibrous vascular growth, with a broad base, arising in scar-tissue; it is crossed by pink, white, or discolored ridges, and is named from a fancied likeness to the crab. Very rarely it attacks mucous membrane. It is more common in negroes than in whites, and is most frequent in the cicatrices of burns, though it may arise in the scar of any injury, as the scar from piercing the ears, and in the scars of syphilitic lesions, tuberculous processes, smallpox, or vaccination. I believe that the scars of tuberculous lesions and the scars even of ordinary wounds in tuberculous individuals are particularly apt to become keloidal. In negroes keloid is not uncommon in the scar remaining after operations upon tuberculous glands of the neck. It is very common in a person with keloid to be able to find some near or distant tuberculous lesion, or a history of former tuberculosis, or the record of the individual having tuberculous tendencies. The victim of keloid usually reacts to tuberculin. The growth seldom begins in early childhood or in old age. It grows slowly, lasts for many years and may eventually undergo involution and disappear. The fact that keloid is especially common in the negro



FIG. 143.—Keloid following a burn.

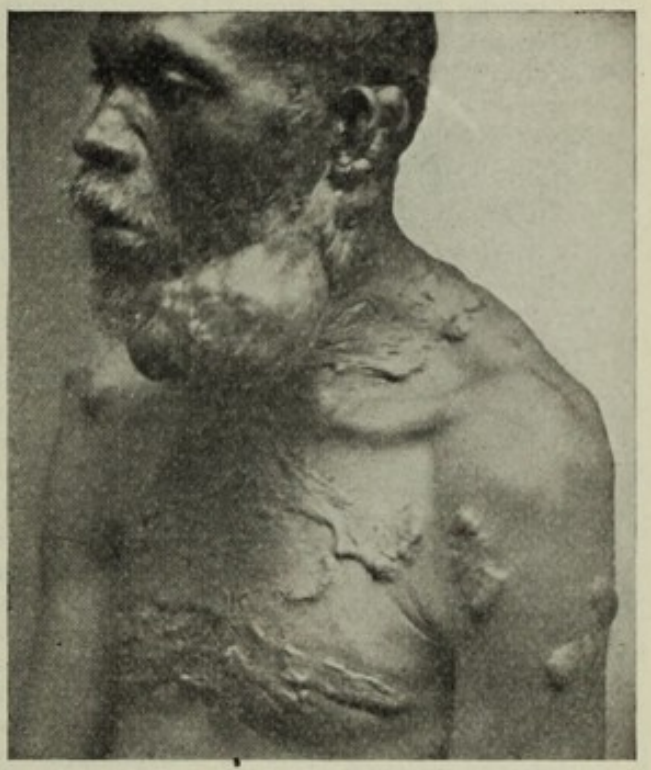


FIG. 144.—Keloid (case of Dr. L. L. Hill, Montgomery, Alabama).

race (a race predisposed to tuberculosis) and that it is so frequently met with in the scars of known tuberculous processes, suggests the possibility of a tuberculous cause for the condition. The rapid return of keloid after operation suggests a near or distant infection which, by furnishing material to a point of least resistance, causes keloid to redevelop. Some cases of keloid have active tuberculous lesions, others have had them, in still others latent or distant lesions may be found by careful search. In many cases there is a family history of tuberculosis. I am at present investigating this important matter. It is certain that the keloid itself does not contain bacteria. Repeated examinations have failed to find them. It is quite possible that the growth contains toxins of tubercle bacilli, the toxins being the irritant cause. I am now seeking to determine if material from keloid introduced into tuberculous animals will cause a reaction. Brenizer ("Annals of Surgery," 1915, lxi) combats the view that tuberculosis is in any direct way causal of keloid. It is usually believed that it is practically useless to remove keloid by operation, as it will almost certainly return; yet a study of the growth removed shows no reason for the inevitable return. Charles A. Porter has reported a case of massive keloid of the face and hands notably benefited by many operations and skin-grafting. In this case, Porter says, "there has been a gradual but distinct

abatement of the tendency to form keloid tissue" ("Annals of Surgery," July, 1909). The fibrous tissue of keloid springs from the outer walls of the blood-vessels. The papillæ of the skin above the tumor are destroyed or replaced by fibrous tissue.

Morphea, spontaneous or true keloid, is a name used to designate a growth of this description which does not arise from a scar; but it seems certain that scar-tissue was present, though possibly in small amount from trivial injury.

Fibrous and papillomatous growths covered with endothelium may spring from any serous membrane. Such a growth of the choroid plexus calcifies early and constitutes a *psammoma* or brain-sand tumor. Such tumors are met with not only in the choroid plexus but also in the conarium and the dura. All psammomata are not fibrous; some are gliomatous and some are endotheliomatous. A *cholesteatoma* is a fibrous growth covered with endothelium and containing layers of crystalline fat. It occurs especially in the pia mater, but may arise in either of the other membranes or even in the brain substance, and is called a *pearl tumor*.

Treatment.—Fibromata should not be let alone, because any fibrous tumor may become a sarcoma. When in accessible regions they should be enucleated. If a hard fibroma of the skin exists, the skin is incised and the tumor is "shelled out." A soft fibroma is removed by an incision carried around the base of its pedicle. A painful subcutaneous tubercle should be excised. If a mole shows the slightest disposition to enlarge, or if it is subjected to pressure or irritation, it should be removed, because if allowed to remain it may develop into a malignant growth. It is often desirable to remove a hairy or pigmented mole not only because it may become malignant but also because it is unsightly. A mole, if not too large, may be removed by the application of solid carbonic acid for thirty seconds. This destroys hair and often causes pigment to disappear. Many moles are best treated by excision. Fibrous epulis requires the cutting away of the entire mass, the removal of the related snag or carious tooth, and sometimes the biting away of a portion of the alveolus with rongeur forceps. A nasopharyngeal fibrous polyp often contains sarcomatous elements or develops into a spindle-celled sarcoma. If the polyp is recent and has a pedicle it may be removed by the cautery loop. Most cases require extirpation, the surgeon cutting wide of the growth. In a severe case a part of the superior maxillary bone is removed by osteoplastic resection to permit of extirpation. Keloid should rarely be operated upon: it will almost certainly return, and will also develop in the stitch holes. Trust to time for involution, or use pressure with flexible collodion, by which method J. M. DaCosta cured a case following smallpox. It may be necessary to operate because of ulceration. If it is necessary to operate, remove the keloid and considerable adjacent tissue and fill the gap with Thiersch grafts. The administration of thyroid extract may be of benefit (a 5-gr. tablet three or four times a day). This drug must be given cautiously, as it may cause attacks characterized by fever, dyspnea, and rapid pulse. Thiosinamin hypodermically has been used, it is claimed, with benefit. A 10 per cent. solution is made, and from 10 to 15 minims can be injected into the gluteal muscles every third day. I have seen two keloids cured by the use of the *x*-rays.



FIG. 145.—Dr. James A. Kelly's case of keloid from piercing ear for ear-rings.

Chondromata (*enchondromata* or *ecchondroma*) are tumors formed usually of hyaaline cartilage, but may be formed of fibrocartilage, or of both. Chondromata are apt to arise from certain glands, the long bones, the pelvis, the rib cartilages, and the bones of the hands or feet, and often spring from unossified portions of epiphyseal cartilage. It has been held by Helmholtz, Sudler, and others that chondroma may arise by the transformation of fibrous tissue into cartilage. Chondromata occur, as a general rule, to which there are many exceptions, between the ages of twenty and forty. There is no sex predilection. They may be single or multiple, and are most commonly met with in the young. They have distinct adherent capsules; they grow slowly, and, if of osseous origin, progressively hollow out the bones by pressure;

they cause no pain; they impart a sensation of firmness to the touch, unless mucoid degeneration forms zones of softness or fluctuation; they are inelastic, smooth or nodular, immovable, and often ossify. A chondroma may grow to an enormous size. A so-called chondroma of the parotid gland or testicle springs from embryonic remains and practically always contains sarcomatous elements, and is known as a *mixed tumor*. Any chondroma may become a sarcoma. Chondromata are notably frequent in persons who had rickets in early life. *Ecchondroses*, which are "small local overgrowths of cartilage" (Sir J. Bland-Sutton), arise from articular cartilages, especially of the knee-joint, and from the cartilages of the larynx and nose. Loose or floating cartilages in the joints may be broken-off ecchondroses or portions of hyaline cartilage which are entirely loose or are held by a narrow stalk, and which arise by chondrification of villous processes of the synovial membrane; only one or vast numbers may exist; one joint may be involved or several; they may produce no symptoms, but usually produce from time to time violent pain and immobility by acting as a joint-wedge. An enchondroma may arise within the medullary canal of a long bone, from foci of dormant cartilage, and may lead to the development of a *solitary cyst* of large size by softening of the tumor. The femur is the most usual site of solitary cyst. It begins very insidiously and progresses gradually. There are slight lameness, trivial pain, tenderness below the level of the trochanter, apparent shortening, and some bulging of bone. The bone may bend or at some spot may thin so that the cyst can be felt. Such a bone fractures from slight force, and after a fracture, when the effused blood and inflammatory exudate have been absorbed, a tumor can be detected distinctly. A solitary cyst of a long bone is apt to be regarded clinically as a sarcoma (Bergmann-Virchow). In the pelvis, with its numerous centers of ossification, there are many sites from which chondromata may arise, and a pelvic chondroma may so block the pelvis of a pregnant woman as to necessitate cesarean section (J. H. Wagner in "Surgery, Gynecology, and Obstetrics," 1916, xxiii).

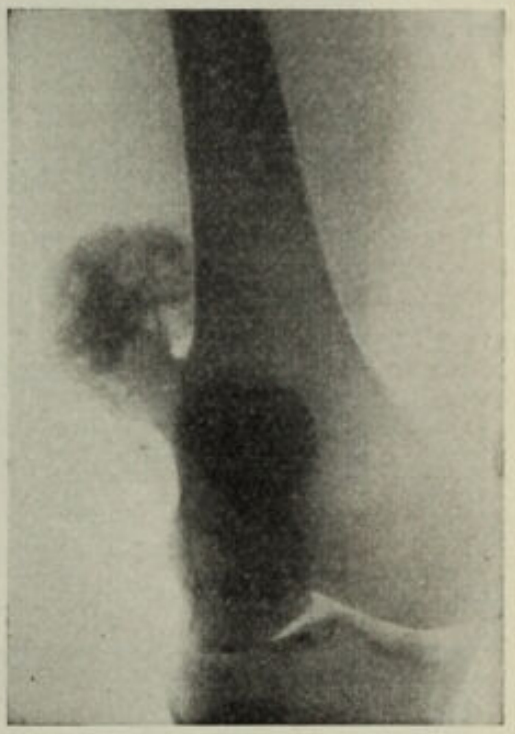


FIG. 146.—Osteoma of femur.

Treatment.—Remove chondromata whenever possible, for, if allowed to remain undisturbed, they are apt to resent this hospitality by becoming sarcomatous. A chondroma of the testicle and of a salivary gland (mixed tumor) is to be regarded clinically as malignant. In an ordinary chondroma incise the capsule and take away the growth, using chisels and gouges if necessary. Incomplete removal means inevitable recurrence. Amputation is very rarely demanded. In malignant chondrosarcoma incision must be outside of the capsule. Loose bodies in the joints, if productive of much annoyance, are to be removed, the joint being opened with the strictest antiseptic care. Amputation is sometimes performed for a solitary cyst of a long bone, the surgeon having looked upon the growth as sarcomatous. If a correct diagnosis is arrived at, an attempt should be made to remove the cyst without amputation. Bergmann succeeded in extirpating such a mass from the femur.

Osteomata are tumors which are composed of osseous tissue. Sir J. Bland-Sutton says that osteomata are ossifying chondromata. Osteomata take origin from bone, cartilage, connective tissue, especially tissue near the bone, serous membrane, and certain glands and organs. Compact osteomata, which are identical in structure with the compact tissue of bone, arise from the frontal sinus, mastoid process, external auditory meatus, and other regions, in those beyond middle life; they are small, smooth, round, densely hard, with small and occasionally cartilaginous bases.

Cancellous osteomata, which comprise the great majority of bone tumors, are similar in structure to cancellous bone. They spring from, and are crusted with, cartilage; they may have fibrous capsules, and are often movable when recent, but soon become fixed; they frequently have broad bases, are angled, nodular, firm (but not so hard as are the compact osteomata), painless except when pressed, occur par-

ticularly at the ends of long bones (Figs. 146 and 147), may grow to large size, and are commonest in youth. An osteoma near a joint becomes overlaid by a bursa, which in rare instances communicates with an adjacent joint.

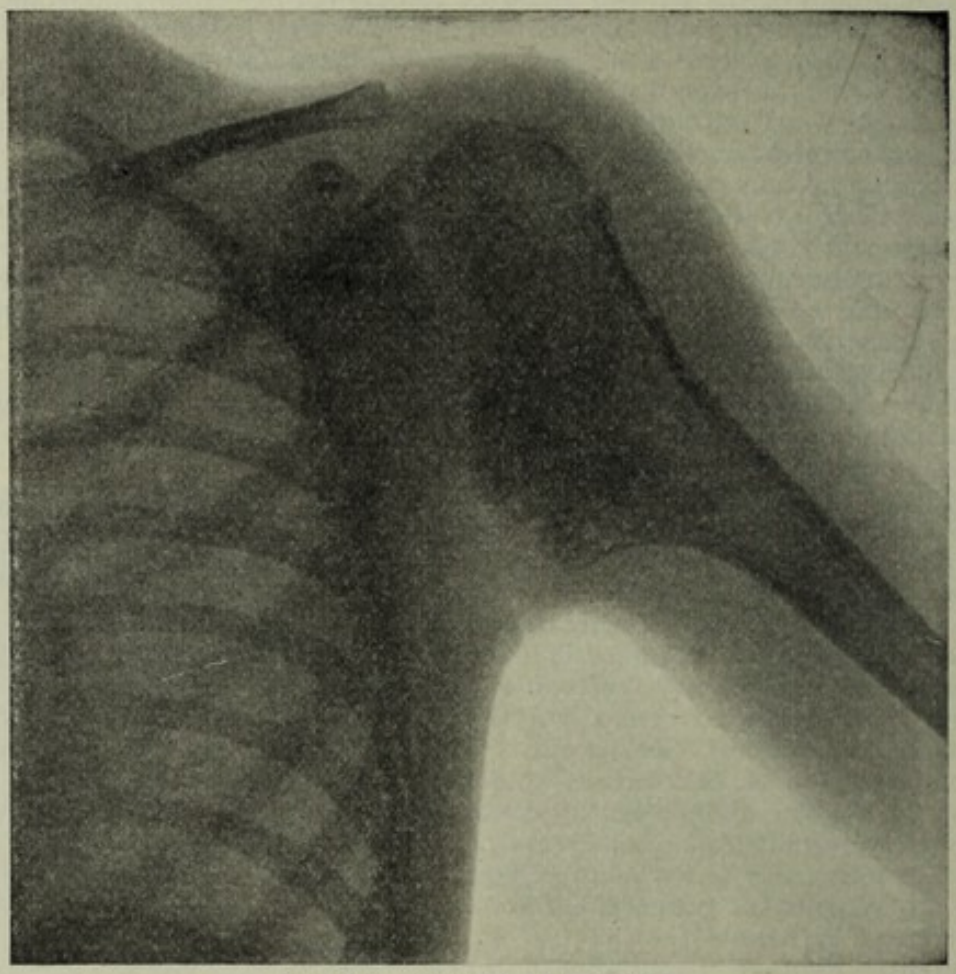


FIG. 147.—Osteoma of humerus.

Osteomata do not tend to become malignant, and do not recur after removal. The term *exostosis* or *osteophyte* has been used as being synonymous with osteoma, but



FIG. 148.—Osteophyte of os calcis.

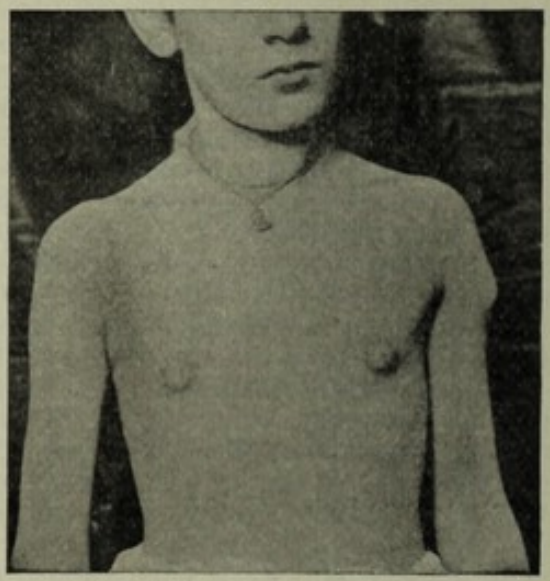


FIG. 149.—Multiple exostoses.

wrongly so, as an exostosis is an irregular, local, bony growth which does not tend to progress without limit, and which is, hence, not a tumor. A true exostosis is seen in the ossification of a tendon insertion (Fig. 148), in a limited growth from one of the

maxillary bones, and in a local growth from the last phalanx of the big toe, which latter form of growth is known as a *subungual exostosis* (Fig 150). A subungual exostosis grows slowly and for six months or more seldom lifts the nail sufficiently to cause much annoyance. It eventually causes severe pain and disability, the nail being raised far from its proper bed. In no case which I have seen has there been a history of infection or injury. Probably the growth begins because of irritation induced by ill-fitting shoes. *Osteophytes of the retrocalcaneal bursa* occasionally form when this bursa is inflamed. Inflammation of this bursa is known as *achillodynia* or *Albert's disease.* The bony masses sometimes found in the brain, lungs, testicles, various glands, and tumors are not true osteomata. Osteophytes may arise in a joint in various forms of arthritis.

Multiple exostoses (Fig. 149) are rare and depend upon some anomaly in and ossification of temporary cartilage. The condition has received various names, viz.: hereditary deforming chondrodysplasia, multiple cartilaginous exostoses, ossifying diathesis, multiple cancellous exostoses, rachitiform enchondrosis, chondral dysplasia, and multiple congenital osteochondromata (Ehrenfried in "Jour. Amer. Med. Assoc.," 1915, lxiv). Multiple and usually symmetric growths of cartilage or of bone and cartilage arise within or on bones, eventually producing deformity. The epiphyseal lines may undergo unnatural ossification. Exostoses arise during the period of active growth of bone. Three-fourths of the cases are males. Volkmann and others assigned

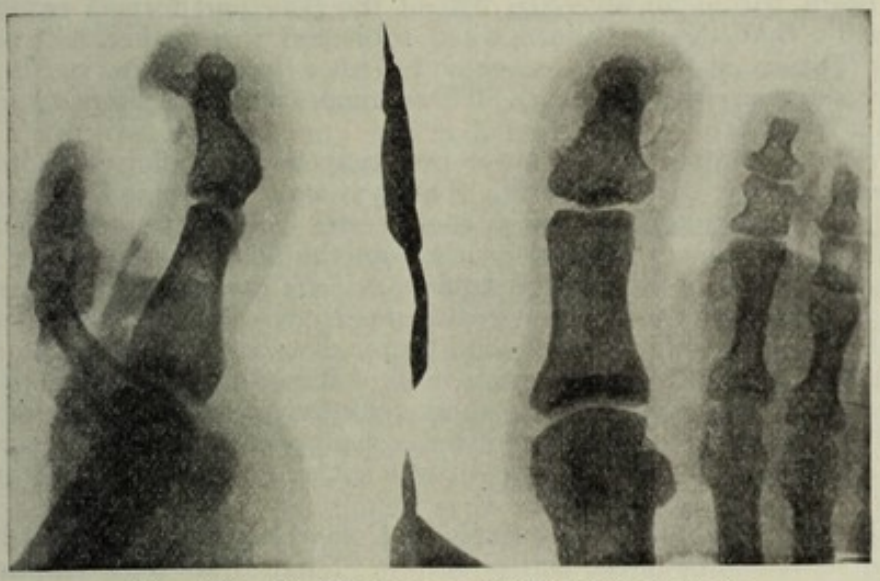


FIG. 150.—Davidson's case of subungual exostosis.

rickets as the cause. Virchow looked upon the condition as hereditary. Lippert traced the condition through four generations, but hereditary influence is not always evident. Tuberculosis has nothing to do with their development. One, several, or many of the growths may diminish in size or even disappear (Bruns, "Beiträge," xxxiv, 1902). In Oberndorf's case many tumors disappeared, but none after maturity ("New York Med. Jour.," March 5, 1910). This patient had syringomyelia and acromegalic symptoms, causing one to think of Charcot's statement that the gray matter of the cord contains the center for the nutrition of the bone. Exostoses within the cranium or spinal canal may cause symptoms from irritation or from pressure. Ehrenfried (Ibid.) has collected reports of 600 cases of multiple exostoses. He believes that most of the cases are hereditary, a mother free from the disease but holding the tendency from her father who had the disease, gives birth to a child which develops the affection, or, a father with the disease procreates a child which develops it. Among resultant deformities he mentions shortness of stature (from lack of growth in the legs), shortness of the arms, dislocation of the upper end of the ulna backward (because that bone grows less rapidly than the radius), and distortion of the limbs, the pelvis, and the shoulder-blades. Scoliosis may occur. In some cases growths become malignant.

Treatment.—Osteomata which are non-productive of pain or trouble do not demand removal. If they produce pain by pressure, if they crowd upon important structures, if they cause annoying deformities, or if they grow rapidly, then remove them by means

of chisels, gouges, or the surgical engine. If in a case of multiple exostoses, after the skeleton has ceased to grow, growths increase in size, remove them. Subungual exostosis should always be removed. The nail may be split and part of it taken away, and the bony mass be gouged away or be cut off with forceps. A better plan is to make a transverse cut on the end of the toe on a level with the dorsal surface of the phalanx, lift the flap, remove the exostosis by chiseling, and restore the flap to place. This operation does not injure the matrix (Davidson in "Amer. Jour. Orthop. Surg.," March, 1916).

Maxillary Tumors of Dental Origin.[1]—Ewing so designates them. They are composed of tooth tissue. Nearly forty years ago Malassez showed that in the fetus there is an excess of epithelial cells over that required for the development of the enamel organ. In the adult the extra cells remain grouped about the tooth from crown to apex, constituting the paradental epithelial débris. From these fetal cells spring supernumerary teeth, and most if not all epithelial cysts and solid tumors of the jaws.

It is probable that the dental follicle plays a part in the development of a dentigerous cyst. Cysts and solid tumors are divided into those connected with erupted teeth and those connected with non-erupted teeth. In the first group Ewing ("Neoplastic Diseases") places adamantinomata and radicular dental cysts, in the second group, coronodental cysts, dentigerous cysts, and odontomata.

Adamantinomata.—These epithelial neoplasms arise from the epithelial remains, and hence begin within an alveolus, distend the bone and form a cavity with such thin bony walls that they crepitate when subjected to pressure. "Eventually the capsule may rupture, and the disease extend further by continuity into antrum, orbit, or other tissues and cavities" (Ewing). These tumors may be solid or cystic and sometimes attain a great size.

Cysts are most common in the lower jaw, may be unilocular or multilocular, and projections may invade the bone itself. The cyst wall is cellular and fibrous, is lined with epithelium, and may contain bone or cementum. The cyst fluid is serous or mucous. From the epithelium cancer may arise, and from the fibrous and cellular structure of the wall, myxosarcoma or spindle-cell sarcoma. *Solid tumors* are much more disposed to malignancy, and are most common in the upper jaw. Even in these so-called solid tumors small cysts are common. A solid tumor distends the bone, but may project from an alveolus and be regarded as epulis. All of these solid tumors are to be regarded as carcinomatous. Adamantinoma is most common in women, is seldom observed until adult life; the growth usually endures and progresses for many years, and there is generally a history that a carious tooth was extracted some time before the tumor was observed.

Radiculodental cysts are usually single, but may be multiple. They develop from the epithelial remains about the end of a root. Small cysts may suppurate. Large cysts do occur.

Coronodental cysts are connected with teeth before their eruption. The cyst arises from the paradental débris, a tooth arrested in development and eruption being the causal irritation. Ewing (Ibid.) says, "Coronodental cysts present small intra-alveolar cavities into which project one or more imperfectly formed teeth. The wall is fibrous and the lining is composed of squamous or cylindric epithelium, or both types. The tooth is usually misplaced, lying horizontally, a position which prevents its eruption." In these cases the person is short one tooth.

Dentigerous cysts (follicular odontomes) result from increase in number of dental follicles. Supernumerary teeth, well formed or rudimentary, are contained within a cyst. There may be one tooth, several, many, or a vast number. The shell of bone is thin and crepitates on pressure.

Dentigerous cysts are equally frequent in the maxilla and mandible, are usually in the bicuspid or molar regions, and are generally noted during or soon after the second dentition (New in "Surgery, Gynecology, and Obstetrics," July, 1915). When a follicular odontome is discovered after the time of second dentition the patient is short one or more permanent teeth. The corresponding milk teeth may be retained. A cyst connected with the third molar appears much later than the second dentition. The position of the portion of the tooth is variable. In the maxilla it is usually just

[1] See Ewing's notable "Treatise on Neoplastic Diseases," and Sir J. Bland-Sutton's striking chapter upon Odontomes in his work on "Tumors." See also Bonney and Ellis in "Surg., Gyn., and Obst.," April 19, 1917. Steinfeld, in "Ohio State Med. Jour.," 1914, and New, in "Surg., Gyn., and Obst.," July, 1915.

beneath the orbit. In a case operated on by me in the Jefferson Clinic the tooth was in this situation.

Odontomata.—There is no hard-and-fast line between odontomata and dentigerous cysts. Ewing (Ibid.) tells us that "the typical odontome is composed of a congeries of more or less perfectly formed teeth usually surrounded by an epithelial membrane and a fibrous capsule." Odontomata are lower jaw growths, are seldom seen in the upper jaw, and are discovered before the patient is twenty-five years of age. As a rule one or more teeth have failed of eruption. A cyst or cysts may form.

A *fibrous odontome* is due to thickening of the tooth-sac, which prevents eruption of the tooth; fibrous odontomes are usually multiple, and are apt to occur in rickety children. A *cementome* is due to enlargement, thickening, and ossification of the capsule, the developing tooth being encased in cement. A *compound follicular odontome* is due to ossification of portions only of an enlarged and thickened capsule, and the tumor contains bits of cementum, portions of dentin, or small misshaped teeth. A *radicular odontome* springs from the papilla and arises after the crown of the tooth has been formed and while the roots are forming; hence it contains dentin and cement, but no enamel. *Composite odontomes* are formed of irregular, shapeless masses of dentin, cement, and enamel. All the above forms occur in man. They present themselves as hard tumors associated with teeth or in an area where teeth have not erupted. Occasionally an odontome simulates necrosis; it is surrounded by pus, and a sinus forms.

Treatment.—The diagnosis is now usually possible by the aid of the *x*-rays. Be in no haste to excise large portions of bone for a doubtful growth; incise first and see its nature. If it be small and superficial, remove an implicated tooth, curet with a sharp spoon, and pack with iodoform gauze. The operation can usually be done through the mouth. Recurrence is common, but malignant change is rare. Large and deep cysts and tumors require bone excision.

Myxomata are tumors composed of mucous tissue. They are rare as independent growths, although myxomatous change is frequent in the stroma of other tumors. The tissue type of these tumors is found in the vitreous humor of the eye and in the perivascular tissues of the umbilical cord (Wharton's jelly). Bowlby states that myxomata are, in reality, soft fibromata whose intercellular substance has been replaced by mucin. The myxomatous state may be a stage in the formation of a fibroma, a stroma not having developed. Myxomata may result from myxomatous degeneration of cartilage, of muscle, or of fibrous tissue. These tumors are soft, elastic, if superficial usually pedunculated, tremulous, and vibratory. The stroma is very delicate and carries minute blood-vessels. Cutting into a myxoma causes a straw-colored, clear jelly to exude. Myxomata grow slowly, are encapsuled, have but little circulation, and the diagnosis may be impossibe before removal of the growth. Deeply placed myxomata offer no earmarks for diagnosis. I operated on a very large one connected with the subdeltoid bursa, and the diagnosis was impossible until an incision had been made. In many myxomata there are projections like glove fingers, and an apparent removal may be incomplete. Some pathologists place myxomata among the malignant tumors, but most consider them as benign tumors, though they tend strongly to become sarcomatous (*myxosarcomata*). A sarcoma may undergo myxomatous degeneration.

Myxomata may arise from the skin; from the mucous membrane of the nose, the frontal sinus, the maxillary antrum, the womb, the auditory meatus, and the tympanum (*gelatinous polypi*); from the parotid and mammary glands; from the subcutaneous tissue, the nerve-sheaths, the intermuscular septa, the bursæ, the rectum, and the bladder (polyps). They may be congenital, but occur most often in young adults, as a result of inflammation. A sudden increase of growth indicates beginning malignancy (sarcomatous change). When a tumor begins to undergo myxomatous transformation we give to it a compound name; for instance, a chondroma undergoing myxomatous change is a chondromyxoma, a fibroma undergoing a like change is a fibromyxoma, etc. *Mucous polypi* grow from the mucous membrane of the nose, particularly from the outer wall near the middle turbinated bone, and often from the roof of the nares. Mucous polypi are soft and jelly-like, of a grayish color, and have stems or pedicles; they may be seen through the anterior nares, may project behind the veil of the palate, and may bulge out from the passages of the nose; they may be, and usually are, multiple; they may be present in one nasal fossa or in both fossæ, and they occur most commonly in youths and adults between the ages of fifteen and thirty-five years.

Hydatid moles of pregnancy are due to myxomatous changes in the chorion. What is known as *pseudomyxoma of the peritoneum* is a cystic condition of the peritoneum arising after leakage of an ovarian cyst or after operation in which cyst fluid ran into the peritoneal cavity. It is thought by most to result from the transplantation of mucous cells, but Goldschmidt (Abstract in "Surgery, Gynecology, and Obstetrics," Nov., 1914) believes it is a plastic peritonitis due to the irritation of a foreign body.

Treatment.—In treating myxomata, remove them promptly and thoroughly, Because of the danger of sarcomatous change. Myxomata tend to recur even without sarcomatous change, and after extirpation the wound should be desiccated. Polypi of the bladder are removed by means of cutting forceps after suprapubic cystotomy has been performed. Nasal polypi may usually be twisted off or be removed by the wire snare or galvanocautery. Occasionally when the growths are numerous and recur rapidly after removal, the inferior turbinated bones should be removed with a saw (Rouge's operation). This operation secures ready access to the area of disease, which can be attacked radically. A very soft myxoma breaks up when removal is attempted, and the base must be cauterized. Electrothermic methods are of high value in these cases.

Myomata are tumors composed of muscle-tissue mingled usually with connective tissue and blood-vessels. Pure myomata are met with in the wall of the gut, but most myomata contain connective tissue. Tumors composed of unstriped muscle tissue are called *leiomyomata*. Leiomyomata are usually benign, but may develop malignancy (*myoma malignum*). Tumors composed of striated muscle-fibers are known as *rhabdomyomata*. They are very rare and are always sarcomatous. Leiomyomata are found in the womb, in the prostate gland, in the walls of the gullet, vagina, stomach, bladder and bowel, in the broad ligament, ovary and round ligament, in the scrotum, and in the skin. Myomata usually begin during or after middle age; they are encapsuled, they grow slowly, they are firm and hard, and produce annoyance by their size and weight or by obstructing a viscus or channel. A leiomyoma of the posterior portion of the middle of the prostate gland is known as a "middle lobe." Leiomyomata may sometimes become arrested in growth and may even undergo atrophy and fibrous change. Malignant change is indicated by adhesion, very rapid growth, and finally by metastasis (to lymph-glands, lungs, etc.) and cachexia.

The so-called common *uterine fibroids* are leiomyomata. Rhabdomyomata are rare, but do occur as vaginal polyps in children and cervical growths in adults. *Uterine myomata* may originate within the walls of the womb (intramural myomata), from the muscular structure of the mucous lining (submucous myomata), or from the muscular tissue of the serous covering (subserous myomata). Intramural uterine myomata may be single or multiple and may grow to an enormous size. Submucous myomata project into the cavity of the womb (fleshy polypi), and may project into the vagina. They distend the uterus and are often accompanied by menorrhagia or metrorrhagia. In some rare cases the projecting tumor is detached by nature and the patient is cured; in some cases the myoma becomes gangrenous. A fleshy polyp may produce inversion of the fundus of the womb. Subserous uterine myomata cause trouble only by the inconvenience of weight or the discomfort of pressure. Uterine myomata are commonest in single women, and arise most frequently between the ages of twenty-five and forty-five. Negro women are especially prone to develop such tumors. They may never produce any symptoms. Some of these growths, by enlarging until they ascend above the pelvic brim, produce abdominal distention; some become jammed or impacted in the pelvis, and produce by pressure retention of urine, obstruction to the passage of feces, or hydronephrosis. Impaction may occur temporarily at each menstrual period. Many myomata produce uterine hemorrhage; some cause retroversion of the womb; some protrude from the cervical canal; some ore so large that they cause disastrous pressure upon the colon (obstruction), upon the iliac veins (great edema), or upon the ureters (hydronephrosis). Uterine myomata usually shrink after the menopause. Pregnancy in a myomatous womb usually ends in abortion. Uterine myomata may undergo fatty, calcareous, or myxomatous change, and may be infected by septic organisms as a result of the use of a uterine sound or of infection of the pedicle after oöphorectomy. Infection of a uterine myoma causes great enlargement, elevated temperature, sweats, and exhaustion. Sarcomatous change may take place. Virchow pointed out this fact in 1863. Cullen found sarcomatous change in 17 cases out of 1400. If there be a carcinoma in some other part of the body, metastatic deposit may occur in a uterine growth.

Uterine fibromyoma, if unoperated upon, often causes death. Noble claims that of cases denied operation or who refuse operation, 33 per cent. die and 28 per cent. become chronic invalids.

The symptoms of myoma of the alimentary canal are similar to or identical with the symptoms of malignant growths. Myomata of the skin are rare growths; they are encapsuled, firm or elastic, and painless.

Treatment.—Cutaneous myomata are removed in the same manner as fibrous tumors. A uterine tumor which causes symptoms should be operated upon. A tumor which causes no symptoms need not be operated upon if the patient can lead an easy life and can rest during the menstrual periods. Rest is an essential of the treatment. Ergot, thyroid extract, barium chlorid, and dilute sulphuric acid are recommended. Radium may arrest and prevent bleeding. In some cases the tumor shrinks, in some it disappears. If operation is required, the form of operation chosen depends upon the case. In some cases the operation should be vaginal, and may be dilatation and curetment, torsion or incision of the pedicle, enucleation, or hysterectomy. In other cases the operation should be by the abdominal route, and may be castration, ligation of vessels, myomectomy (cutting through the pedicle and closing with deep sutures), enucleation, shelling out growths from the wall, partial hysterectomy, or complete hysterectomy. Castration aims to create an artificial menopause, and so arrest hemorrhage and cause the shrinking of the growth. Sometimes it acts admirably, sometimes it fails, and it brings with it its own perils, for the sudden creation of the menopause is a great danger to the nervous system. For subserous myomata myomectomy is often the operation of choice. A very large tumor, a tumor which continues to enlarge after the menopause, or an infected tumor requires partial or complete hysterectomy. If a myoma of the prostate causes severe obstruction, perform a suprapubic cystotomy and remove the enlarged gland; or make both a suprapubic and a perineal opening, push the gland into the perineum, and shell it out with the finger, or if the condition is desperate simply make suprapubic drainage.

Neuromata.—A *true neuroma* (*ganglioneuroma*) is due to the hyperplasia of ganglion cells and may arise from the sympathetic nervous system, or the cerebrospinal nerves and ganglia, and when glia tissue is abundant it is called a *glioneuroma* (Behan in "Surgery, Gynecology, and Obstetrics," Sept., 1916). New ganglia may be formed. The true neuroma contains many septa of connective tissue which separate aggregations of nervous elements. Networks of fibrils or actual nerve-fibers may come from the cells. The most usual site for these congenital growths is in or about the suprarenal gland, from the embryonic cells of which they spring. Behan (Ibid.) points out that ganglioneuroma may spring from sympathetic ganglia, the coccygeal gland, the cords of the sympathetic, the brain, the spinal cord, the dura mater, the gasserian ganglion, the optic nerve, and the capsule of the knee. The condition is most commonly found in those under the age of twenty, and is usually solitary, though instances of metastasis have been reported. The growth is smooth and hard. In most cases the condition is not diagnosticated during life, but in some cases pressure causes symptoms. The tumor may attain large size. A *false neuroma* or *neurofibroma* is a fibrous tumor growing from a nerve-sheath or the connective tissue of a nerve, and is identical in structure with the sheath. False neuromata may be single, but they are often multiple; they may be as small as peas or as large as oranges; they are smooth and movable, and may cause great pain or may be painful only when pressed or struck; they may spring from roots, trunks, or branches, and they may be linked with the disease known as *molluscum fibrosum*. In *plexiform neuroma* some branches of a nerve enlarge and lengthen like an artery in a cirsoid aneurysm, the mass feels like beads or like a bag of worms; it is mobile, and no pain is felt on moving it, and it is generally congenital. In plexiform neuroma the nerve-sheath undergoes myxomatous change. *Malignant neuroma* is usually a primary sarcoma of a nerve-sheath, though any false neuroma may become sarcomatous.

Traumatic neuromata are false neuromata, and are occasionally well exhibited after nerve section or amputation. After nerve section the distal end shrinks and atrophies, the proximal end enlarges and becomes bulbous. A traumatic neuroma is composed of fibrous tissue which contains nerve-fibers. Such a growth is usually but not always painful on pressure or during dampness, and is most commonly seen in a stump which did not heal by first intention. In performing an amputation cut the nerves high up, and thus keep them out of the scar, permit them to remain mobile in their sheaths, and so prevent a tender stump. A tender stump may be due to anchoring of a nerve in a scar, the nerve ceasing to glide when the individual moves the

extremity. The condition known as painful subcutaneous tubercle was discussed on page 299.

Treatment.—The treatment for a true neuroma is thorough extirpation and, if the tumor is large, the operation may be very formidable. A false neuroma is to be removed, if possible, without destroying the nerve-trunk. If, in removing a neuroma, it is necessary to exsect a portion of a nerve-trunk, if possible always suture the ends of the divided nerve so as to facilitate restoration of function. For multiples neuromata—at least should the number be large or should molluscum fibrosum exist—surgery can do nothing. Plexiform neuromata may often be removed, but amputation may be required. Painful neuromata in stumps should be excised.

Gliomata.—These tumors develop from neuroglia and more often from the white substance than from the gray. They are usually single, and arise not unusually in the brain, rarely in the cord, and very rarely in the cranial nerves. They may take origin in one of the cerebral hemispheres, in the cerebellum, in the pons, or in the medulla. Some gliomata are soft and bear a close relationship to sarcoma; others are hard and resemble fibroma.

A glioma is a circumscribed growth in contrast to a gliosis, which is a wide-spread and unlimited hyperplasia of the neuroglia. Syringomyelia is due to gliosis of the spinal cord.

"A glioma consists of cells containing rounded or oval nuclei with very little protoplasm and fine protoplasmic extensions which interlace and form an intercellular reticulum" (Stengel).

A glioma passes almost insensibly into surrounding tissue, and there is no distinct edge; hence, because of the slight differentiation from brain substance, it may be overlooked during exploration. It is harder than the surrounding tissue, is vascular and of a pink or red color, and the normal shape of the part is often very little altered, although the tumor may reach the size of a lemon.

Hemorrhage may take place into a glioma, softening may occur, cavities may form, cystic degeneration may be extensive, or the growth may become sarcomatous or psammomatous. The symptoms of a glioma of the brain depend on the situation. It is probable that soft glioma, at least, belongs in the group of malignant tumors.

Treatment.—When a glioma of the brain can be localized and is hard, removal should be attempted. No attempt should be made to remove a soft glioma.

Angiomata or Hemangiomata.—An angioma is a tumor composed largely of dilated blood-vessels. The older surgeons called such growths *erectile tumors*. Some of the so-called angiomata are not genuine new growths, but are due to dilatation and elongation of blood-vessels.

Simple or **capillary angiomata, nevi, telangiectases,** or **"mother's marks,"** which affect the skin or subcutaneous tissue, are composed of enlarged and twisted capillaries and of anastomosing vessels surrounded by fat. These growths are congenital or appear in the first few weeks of life; they are flat and slightly raised, and are of a bright pink color if composed chiefly of arterioles, and are bluish if composed mainly of venules; they can be almost completely emptied by pressure; they occasionally pass away spontaneously, but usually grow constantly and may become cavernous; they may ulcerate and occasion violent or fatal hemorrhage. One or several large vessels connect a nevus to adjacent blood-vessels. **Port-wine** or **claret stains** are pink or blue discolorations due to superficial nevi of the skin; they may be small in extent or they may involve a very large area, are not elevated, and do not usually spread. *Telangiectasis* is a form of nevus involving the skin and subcutaneous tissue in which many arterioles and venules exist. Simple angiomata are common on the forehead, the scalp, the face, the neck, the back, and the extremities. They may appear on the labia, the tongue, or the lips.

Cavernous angiomata, or **venous nevi** (Figs. 151–154), resemble in structure the corpora cavernosa of the penis; they consist of large endothelial lined spaces with thin walls carrying blood, and there may be distinct vessels as well. Arteries send blood into the spaces, the veins receive it from the spaces. These channels and sinuses are enormously distended capillaries. Cavernous angiomata arise in the skin and subcutaneous tissues; they are usually congenital, but may develop from simple angiomata; they are purple or blue in color; are more distinctly elevated than the capillary nevi; may be either cutaneous or subcutaneous; swell when the child cries, and are apt to pulsate; they may be emptied by pressure and often look like cysts with very thin walls. Cavernous angiomata may arise in the breast (Fig. 153), the tongue, the lip, the cheek,

the gums, the subcutaneous tissues, the liver, the spleen, the kidney, or the muscles. If an angioma contains an excess of fat, the growth is called a "nevoid lipoma."

Plexiform angiomata are known as "cirsoid aneurysms" or aneurysms by anastomosis (see page 380).

Angiomata noticed soon after birth may disappear completely or may enlarge progressively.



FIG. 151.—Dr. Hansell's case of cavernous angioma of the eyelids.



FIG. 152.—Cavernous angioma of face.

Treatment.—A capillary nevus can often be quickly cured by touching it with fuming nitric acid. A second application of acid may be required. The growth may be destroyed by heat—"a knitting-needle at a dull-red heat or the galvanocautery" (Wharton). The application of ethylate of sodium, electric desiccation, fulguration, or electrolysis will destroy the growth. Solid carbon dioxid is valuable to destroy

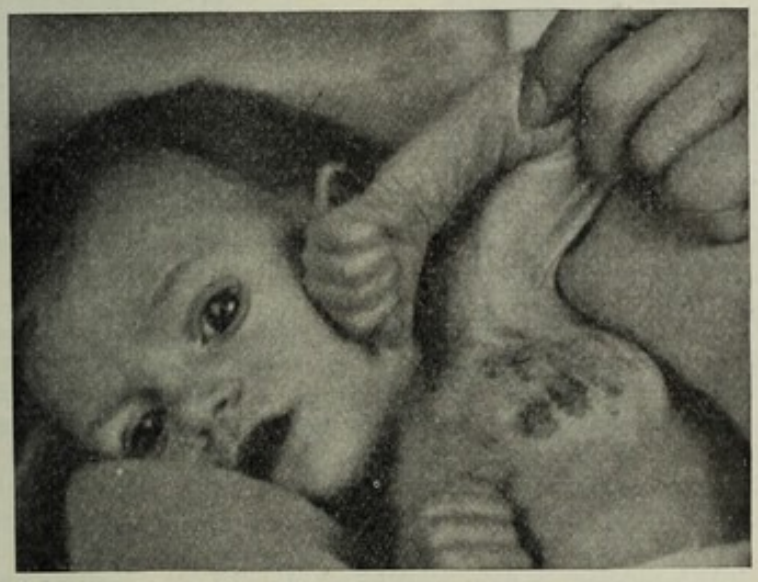


FIG. 153.—Congenital cavernous angioma of breast (author's case).

capillary nevi. Often but one application is necessary, but in some cases two or more are required. Astringent injections are dangerous unless the base of the nevus is first ligated, because they may lead to the formation of emboli. Injection of boiling water was advised by Wyeth. It is usually very satisfactory. The surgeon wears white cotton gloves over his rubber gloves in order that he may handle the hot syringe. The needle is introduced through sound skin and is carried beneath the growth, but

must not approach too closely the skin of the other side. Babcock ("N. Y. Med. Jour.," March 3, 1917) injects quinin and urea hydrochlorid. It causes no coagula, but does produce necrosis. Considerable pain and edema follow the injection and sometimes an ulcer forms. For an extensive area Babcock uses a 33 per cent. solution—for a limited area, a 50 per cent. solution. The material is supplied in ampules each containing 2 c.c.

Small port-wine stains may be removed by electrolysis or multiple incisions, but extensive stains are ineffaceable. Solid CO_2 may be used. Two or three applications are made in the same place, and then another spot is selected. It usually fails to cure. Small nevi may be ligated under harelip pins, larger nevi may be strangulated in sections by the Erichsen suture (Fig. 155), or may be completely excised. Excision is usually the best plan for the cure of angiomata if it will not produce serious disfigurement. It is rapid, thorough, and if the growth is small, leaves but a trivial scar. Excision should be employed if we feel sure that the edges of the wound can be subsequently approximated and that there will not be a dangerous loss of blood. It is sometimes justifiable to excise an angioma even when approximation of the wound will obviously be impossible. In such a case the raw surface should be covered with Thiersch grafts.

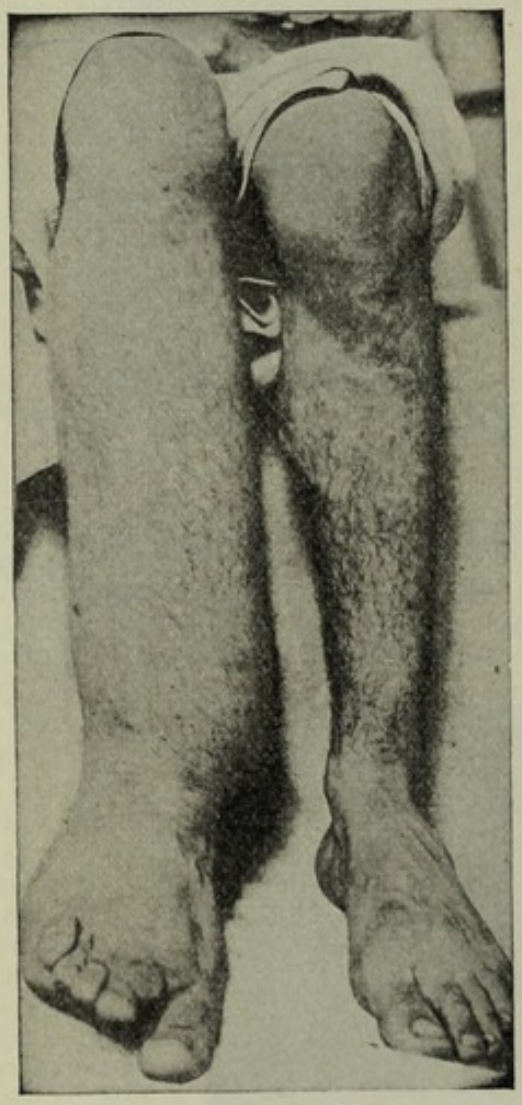


FIG. 154.—Cavernous angioma: Subcutaneous tissue of leg.

Most superficial nevi and some cavernous angiomata can be treated by solid CO_2 and, if this fails, by excision. The incisions must be beyond the dilated vessels. In large angiomata involving the skin and also deeper parts, or involving a structure like the lip, which it is undesirable to remove, electrolysis should be employed.

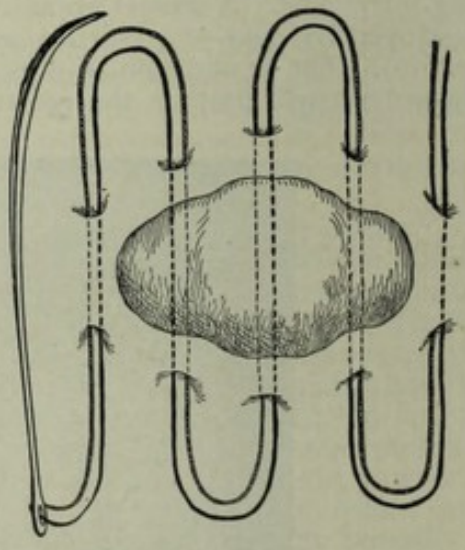


FIG. 155.—Method of applying Erichsen's suture.

The operation should be carried out with aseptic care, and if the tumor is large an anesthetic should be given.

The positive pole produces a firm and hard clot. One or more needles connected with the positive pole are inserted into the tumor, the needles being insulated to within about $\frac{1}{4}$ inch of their points. A flat moist pad is placed upon the skin near the tumor and is attached to the negative pole, and the pad is moved from time to time during the operation.

From 25 to 75 milliamperes is the proper strength, and the current is passed for ten minutes. The current is increased for a moment before withdrawing the needles, otherwise they will stick to the tissue and cause bleeding when torn loose. After the withdrawal of the needles the nevus will be found to be hard, but the hardness will

gradually disappear. It may be necessary to repeat the operation a number of times at intervals of ten days.[1]

When solid CO_2 is applied it subjects the tissue to a temperature of 79° F. below zero. It is called carbonic-acid snow. It is applied with pressure. This drives out the blood. It is held against the part for thirty or forty seconds. It drives the color out of the part, but a few minutes after the cessation of the action color returns, reaction occurs, the surface becomes moist, and fibrinous inflammation takes place (E. R. Morton, "Lancet," May 7, 1910).

Necrosis seldom arises. Within an hour a vesicle forms, which should be opened aseptically. A crust gathers, which drops off in about two weeks, leaving "a soft and elastic scar," the color of the normal skin (Morton, Ibid.).

Radium is particularly powerful in removing angiomata, and in many cases it should be the treatment. In some cases the *x*-rays are preferred.

I always ask an experienced roentgenologist to see my angioma cases in order that I may learn which ones are suitable for treatment by radium or *x*-rays.



FIG. 156.—Cavernous angioma and lymphangioma.

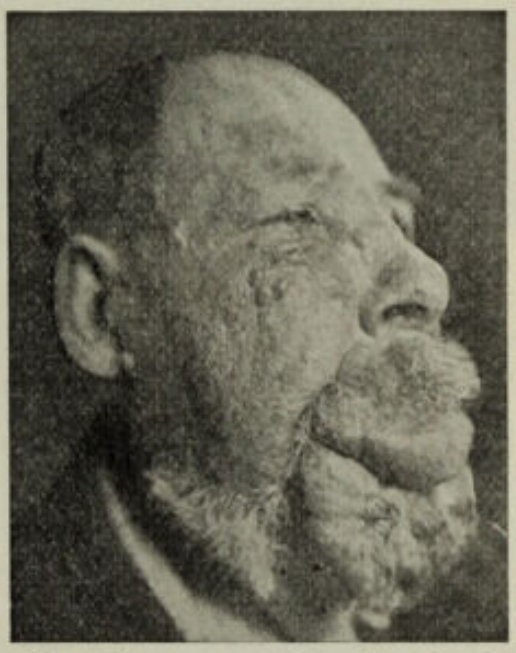


FIG. 157.—Cavernous angioma, lymphangioma, and lymphangiectasis, also beginning cancer.

Lymphangiomata are tumors composed of dilated lymph-vessels and are often, though not invariably, congenital (Fig. 157). A *lymphatic nevus* is a colorless or faintly pink elevation; if it is punctured with a needle, lymph flows from the puncture. One or several nevi may be present in the same individual. The dilatation is due to blocking of the lymph-channels. Local lymphangioma of the tongue is manifested by a cluster of papillary projections containing lymph. *Macroglossia* is a congenital enlargement of the anterior portion of the tongue, which enlargement grows more and more marked, until finally the tongue is forced far out of the mouth. This condition of tongue enlargement is due to lymphangioma of the mucous membrane (Fig. 158). *Lymph scrotum* is due to a similar growth. A collection of warty-looking lymphatic dilatations is called *lymphangiectasis*. Just as cavernous hemangiomata constitute a variety of blood-vessel tumors, so *cavernous lymphangiomata* constitute a variety of lymph-vessel tumors, and the spaces of the latter are filled with lymph instead of with blood (Fig. 159). The two conditions may be combined (Figs. 156 and 157). Areas affected with lymphangiectasis are liable to repeated attacks of erysipelas-like inflammation. Whether this inflammation is causative or secondary is not known. In tropical countries block-

[1] Cheyne and Burghard's "Manual of Surgical Treatment."

ing of lymph-channels may be brought about by the filaria sanguinis hominis, a parasite which lurks in the lymph-vessels during the day and is found in the blood at night only. Lymphangiectasis is often the first stage of elephantiasis.

Treatment.—Radium may cure a lymphangioma. A lymphatic nevus may require excision. In macroglossia, if radium fails, the bulk of the mass should be removed by a V-shaped cut, the mucous membrane being sutured so as to cover the stump. In conditions due to the filaria, anilin-blue has been given internally.

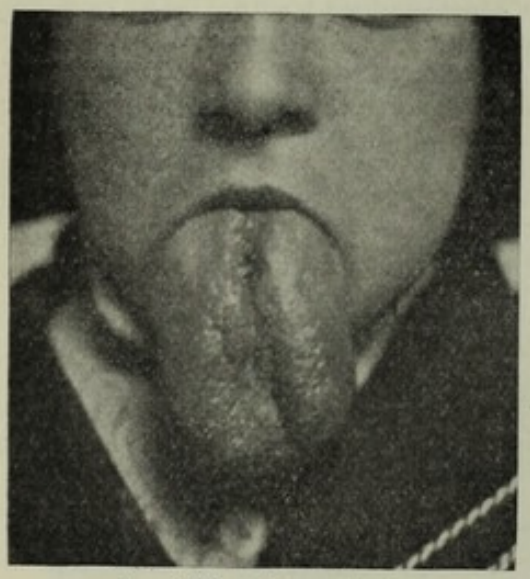


FIG. 158.—Macroglossia.

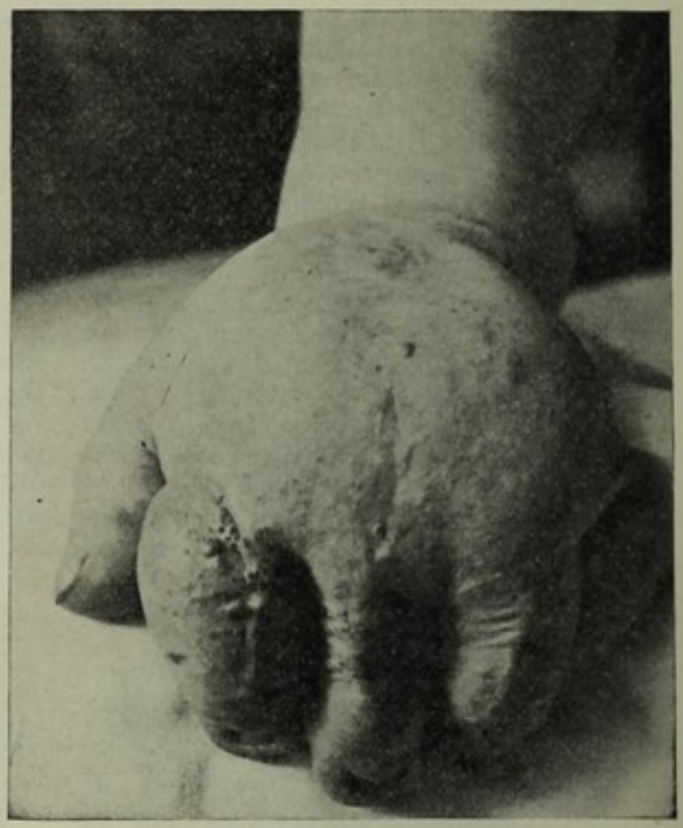


FIG. 159.—Author's case of lymphangioma of both hands.



FIG. 160.—Sarcoma of antrum.



FIG. 161.—Sarcoma of antrum.

Malignant Connective-tissue Tumors, or Sarcomata.—A sarcoma is composed of cells of the connective-tissue type and placed in atypical arrangement. It is the

malignant tumor derived from mesoblastic cells. The definition is useful clinically, as it makes clear its difference from cancer, but in some respects it is wrong from the embryologic standpoint. Ewing says: "Thus it permits the inclusion of gliosarcomas, which are of ectodermal origin, and it accepts as sarcoma certain tumors chiefly of endothelial origin, while rejecting others" ("Neoplastic Diseases"). In structure a sarcoma exhibits imperfect development. Sarcomata are embryonic in structure, the intercellular substance being very scanty, and they *resemble* a process of chronic inflammation. They rarely have a definite stroma, and the constituent cells, as a rule, proliferate with great rapidity. If a sarcoma has a stroma of connective tissue, this stroma contains lymphatics and such a sarcoma infects adjacent glands. In most cases there are no connective-tissue stroma and no lymphatics. In a sarcoma without a definite stroma the blood-vessels are not surrounded by lymph-spaces and are quickly invaded by cells (B. H. Buxton). The rapidly growing forms are very vascular, the blood flowing in vessels whose walls are very thin or running in canals lined by endothelium and bounded by sarcomatous cells. Such a tumor may pulsate and have a bruit, and hemorrhage often takes place into its substance. A rapidly growing soft sarcoma with dusky skin above it (Fig. 162) may be mistaken for an abscess. A slowly growing sarcoma has but few vessels. Sarcoma tends strongly to infiltrate adjacent parts. The growth disseminates by means of the blood and the vessel walls, particles of the tumor being carried by the venous blood to the heart, and from this organ



FIG. 162.—Small round-celled fungating sarcoma of neck.



FIG. 163.—Dr. Ford Ware's case of sarcoma of the scapula in a child five years of age.

to the lungs, where they lodge and form secondary growths. Emboli from these secondary foci are sent out by the arterial blood to various portions of the body, as the bones, kidneys, brain, liver, etc. This process is known as *metastasis*. In some cases sarcoma is disseminated widely throughout the body, almost all the tissues showing minute white spots of secondary sarcoma which resemble tubercles. Such wide-spread dissemination is called *sarcomatosis*. Sarcoma follows the vein walls for considerable distances and builds elongated masses of tumor substance inside the veins. The primary tumor may possess a capsule when it is in an early stage, but soon loses this except in very slow-growing varieties or in mixed forms growing by central proliferation, but secondary sarcomata are often encapsuled. Sarcomata may arise at any age from birth to extreme senility, but they are commonest during youth and early middle age. They are not hereditary. They often follow traumatism and inflammation. A number of observers maintain that they are due to parasites (the question of the parasitic origin of malignant disease is discussed on page 294). A sarcoma may be primary or may arise from malignant change in an innocent connective-tissue growth (chondrosarcoma, fibrosarcoma, etc.). A sarcoma rarely affects adjacent lymphatic glands unless it contains lymphatics, and the great majority of sarcomata do not contain them. Occasionally sarcoma cells are carried to adjacent glands by the vein walls rather than by the lymph-stream. Sarcoma of the tonsil, sarcoma of the testicle, melanotic sarcoma, and lymphosarcoma do affect the glands. The skin over the tumor may give way, a bleeding fungous mass protruding (fungus hæmatodes)

(Figs. 162, 164, and 165), and suppuration may cause septic enlargement of adjacent glands. In the course of growth of a sarcoma there may be irregular episodes of elevated temperature. After removal of a sarcoma the growth tends to recur, and the recurrent tumor may be either more or less malignant than its predecessor, the degree of malignancy being in direct ratio to the number and smallness of the cells. A sarcoma is malignant by local tissue infection and by dissemination. Sarcomata rarely cause pain when they are not ulcerated. They are commonest in the skin and connective tissue of the extremities, but they also arise from neuroglia, bone, med-



FIG. 164.—Small round-celled sarcoma of neck. Skin has given way and a bleeding mass is exposed.



FIG. 165.—Sarcoma of neck (Horwitz).

ulla of bone, periosteum, the lymphatic glands, fascia, the breast, the testicle, the eyeball, the parotid, and other parts. A pigmented mole may become sarcomatous. Hemorrhages into a sarcoma often occur, with the result of suddenly increasing the size of the mass and formation of blood-cysts. Sarcomata are subject to partial fatty degeneration, to myomatous changes which produce cavities filled with fluid, to calcification, and occasionally to necrosis of large masses.



FIG. 166.—Small cell sarcoma from fascia of foot.

Sarcoma of Bone and of Periosteum. (See page 450.)

Varieties of Sarcomata.—The following species of sarcomata are recognized:

1. *Round-celled sarcoma* is a tumor composed of round or spherical cells and resembling a chronic inflammatory area. The intercellular substance is scanty, the mass is soft and vascular, and grows with great rapidity. It often softens, and may become

cystic. The cells may be small or large. The smaller the cells, the more malignant the growth. A growth composed of small round cells is the most malignant form of sarcoma (Fig. 169). *Lymphosarcoma* is a form of round-celled sarcoma which arises

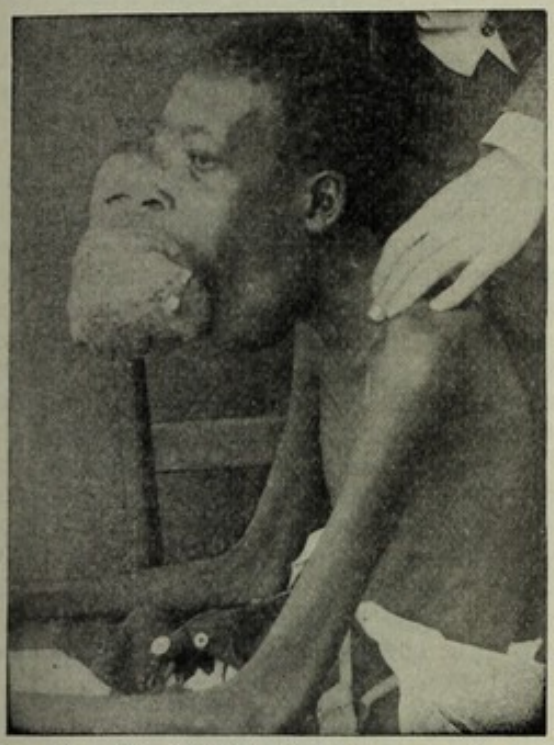


FIG. 167.—Dr. W. R. Bishop's case of small-celled sarcoma of the antrum.

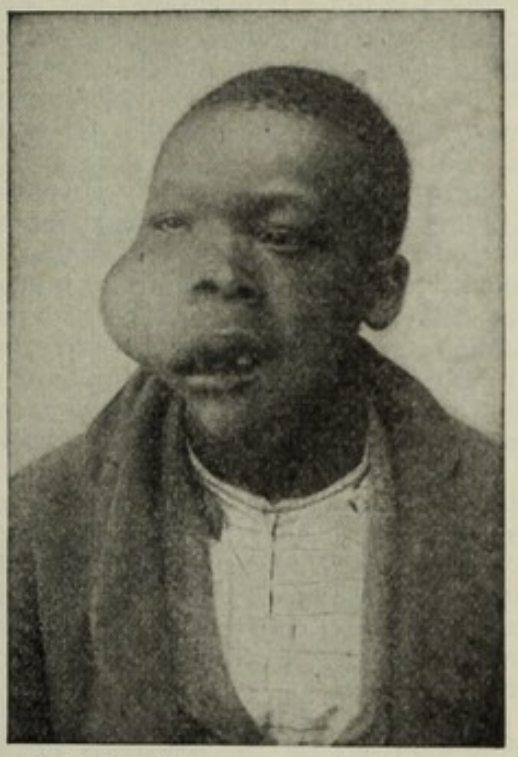


FIG. 168.—Osteosarcoma of eighteen months' standing of right side of superior maxilla. Note bony lump on left side of lower jaw.

from lymphatic glands, lymphoid tissues, the thymus gland, the spleen, and some other structures. The structure of a lymphosarcoma bears some resemblance to the structure of a lymph-gland in the fact that it has a reticulum which looks like that of lymphadenoid structure. *Chloroma* is a form of lymphosarcoma arising particularly from the medulla of the bones of the cranium and face. Secondary growths occur in the sternum,



FIG. 169.—Small round-celled sarcoma of the neck.

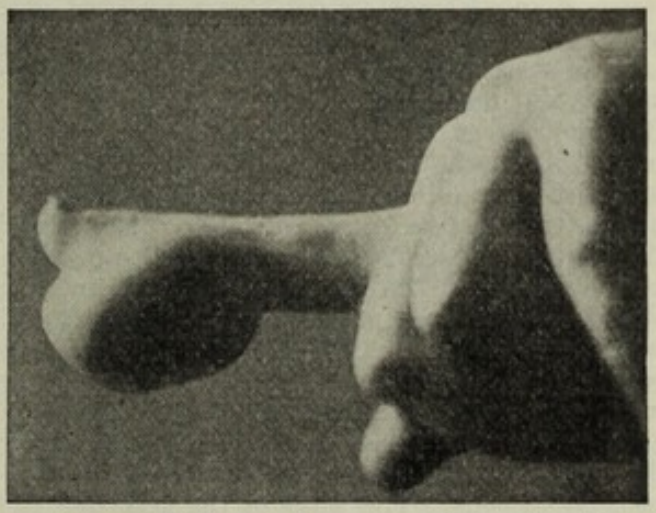


FIG. 170.—Spindle-celled sarcoma of sheath of flexor tendon of finger.

vertebræ, seldom in the long bones, especially in the skull, orbit, sinuses, and lymph-glands of the mediastinum. The first symptom may be blindness from optic neuritis, exophthalmos, deafness, enlarged axillary or inguinal glands, or bleeding into the pleura. It is often but not always, associated with the blood-picture of leukemia.

The cells may resemble those of bone-marrow, but they are not diagnostic. In a chloroma of the mammary gland reported by Reid, the blood-picture of leukemia was absent. The cells contain greenish pigment, hence the name. What is known as *glioma* of the retina is not a true glioma, but is really a sarcoma composed of small round cells. It often arises in infancy and is sometimes noted at birth. It may be a family disease. Wilson reported 8 children in one family with retinal glioma ("Trans. Path. Soc.," at Dublin, 1871–74). Newton reported a family of 16 children, 10 of whom died of retinal glioma, and in 7 of them the condition was bilateral ("Australas. Med. Gaz.," May, 1902).

2. *Spindle-celled sarcoma* is a tumor composed of large or small spindle-shaped cells lying in a matrix, which may be homogeneous, but which may show some attempt at fiber formation. Angular cells and stellate cells are often present. The cells may be placed in columns, which are at some places nearly parallel and which at others diverge or interlace. Often there is no orderly arrangement. Spindle-celled sarcomata are usually harder than round-celled growths, but are sometimes quite soft. Cystic changes may occur. If there is a large amount of intercellular substance the growth is known as a *fibrosarcoma*. A *rhabdomyoma* is really a spindle-cell sarcoma containing striated muscle-cells. The spindle-cell sarcomata often contain cartilage. Spindle-cell growths are by no means as malignant as round-cell tumors. Often they do not show any tendency to metastasis. The greater the amount of intercellular substance and the fewer the cells, the less the malignancy. Bloodgood points out that in one group of cases (the least malignant) the spindle cells exhibit a disposition to form fibroblasts (*fibrospindle-cell sarcoma*). In another group (the most malignant) there are no fibroblasts and round cells are distributed among the spindle cells (*mixed spindle-cell* and *round-cell sarcoma*). Spindle-cell growths constitute the majority of sarcomata met with in practice.

3. *Giant-cell sarcoma* resembles in structure the red marrow of growing bone and is characterized by the presence of numerous very large cells with many nuclei, looking exactly like the myeloplaques of bone-marrow. Such a growth is maroon colored on section and contains giant-cells surrounded by round cells or by spindle cells. Bloodgood says that the tumor when fresh has a striking "hemorrhagic mottled coloring," and further, the tumor is very friable and "resembles hemorrhagic granulation tissue" ("Jour. Amer. Med. Assoc.," Jan. 1, 1908). It arises usually from bone, especially from the interior of the end of a long bone, hence is often called *medullary* or *myeloid sarcoma*. As a matter of fact it is only medullary or myeloid when it springs from bone-marrow. The term "osteosarcoma" should be restricted, as Bloodgood suggests, to bone tumor with accompanying formation of new bone. Giant-cell sarcoma is almost invariably single, but Rehn reported a case of multiple giant-cell sarcoma of bone, and Crile and Hill reported another. Bloodgood denies the occurrence of metastasis. *Epulis* is a form of giant-cell sarcoma. The giant-cell tumor may arise from other structures than bone. Giant-cell sarcoma is the least malignant form of sarcoma. Metastases do not occur and the growth often admits of complete extirpation and cure. Some surgeons do not class these growths with sarcomata. Bloodgood regards their malignancy as very slight. Friedländer looks upon them as benign angeiomata in which giant-cells have been formed by endothelial cells budding into spaces lined with endothelium. Giant-cell growths are most common in those under twenty-five years of age. They usually come on almost suddenly after a traumatism. A giant-cell sarcoma within a bone slowly expands it. Although tenderness exists from the start, there is seldom much pain until expansion is considerable. When the bone becomes very thin it may crackle on pressure. This is called the *ping-pong bone* (Connell in "Surgery, Gynecology, and Obstetrics," April, 1915). The tumor develops slowly and runs a long course. It does not penetrate the bone as would a malignant medullary sarcoma.

4. *Alveolar sarcoma* is a tumor containing both round cells and spindle cells, and characterized by the formation of acini, filled with round cells of large size resembling epithelioid cells. The walls of the acini are formed of spindle cells and fibrous tissue, and in these trabeculæ are the blood-vessels. The collection of the cells in the alveoli makes the structure resemble that of a cancer. Such growths are often pigmented. Alveolar sarcomata arise particularly from moles of the skin, but may arise from lymphatic glands, serous membranes, the testicle, and other parts. Such growths are very malignant.

5. *Melanotic or Black Sarcoma* (Fig. 171).—The color of such a tumor is due to pigment in the cells or matrix. These growths are usually composed of round cells,

but may consist of spindle cells, and they are sometimes alveolar. Melanotic sarcomata spring from parts which contain pigment (for instance, the skin and the choroid coat of the eye, pigmented moles, and pigmented nevi); they are very malignant; they implicate related lymphatic glands, undergo early metastasis, and during their existence the urine contains pigment. Melanuria does not of necessity mean that there is a melanotic neoplasm. It may occur as a result of protein destruction when there is no melanotic growth (Peters in "Arch. Int. Med.," Nov., 1923).

Early metastasis is by lymph-vessels and leads to secondary glandular tumors. Later metastasis is by the blood-vessels and leads to secondary tumors in the lungs, liver, and other parts. The tumors occur usually in those beyond middle life. They soon ulcerate and later fungate. The patient usually dies in from one to six years (see Hetzler and Gibson in "Annals of Surgery," 1914, lx).

Malignant growth from a congenital pigmented mole used to be regarded by most observers as melanotic sarcoma, but Bloodgood would place these growths in a group by themselves. He says that the weight of opinion is on the side of those who maintain that the cells are of epithelial origin misplaced early in embryonic life, and that the tumor is a cancer. Many surgeons still regard such a tumor as sarcoma.

6. *Hemorrhagic sarcoma* is a sarcoma containing blood-cysts which result from parenchymatous hemorrhages.

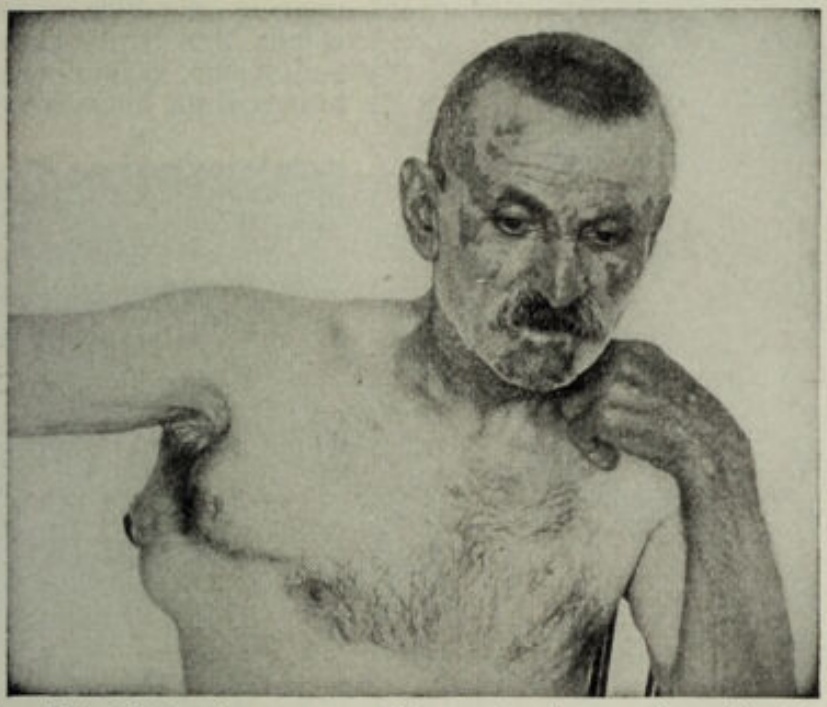


FIG. 171.—Melanotic sarcoma. Observe the pigmentation of the face.

7. *Angeiosarcoma* or *hemangeiosarcoma* takes origin from the outer coat of a blood-vessel, and in this differs from endothelioma, which arises from the lining cells of lymph spaces. The growth is often very vascular, and when the blood-vessels are notably dilated the tumor is called a *telangiectatic sarcoma*. The ordinary forms of angeiosarcoma are only moderately malignant, but alveolar and melanotic forms occur which are highly malignant. Angeiosarcoma may arise in the skin, in a serous membrane, in intermuscular structure, in bone, or in a salivary gland. It most frequently takes origin from a nevus.

Perithelioma is a very malignant variety of angiosarcoma which is most often noted growing from the skin, the kidney, or the bone. It orginates from the perithelial cells, which are between the capillaries and the perivascular lymph-spaces.

8. *Cylindroma, or Plexiform Sarcoma.*—In this variety the sarcoma cells adjacent to vessels have undergone hyaline or myxomatous degeneration; the cells distant from vessels are unchanged. Section shows the sarcoma cells apparently contained in spaces with hyaline walls. These degenerative changes occur most often in the angiosarcomata. Cylindromata arise from the brain, salivary glands, lacrimal glands, and rarely from the subcutaneous tissue. These growths are only moderately malignant.[1]

9. *Mixed tumors* consist partly of mature and partly of embryonic tissue, the

[1] Stengel, "Text-book of Pathology."

cellular elements exceeding the adult elements in amount. Among these mixed tumors are *fibrosarcoma* or the *recurrent fibroid tumor*, *myxosarcoma* (Fig. 172), *chondrosarcoma*, *gliosarcoma*, and *osteosarcoma*.

10. *Endotheliomata* are tumors springing from the endothelium of lymph-spaces, and the name is retained no matter what changes the growths ultimately undergo. Some writers have included under the term "endothelioma" *psammoma*, myxosarcoma, angiosarcoma, and plexiform sarcoma. Others consider endothelioma a special and characteristic form of sarcoma. Some would not consider it with the sarcomata at all. The growth may take origin from the "endothelium of the perivascular lymph-spaces, of the lymph-vessels, and of the great serous cavities (peritoneum, pleura, meninges)."[1] The characteristic cell is the endothelial cell, usually known as the epithelioid cell. The structure of these tumors is very variable and depends upon the origin; some tumors "recalling the original vascular network" ("American Text-book of Pathology"), others being distinctly alveolar. Many pathologists consider a *psammoma* of the dura to be an endothelioma with a fibrous stroma. A psammoma contains calcareous particles. In appearance an endothelioma strongly resembles cancer, and such a growth is often spoken of as endothelial cancer. Such growths can arise in many different situations, but are particularly common in the skin over the parotid gland, the lymph-glands, the bone, peritoneum, pleural membrane, membranes of the brain, ovary, and testicle.



FIG. 172.—Hansell's case of cystic myxosarcoma of the orbit.



FIG. 173.—Myxosarcoma of eyeball.

I have removed an endothelioma of the tonsil, one of the mammary gland, two of the nasopharynx, one of the superior maxillary bone, and three of the carotid gland. The proliferating endothelial cells lie in lymph-spaces. Many endotheliomata grow rapidly, secondary growths form, and metastases are apt to pass to the serous membranes. Certain endotheliomata grow slowly, do not infiltrate adjacent structure, and do not produce secondary growths. In the brain and cord endothelioma may produce no symptoms for a long time. It is not as yet possible, clinically, to differentiate distinctly between endotheliomata and ordinary sarcomata.

11. *Mycosis*, or *granuloma fungoides*, is a disease which resembles sarcoma in many particulars and may perhaps be a form of sarcoma. It attacks the skin and subcutaneous tissues. It is preceded for months or years by an eczematous or urticarial condition. The skin becomes red and swollen; numerous pinkish or reddish nodules or flat areas of induration form; the nodules become distinct tumors, soften at their centers, usually ulcerate, and fungation takes place. When ulceration occurs mushroom-like growths form. Microscopically, the tumor resembles a lymphadenoma. Mycosis fungoides is considered by some pathologists to be multiple cutaneous sarcoma. It

[1] "An American Text-book of Pathology," edited by Hektoen and Riesman.

is very chronic and lasts for months or even years. It was first described and was named by Alibert.

Treatment of Sarcomata.—Remove a sarcoma at once if it is in an accessible spot. Never delay removal, and always cut well clear of it. If affecting a part where amputation is impossible, a very rapidly growing sarcoma will almost inevitably return, and the very malignant variety, if uninterfered with, may terminate life in six months; but even in such a case operation may postpone the evil day and render it possible that death will occur from metastatic growth in an organ, and that the patient will escape the horrors of ulceration and hemorrhage from the original tumor. Slowly growing and hard tumors offer better prospects of cure. The mixed tumor (as a recurrent fibroid) may repeatedly recur, and yet the patient may be cured at last by a sixth, an eighth, or a tenth operation. In a case of spindle-cell sarcoma of the breast the younger Gross performed 22 operations in the course of four years, and eleven years later the woman was well. In a case of recurrent fibroid of the neck the younger Gross operated five times. Three years after Prof. Gross's death I operated upon the same patient, and again two years later. Nine years after the last operation she was alive and well. In sarcoma of a long bone (though not in giant-cell sarcoma) amputation should, as a rule, be performed. Bloodgood proves that in some of these cases extensive excision is just as useful. In giant-cell sarcoma incision and curetting may be employed, or, if this is insufficient, subperiosteal excision. Curetting is admissible only when there is a definite shell of bone beyond the tumor. Bloodgood has reported the cases of giant-cell sarcoma from Halsted's clinic. The reports show that excellent results follow this plan of treatment. If the soft parts are involved, they must be removed wide of the growth. Amputation is necessary only when the removal of soft parts must be so extensive as hopelessly to mutilate the limb. In sarcoma of either jaw-bone, excise; of the eye, enucleate; of the testicle, remove the gland. Sarcoma of the ovary in adults demands removal, but in children the operation is generally useless. Sarcoma of the kidney in adults calls for nephrectomy, but in children the operation is usually of little avail. In my experience, in the cases of sarcoma of the kidney which survived operation the growth always appeared in the other kidney. In melanotic sarcoma extirpate the growth widely and remove anatomically related lymph-nodes, or in some cases amputate far away from the tumor and remove lymph-nodes. The probability of recurrence is very strong. In very malignant sarcoma even amputation does not often cure. Removal of a sarcoma when there is no hope of a cure is often justifiable to prolong life, to relieve the patient of a foul, offensive, bleeding mass, and to permit of an easier road to death by means of metastasis to an internal organ. In an inoperable case the ligation of the vessel of supply may do

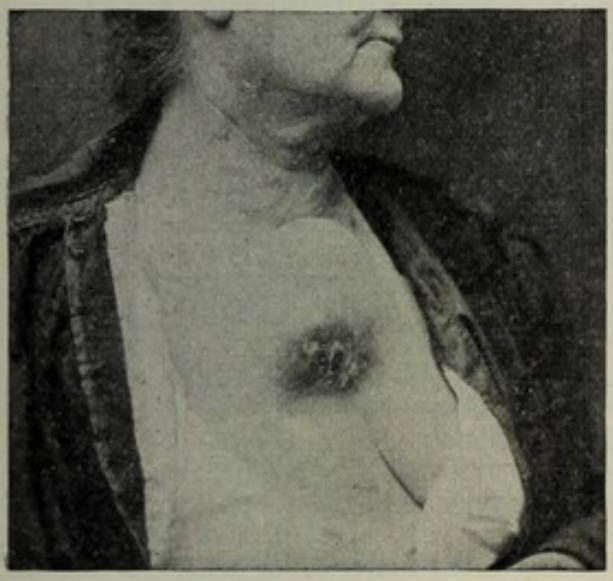


FIG. 174.—Recurrent sarcoma of the sternum.



FIG. 175.—Periosteal sarcoma of the femur.

good. In sarcoma of the tonsil Dawbarn advises the extirpation of the external carotid artery on each side and the ligation of its branches. The operation is performed first on the side occupied by the tumor and in a week or so on the other side. I employed it in 7 cases, with distinct but temporary benefit. Occasionally, though very rarely, suppuration cures a sarcoma. Wyeth, of New York, reported a case of sarcoma of the abdominal wall. It was found possible to remove only part of the growth; suppuration followed and the tumor disappeared, and ten years later had not returned. A study of statistics seems to indicate that more cases of sarcoma are cured after operation if the wound suppurates than if it remains aseptic, and it has been proposed to infect deliberately the wound with pus germs to lessen the danger of recurrence. If the wound is large, it should not be infected until it is nearly healed. If it is small, it may be infected at the time of operation or soon after. After amputating for sarcoma Wyeth waits until the wound is nearly healed and then infects it by inserting a gauze drain saturated with cultures of pure Streptococcus pyogenes (Wyeth's "Surgery"). After removing a sarcoma from any region the patient should be given courses of injections of Coley's fluid (see below).



FIG. 176.—Inoperable sarcoma of the back.

It has been observed that an attack of erysipelas occasionally greatly benefits a sarcoma, causing large masses of the growth to soften or to slough and exposing a granulating surface. Busch noticed this in 1866, but the fact had been observed in the seventeenth century. Interest was decidedly awakened by Billroth's case of sarcoma of the pharynx which was cured by an attack of facial erysipelas. It was suggested that in inoperable cases of sarcoma erysipelas might be established artificially. Fehleisen inoculated tumors with cultures of erysipelas. Lassar in 1891 employed the toxins (cultures rendered sterile by heat and filtration). In 1892 Coley began his observations. The first plan was as follows: a bouillon culture was made of the streptococci; this culture was filtered through porcelain and an injection was given once a day into and about the sarcoma. The first dose was 10 min. and it was progressively increased. The effect was to cause a febrile reaction, and sometimes the injections were followed by softening or suppuration. Coley's present method is as follows: Make cultures of erysipelas cocci in cacao broth; after three weeks inoculate them with the Bacillus prodigiosus, and cultivate the mixed growth for four weeks. The mixed cultures are maintained at a temperature of 136° F. until they become sterile. This sterile fluid contains the toxins. The usual dose for an adult is from 1 to 8 min. Coley has given as high as 24 min. I have never given over 18 min. Most cases will show reaction at 4 to 6 min. The first dose for an infant is 1/10 min. If in an adult the fluid is injected remote from the tumor, the initial dose should be 1 min. If the fluid is injected into the tumor the initial dose is $\frac{1}{4}$ to $\frac{1}{2}$ min. (Coley in "Amer. Jour. Med. Sci.," March, 1906). Some cases are treated purely by distant injections (gluteal or pectoral regions), others by alternately injecting the tumor and some distant point. The latter plan combines local action and systemic effect. The dose should be gradually increased until a chill occurs in from one-half an hour to two hours after the injection, followed by a temperature of 101° to 104° F. In some cases there is so much depression after reaction that injections are given every other day, but if safely possible they should be given every day. The object is to obtain a reaction with each injection. The more vascular the tumor, the more severe the reaction (Coley). If an area softens during treatment Coley advises us to open and drain the softened area. If improvement is to occur it usually begins in from one to four weeks. If there is no improvement within four weeks there probably will not be any. In most cases as injection is continued susceptibility diminishes; in some few, it increases. It seems definitely proved that cases are occasionally cured by Coley's

fluid. It is generally stated that spindle-cell sarcomata are influenced most favorably and that round-celled sarcomata are very refractory. Harmer in a study of 91 cases regards the small round-cell sarcomata as most amenable to the treatment, spindle-cell sarcomata as coming closely next, and the mixed-cell type as decidedly refractory ("Boston Med. and Surg. Jour.," Jan., 1915, clxxii). Cancers are seldom benefited. The method is not entirely free from danger, but the danger is very slight if treatment is begun with the minimum dose. The toxins seem of value in postoperative cases to prevent recurrence. For this purpose the fluid is used twice a week for several months and at greater intervals for a long period of time. During the autumn of 1910 I brought before my class in the Jefferson Hospital a colored woman (Fig. 177) with an inoperable spindle-cell sarcoma of the thigh and groin. A portion of the growth was removed and the remainder completely disappeared from injections of Coley's fluid. She remained well over three years after treatment was suspended, when I lost sight of her. This patient had a violent reaction every day for weeks. She was given as much as 7 min. at a dose.

How the toxins act is uncertain. They produce some change in the blood-serum, and the valuable effect is systemic. Nearly always they cause leukocytosis. Probably they cause the formation of antibodies antagonistic to the sarcoma cells. The treatment, as Coley insists, is not a substitute for operation. The fluid is used in inoperable cases. In sarcoma of long bones a trial of it is made before advising operation. It is given after all operations for cancer or sarcoma to combat recurrence and it may be tried in inoperable cancer. Coley ("Surg., Gynec., and Obstet.," August, 1911) has had 65 cases of inoperable sarcoma in which the tumor disappeared



FIG. 177.—Huge sarcoma of buttock cured by partial extirpation and Coley's fluid.

as a result of treatment: 7 are alive and well at the end of fifteen to eighteen years; 7 are alive and well at the end of ten to fifteen years; 17 are alive and well at the end of five to ten years; 10 are alive and well at the end of three to five years. The others could not be traced.

Emmerich and Scholl claim good results in inoperable sarcoma from the injection of erysipelas serum. A sheep is injected with cultures of erysipelas, the blood is drawn, the serum separated, filtered to remove cocci, and injected about the sarcoma. Results are not definite. Among other agents which have been used to inject inoperable sarcomata we may mention alcohol, chlorid of zinc, arsenic, corrosive sublimate, thiosinamin, pepsin, alkalis, etc. The injection of anilin products into the sarcoma, which once received qualified commendation from some observers, has been abandoned. The *x*-rays are sometimes of benefit, but are not so serviceable as in carcinoma, and possess a certain danger, for occasionally after using them dissemination occurs rapidly. Abbé and others have obtained some remarkable results by radium, but such results are exceptional and not the rule.

Hypernephromata, or Adrenal Tumors.—Some hypernephromata bear a strong resemblance to adenomata and carcinomata. Some adrenal tumors are benign, and among such tumors we note fatty and fibrous growths and growths resembling glioma. Another benign growth imitates the structure of the cortex of the adrenal. Malignant tumors occur, and many of them are identical or almost identical with sarcoma. One form is composed of epithelioid cells and resembles endothelioma. An adrenal tumor may arise from the adrenal body proper or from "rests" in ectopic portions of adrenal within the kidney, ovary, testicle, solar plexus, renal plexus, liver,

mesentery, or some other part. Some of these tumors attain a large size. Metastases are late, but tend to occur eventually even in hypernephromata which seem benign, and may occur even when the primary growth has given rise to no symptoms. The metastases are lodged particularly in the bones, the lungs, and the liver. In a case from which I removed a goiter and in which death resulted from reactionary hemorrhage the tumor (which I had considered to be adenoma) was found to be composed of adrenal tissue. Unfortunately, an autopsy was not permitted.

Accessory adrenals are common. They are known as *adrenal rests*. "They are found oftenest in the connective tissue about the main adrenals, but also in the kidneys, the right lobe of the liver, along the renal vessels and spermatic veins, in the inguinal canals, and in the broad ligaments" ("American Text-book of Pathology").

Innocent Epithelial Tumors.—These growths imitate an epithelial tissue of the mature and healthy organism.

Papillomata, or Warts (Figs. 178 and 179).—Papillomata are formed upon the type of cutaneous and mucous papillæ. A papilloma consists of a fibrous stroma, which contains blood-vessels and lymphatics and is covered by epithelium of the variety ap-

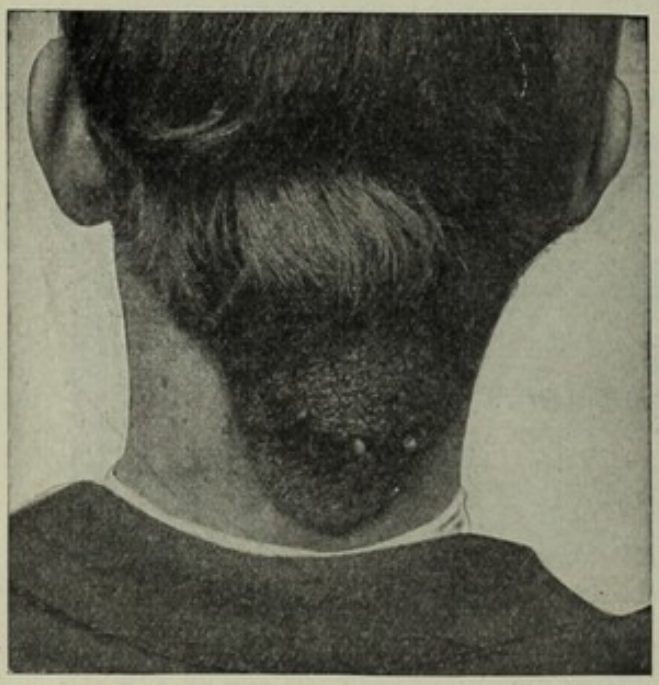


FIG. 178.—Keen's case of papilloma with angioma.



FIG. 179.—Adolescent warts. Boy about fifteen. Two years' duration (Dr. W. L. Clark).

pertaining to the diseased part. Papillomata grow from the skin and from mucous membranes; they may be single or multiple; many may form in one region, or various distant parts may be affected; they may be painless or may be ulcerated or bleeding; they vary in color from light pink to deep brown or black. Papillomata of the skin are usually hard; papillomata of mucous membranes are soft. A skin-wart may be smooth and rounded, or may look like a small cauliflower, the epidermis upon it being very rough. A papilloma of a mucous membrane looks like a small cauliflower. Papillomatous masses may gather around the anus, the vagina, or the penis during the existence of a filthy discharge (*venereal warts*, Fig. 180), and crops of warts may appear on the hands of those who work in irritant material (as petroleum). Papillomata are apt to arise in mucous membranes about carcinomata or chronic ulcerations. A large crop of warts may disappear in a single night; hence the popular belief in the efficacy of charms. Warts are particularly common on the skin of the back of the hands and fingers, the skin of the back, and the skin of the neck and scalp. A single skin-wart may reach the size of a walnut and become pigmented. The squamous epithelium covering a skin-wart may become horny (*a wart-horn*). Other cutaneous horns arise from the nails, from the scars of burns, or from ruptured sebaceous cysts.

Villous papillomata grow chiefly from the bladder, but they may also grow from the stomach and intestine. A papilloma of mucous membrane covered with squamous epithelium looks like a wart of the skin. Papillomata of the larynx are formed of squamous epithelium. Villous papillomata form tufts like the villous processes of the chorion; they may be single or multiple, and may be sessile or pedunculated; they are very vascular, and are apt to bleed freely. Papillomata may arise in cysts of the paroöphoron, in cysts of the mammary gland, from the choroid plexuses of the ventricles of the brain, and from the spinal membranes. Papillomata may give rise to hemorrhage or may impair the function of a part. Any papilloma may become a cancer. It seems likely that laryngeal papillomata are due to a filterable virus (see the observations of Ullman, of Vienna, as quoted in the "Lancet," Nov., 24, 1923). Perhaps all warts are so caused.

Treatment.—Venereal warts are treated by repeatedly washing with peroxid of hydrogen, drying with cotton, and dusting with a powder composed of borated talcum or of equal parts of calomel and subnitrate of bismuth, or of oxid of zinc and iodoform. If they do not soon dry up, cut them off with scissors and burn with the electric cautery. Ordinary warts may usually be destroyed in a short time by daily applications of lactic or chromic acid. Most warts are easily destroyed by solid CO_2. It is held in contact with the wart for thirty or forty seconds. In a few days the warts



FIG. 180.—Venereal warts.

drop off or can be easily picked off. In multiple warts of the face Kaposi applies daily for several days a portion of the following combination: sublimed sulphur, 5 dr.; glycerin, 1½ dr.; acetic acid, 2½ oz. Keeping a wart constantly moist with castor oil will usually cause it to drop off. Warts, and even extensive callosities, may be removed by painting once a day for five days with pure carbolic acid and covering with lint kept wet with boric acid. A convenient plan is to paint a wart daily with a solution containing 1 part of corrosive sublimate to 30 parts of collodion (hydrarg. chlor. corros., ½ dr.; collodion, 15 dr.). Large warts should be excised or destroyed by the electrothermic method. Villous papillomata of the bladder, if not cured by fulguration, demand the performance of a suprapubic cystotomy in order to remove them. A papilloma of the larynx may be removed by the cautery or may be destroyed by sparking.

Adenomata are tumors corresponding in structure to normal epithelial glands. They have a framework of vascular connective tissue, and they may contain acini and ducts like racemose glands or tubules like tubular glands. The acini or tubules contain epithelium of either the cylindric or polyhedral variety. Adenomata grow from secreting glands; either they cannot produce the secretion of the glands from which they spring, or they do secrete, but the fluid is retained and not discharged by the gland-ducts. Adenomata occur in the mammary gland, the parotid, the ovary, the thyroid gland, the liver, the sweat-glands, the sebaceous glands, the kidney, the

pylorus, and the prostate; and they may spring as pedunculate growths from the mucous lining of the intestine and uterus. They are encapsuled, are usually single, but may be multiple, are of slow growth, but may attain a great size; they do not tend to recur after thorough removal, do not involve lymph-glands, and do not disseminate; they are firm to the touch; they tend to become cystic (especially in the thyroid gland), the fluid which distends the ducts being formed by mucoid liquefaction of the proliferating epithelium. If cysts form, the growth is spoken of as a *cystic adenoma*. If the framework of an adenoma contains considerable fibrous tissue, the tumor is named a *fibro-adenoma*. Adenomata are particularly liable to become carcinomatous.

In the breast a fibro-adenoma has a distinct capsule; it is elastic and movable, is usually superficial, and one occasionally exists in each gland. They are most common before the age of thirty, and are often painful, especially during menstruation. Cystic adenomata of the breast attain a large size; they are encapsuled and grow slowly, are most common after the thirtieth year, and are rarely painful. Both fibro-adenoma and cystic adenoma may arise in the male breast. Young unmarried women not unusually develop in the breast small, very tender, and painful bodies, most usually around the edge of the areola, which bodies increase in size and become more tender during menstruation; they are only cysts of the mammary tissue.

Adenomata of the thyroid gland usually begin before the fifteenth year. They may arise in the prostate if that gland be already the seat of senile hypertrophy. Adenomata of mucous glands may arise in the young or middle aged. Adenomata of mucous membranes often cause hemorrhage and interfere with function.

Treatment.—Adenomata should be extirpated. To let them alone exposes the patient to the danger of cancerous change. By confusing adenomata of the mammary gland with small areas of chronic mastitis an erroneous belief has arisen that the former as well as the latter may sometimes be cured by the local use of iodin, mercury, ichthyol, and the internal use of iodid of potassium. The treatment in the breast, as elsewhere, is excision.

Malignant Epithelial Tumors, Carcinomata, or Cancers.[1]—Cancers are tumors taking origin from epithelial structures and composed of embryonic epithelial cells. The cells are clustered in spaces, nests, or alveoli of fibrous tissue and proliferate enormously, extending beyond normal anatonic boundaries and as an invading host entering into connective tissue by way of the lymph-spaces. Certain cells "pass out of somatic coördination" with the other body cells and become as parasites (Walker in "Lancet," May 13, 1911). Such cells constitute cancer. The unrestrained and unlimited reproduction of epithelial cells and the assumption by them of parasitic properties are the characteristics of cancer. The healthy epithelium has a strictly limited power of reproduction, as is illustrated by a skin-graft. Cancerous epithelium has an unlimited power of reproduction. The alveoli of cancer are distended lymph-spaces filled with proliferating cells. The cells of a cluster are not separated by any stroma, and the walls of the alveoli carry blood-vessels and lymphatics. The growth may have been cancerous from the start, or may have begun as an innocent epithelial tumor which became cancerous. Cancers are always derived from epithelium (of glands, of skin, of mucous membrane, etc.), and if found in a non-epithelial tissue must be secondary, or must have arisen from a depot of embryonal epithelial cells of prenatal origin or from a dermoid cyst lying in the midst of a non-epithelial tissue, or epithelial cells must have been displaced by inflammation or injury so as to be among mesoblastic elements. For instance, the bone does not normally contain epithelial cells. If osteomyelitis arises, operation is performed, and a lot of skin may be buried in the bone cavity or an epithelial graft may adhere. Such an epithelial area may become cancerous. Carcinomata have no capsules, rapidly infiltrate surrounding tissues, and are firmly anchored and immovable. In the beginning a cancer is a local lesion, but it soon attacks adjacent tissue and related lymph-glands, and by means of the lymph-cells is carried to other structures, producing secondary tumors and diseases and enlargement of more distant lymph-glands. Finally, lymph containing cancer-cells reaches the blood by the lymph-vessels and passes to distant parts, and secondary tumors or metastatic deposits form. When lymphatic vessels are obstructed, lymph filled with cancer-cells may flow in a direction the reverse of that pursued in health. Wide-spread or general dissemination may be due to carcinomatous thrombosis of a vein, or perforation of the wall of a vein, multiple emboli forming. Strange to

[1] For most valuable statistical information about cancer consult that learned book issued by the Prudential Insurance Co. of America, written by Frederick L. Hoffman, and entitled "The Mortality from Cancer Throughout the World."

say, emboli composed of cancer-cells may be surrounded by blood-corpuscles and move against the blood-current. A secondary growth (Fig. 181) consists of cells identical in character with and similar in arrangement to those of the parent growth. It may

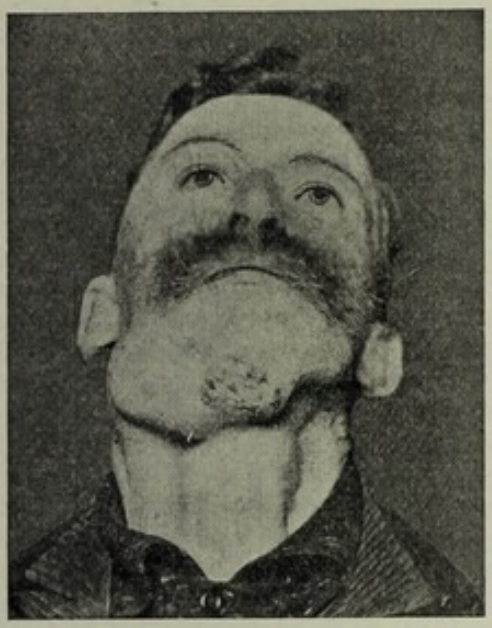


FIG. 181.—Secondary carcinoma of the submental and submaxillary lymphatic glands following carcinoma of the lip (Senn).

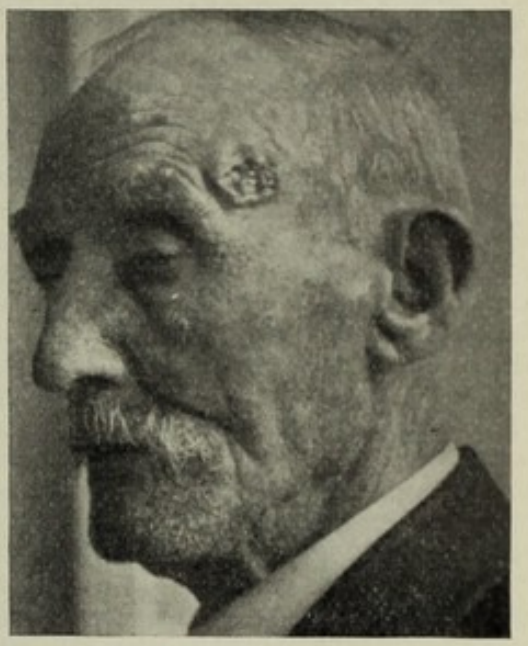


FIG. 182.—T. Turner Thomas's case of epithelioma of the temple.

be clinically more or less malignant than the parent growth. The cells of the secondary growth were transported from the primary growth and multiply in their new situation. The cells of a primary carcinoma of the liver may secrete bile, and the cells of a metastatic area may do the same. Fütterer has reported a case of carcinoma of the thyroid the pulmonary metastases of which secreted colloid. Stewart reported a case of cancer of the lungs and liver secondary to cancer of the pancreas. The secondary



FIG. 183.—Epithelioma involving superficial tissues, periosteum, and bone of forehead. Patient was sixty-seven years of age (Dr. W. L. Clark).

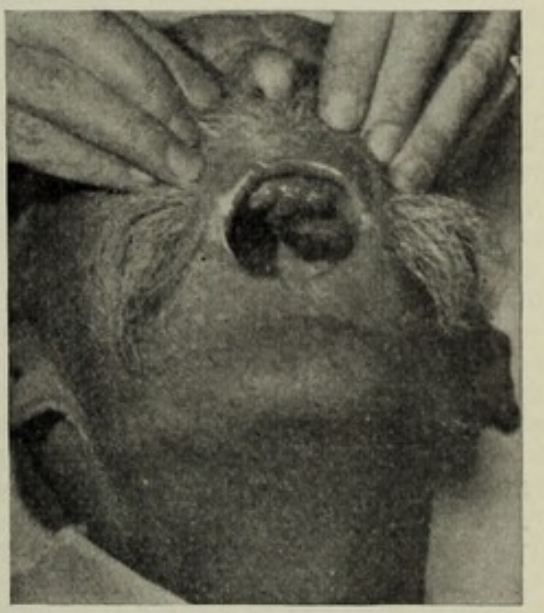


FIG. 184.—Carcinoma of hard palate, alveolus, and buccal surface. Duration six months. Patient was seventy-two years of age (Dr. W. L. Clark).

growths were of a structure similar to the pancreas and contained trypsin. Metastases from a columnar-cell rectal cancer are composed of columnar cells. Metastases from a squamous-cell epithelioma are composed of squamous cells. In rare cases metastasis of carcinoma of the stomach has occurred in the rectum. Schnitzler reported 11 cases ("Mitt. a. d. Grenzgeb. d. Med. u. Chir.," 1908, xix, No. 2). Such

a condition is probably due to implantation. Contact cancer has already been referred to (see page 294). We often speak of lymph-nodes enlarging when affected with cancer. The enlargement certainly occurs, but is not due to growth of the cells of the lymph-node. It results from multiplication of the carcinoma cells deposited in the gland. As Henry Morris says ("The Bradshaw Lecture," "Lancet," Dec. 12, 1903), the parenchyma of the involved part does not undergo transition into cancer. After the overgrowth of epithelium has lasted for a length of time the patient becomes poisoned by materials absorbed from the seat of disease, and finally dies from cachexia and exhaustion or some complication. These materials are probably enzymes. During the progress of cancer irregular fever may arise from time to time. Cancer is rare before the age of forty, although occasionally it is met with in younger persons. Over 80 per cent. of cancer deaths are in those beyond the age of forty-five. Cancer of the rectum is sometimes met with as early as the twenty-fourth year. I have operated on a woman of twenty-six for cancer of the breast, on a man of twenty-four for cancer of the stomach, and on a man of twenty for epithelioma arising in the old scar of a burn (see Fig. 42). Karsner ("Proc. Path. Soc. Phila.," Feb., 1910) reports 10 cases of carcinoma occurring before the age of twenty-four: 1 was seven; 1, ten; 1, eleven; 1, fourteen; 1, nineteen; 1, twenty-one; 1, twenty-two, and 3, twenty-three. In De la Camp's collection of 9906 cases of cancer only 19 were under twenty years of age. *x*-Ray cancer is most apt to occur in young people. When xeroderma pigmentosum exists in children cancer may arise in areas of the disease. If cancer appears in a young person, growth is apt to be extremely rapid and after extirpation early recurrence is common. A carcinoma is often the seat of pricking pain; the growth tends strongly to recur after removal; is prone to ulcerate, causing pain, hemorrhage, and cachexia; makes rapid progress, and is often fatal in from one to two and a half years. It is more common in women than in men, and rarely exists in association with tuberculosis. After a cancer has existed for a considerable time in an important structure, or after a superficial cancer has ulcerated and become hemorrhagic, there are noted in the individual evidences of illness and exhaustion. We speak of this condition as the *cancerous cachexia*, and in it the muscles are wasted, the body weight is constantly diminishing, the complexion is sallow, the face is sunken, pearly white conjunctivæ contrast strongly with the yellow skin, the pulse is weak and rapid, and night-sweats occur. The above condition is due to the absorption from the diseased tissues of toxic products, which damage the blood-corpuscles, and also to pain, loss of sleep, deprivation of exercise, malassimilation of food, and perhaps bleeding. It is held that cancer cells contain an enzyme which disintegrates the body cells; hence the wasting. From the disintegrating body cells poisons also come, hence some of the toxemia. Perhaps the materials from disintegrating body cells favor the proliferation of cancer cells. Mental depression is not believed by many surgeons a cause of recurrence. As J. D. Bryant says, it is simply expressive of a condition of nutritive failure which may favor recurrence. We must remember, however, that the great name of Paget is associated with the belief that not uncommon antecedents of the disease are "deep anxiety, deferred hope, or disappointment" ("Lectures on Surgical Pathology," 1863). Victims of rheumatoid arthritis are particularly liable to cancer. Recurrence after operation is due to the growth of cells which were not removed at the operation. Cancer may kill by obstructing a canal, by destroying the functions of a viscus or organ, by hemorrhage, by anemia, by sepsis, or by exhaustion. The duration of life varies in different forms of cancer and in different situations of the growth. After the first symptoms appear, cancer of the gall-bladder, as a rule, causes death in about four months; cancer of the stomach, in less than a year; cancer of the face, in from three to three and one-half years. Billroth's case of carcinoma mastitoides killed the patient in six weeks.

Serum Reaction in Cancer.—Kelling in 1906 pointed out that the blood-serum of a cancer patient has a hemolytic action on the red corpuscles of the lower animals and on those of non-cancerous human beings, but has only a limited power of destroying the red blood-cells of a cancerous patient. It has been known for some time that the serum of persons affected with certain diseases is able to destroy the red blood-corpuscles of normal individuals; in other words, such sera are hemolytic to the red blood-corpuscles of healthy human beings. The agents in a serum which hemolyze the red corpuscles in other sera are called isohemolysins. Isohemolysins are contained in the sera of syphilis, tuberculosis, and cancer. Williams ("Med. Record," 1916, xc), after 90 observations, believes that Kelling's test is of value in the diagnosis of carcinoma. Freund and Kaminer pointed out that normal serum dissolves carcinoma cells, but the serum

of a victim of carcinoma does not, and that cancer serum inhibits the solvent action of normal serum. They suggested that this fact might be employed diagnostically. It is called the cytotoxic reaction. In about two-thirds of cancer cases the reaction is positive, but in one-third it is negative. The test is not conclusive and is unreliable. Cobra poison contains hemolysins and has been used as a test for carcinoma (Weil's reaction). The results are positive in about 80 per cent. of cancer cases. Weil pointed out that the serum of a dog suffering from advanced lymphosarcoma destroys the red corpuscles of normal dogs, but is resisted by the red corpuscles of animals that are victims of the same disease. Attempts are being made to utilize the serum reaction for diagnostic purposes. Different observers employ different technic and differ widely in their conclusions. Freund and Abderhalden claim to find sero-enzymes in the serum of cancer patients, and claim that these ferments digest coagulated cancer protein just as the ferments in the serum of pregnant women digest placental protein. Some claim that the Abderhalden test is very valuable (Levin, Erpicum, and others). Some think it of no value or impracticable (Leitch, Fritsch). The complement-fixation test, the epiphanin test, and the miostagmin reaction are of very doubtful practical use. Crile is disposed to think highly of the diagnostic value of the serum reaction. Janeway's conclusions are wisely cautious. He states that a negative reaction is not proof positive that cancer is absent. A positive reaction makes the existence of malignant disease probable, especially if advanced tuberculosis and syphilis are absent.

The fact that the serum of a cancer patient contains agents destructive to red corpuscles explains the anemia and cachexia of cancer. Janeway points out that the serum of sufferers from benign tumors never exhibits the reaction.

Some Theories as to Cause of Carcinoma.—Heredity is discussed on page 293.

1. *Contusion and Irritation.*—As Dennis says, clinical evidence points strongly to the view that inflammatory changes following irritation are responsible for cancer. Individuals with phimosis are particularly prone to cancer of the penis. A jagged tooth or an ill-fitting plate may be responsible for cancer of the tongue; so may the common habit of lathers of carrying nails in the mouth. A carious tooth may light up cancer of the gum. Repeated application of the *x*-rays or radium rays may be causal. Those who smoke a short-stemmed clay pipe, which grows hot when in use, are most liable to cancer of the lower lip. Abbé also indicts cigarettes and cigars. In the East those who chew buyo leaves are liable to cancer of the region of the cheek against which the leaf is held. The chew is composed of buyo leaves, slaked lime, betel-nut, and tobacco. Our own tobacco chewers are exposed to a like peril.

Rubbing the tongue or gums with snuff favors the development of the disease.

The natives of Kashmir are liable to Kangri disease. It is cancer of the skin of the abdomen and is due to heat. These men in cold weather carry a box of hot embers strapped to the belly. In the old days chimney-sweeps often developed cancer of the scrotum, which was always irritated by soot in the cutaneous folds. Cancer of the gall-bladder may arise if gall-stones exist. Cancer of the skin of the hands may arise in *x*-ray workers. Volkmann pointed out many years ago that paraffin workers are liable to cancer of the skin. Cancer of the skin may be induced by the influence of light (James Nevins Hyde in "Amer. Jour. Med. Sciences," Jan., 1906). Anilin workers are rather liable to cancer of the urinary bladder. Nassauer reported 89 cases (editorial in "Jour. Amer. Med. Assoc.," July 31, 1920). An ulcer may be the irritating focus which leads to the development of cancer at its edge (see Marjolin's Ulcer, page 87). So may a scar. As is well known, certain innocent tumors may become cancerous. The believers in the parasitic theory maintain that irritation and inflammation simply open the gates to the real cause, which they assert is a parasite.

In certain regions of the body, notably the tongue and lip, we regard prolonged chronic inflammation as very apt to eventuate in cancer, and if an ulcerated area is not soon cured by ordinary means we advise operation. A condition of irritation persisting in spite of ordinary treatment is prone to eventuate in cancer, but if it is not yet demonstrably cancerous it is called the *precancerous* stage of cancer. It probably is already cancer, although so early as to lack the positive signs.

A wart is the result of inflammation and a wart may become a cancer. The edge of a gastric ulcer may become cancerous. Cancer may arise from a scar (see Fig. 45) or the edge of an old ulcer of the skin, the lip, the cheek, or the tongue.

Certain benign tumors tend to become cancerous, especially if irritated by injuries, caustic applications, or inefficient attempts to remove them surgically. Any papilloma and any adenoma may become cancerous. A benign epithelial tumor is always a menace and is to be regarded as a possible or potential carcinoma.

Whereas chronic inflammation or irritation of epithelial structures is not infrequently followed by carcinoma, a single traumatism, as a blow, seldom is. Nevertheless well-established cases are on record of cancer due to a single trauma (Coley in "Annals of Surgery," April and May, 1911). A woman with cancer of the breast is apt to lay the blame upon a blow, but very seldom can the surgeon regard the blow as causal. In many cases cancer was present when the injury was received, and the injury drew attention to the tumor. In some other cases the blow was casual and not causal.

2. *The Inclusion Theory of Cohnheim.*—This theory was set forth on page 292.

3. *The Thiersch Hypothesis.*—This maintains that normal, healthy connective tissue has a restraining influence on the growth of adjacent epithelium; when connective tissue degenerates (as in advancing years or after prolonged irritation) its control over epithelium is weakened, and the epithelium grows more rapidly than it does normally, and from the moment it invades the connective tissue cancer exists. This theory assumes that the connective tissue is a police force and the epithelial cells members of the criminal class. When the first is weakened or corrupted, the second becomes active and uncontrolled.

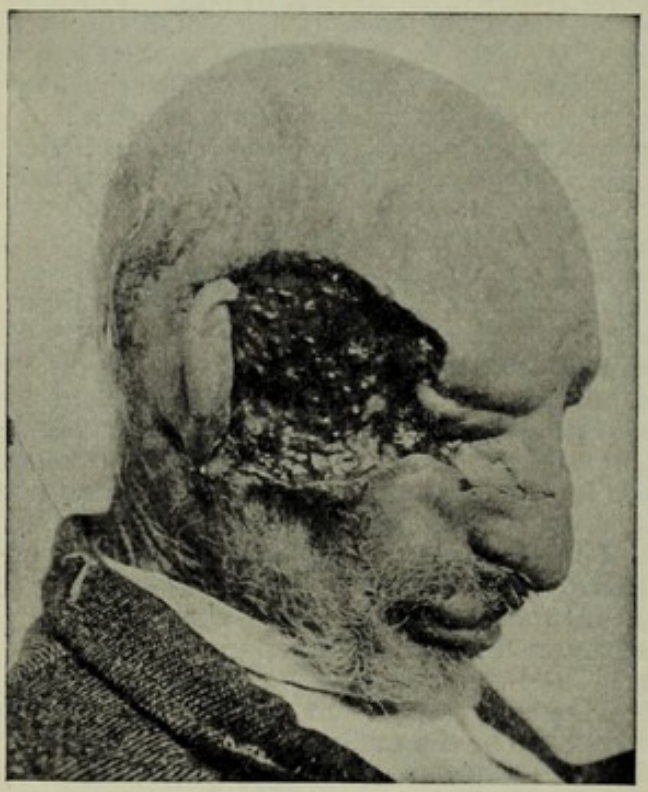


FIG. 185.—Epithelioma of right temporal region. Paralysis of right side of face. Papule noticed by patient two years prior to admission.

4. *The Parasitic Theory.*—Various agents have been described as causes, viz., bacteria, protozoa, and yeast fungi.

This theory was discussed on page 294. We do not regard it as proved, and even Plimmer, warm advocate as he is of the theory of contagion, admits that as yet there is no clearly demonstrated case of contagion of cancer from one man to another. I can find no authenticated case on record of a surgeon having been infected by cancer during an operation. Transplantation has been carried out from one animal to another of the same species, although attempts to do so usually fail. Tyzzer, of Harvard, succeeded in nearly 46 per cent. of his inoculation experiments with the Jensen tumor, and he has kept up the tumor formation for ten generations. (See "Fourth Report from the Harvard Medical School of the Caroline Brewer Croft Fund Cancer Commission.") It is a serious question, however, if mouse cancer is really cancer at all. Mouse cancer is far more strongly hereditary than human cancer; spontaneous cure is by no means uncommon; metastasis is rare, and the disease may occur as an epidemic in a laboratory. It has been asserted that mouse cancer may revert to sarcoma (Apolant in "Münch. med. Wchnschr.," 1907, liv), and that it may revert to adenoma (Ibid.). These tendencies separate mouse cancer very positively from human cancer. It is said that epidemics of fish cancer may occur in a hatchery. Cancer has not been transplanted from an animal of one species to an animal of another species. If a portion of human cancer is implanted in the tissues of an animal, the cells of the growth retain their vitality for a very few days and then perish. If a piece of mouse cancer is transplanted into a rat the same thing happens. In any case even a successful transplantation of cells is a very different thing from contagion. The late Prof. Nicholas Senn deliberately implanted a piece of cancer in the tissues of his own forearm, without result ("Jour. Amer. Med. Assoc.," April 28, 1906). Recently advocates of the contagion theory claim that mouse cancer can be reproduced after transplantation even when the cells in the inoculated matter have been first killed by exposure to the intense cold induced by liquid air (Salim, Moore, and Walker in "Lancet," Jan. 25, 1908). If these observations should be sustained, they would indicate that the element responsible for growth of a graft is not cellular and might be microbic. Alibert carried

out similar experiments and claims to have obtained like results. Most observers believe that transplantation cancer is due to cell transplantation.

Experiments on plant tumors are striking, important, and are perhaps applicable to human tumors.

That local overgrowth known as crowngall is, in fact, a tumor. Erwin F. Smith ("Mechanism of Tumor Growth in Crowngall") believes that the growth is due to the removal of normal inhibitions, that is, to loosening of the brakes, and that the lessening of inhibitions is caused by the metabolism of mild, continuously acting intracellular bacteria which develop substances having osmotic power to draw water and cell food into the area. These substances are alcohol, aldehyds, acetone, acids, and alkalies.

5. *The Biologic Theory.*—In a unicellular organism the function of reproduction is, of course, possessed by the cell. In a multicellular organism certain cells are set apart for the performance of the function of reproduction. All the other cells possess the potentiality for reproduction, but fail to exercise it. If cells undergo atavistic reversion they may again assume the reproductive function. If they do so, unrestrained growth will result, and such unrestrained growth is cancer.

N. F. MacHardy ("Lancet," Oct. 24, 1903) states that if a unicellular organism has not sufficient reproductive energy it fuses with another cell and is thus stimulated to produce numerous daughter-cells. In multicellular organisms cells may also fuse, take on active reproductive power, and produce hosts of new cells. When cells are persistently irritated, MacHardy affirms that they become worn out by making repeated attempts at repair, undergo atavistic reversion, and actively assume the power of reproduction. According to this theory cancer is expressive of atavistic reversion of epithelial cells.

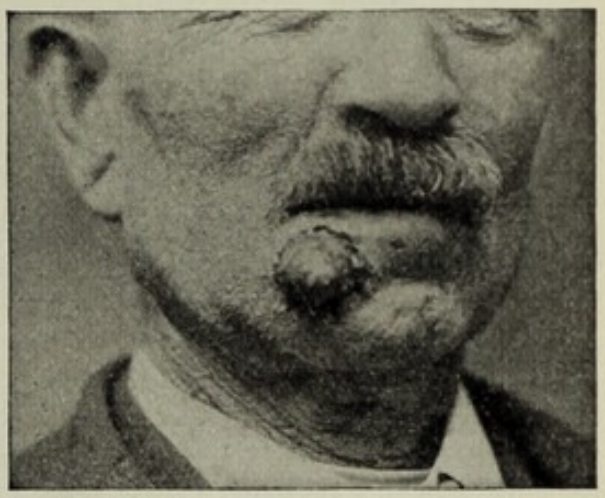


FIG. 186.—Carcinomatous horn.

The Prevalence and the Alleged Increase of Carcinoma.[1]—Crile states that in hospital autopsies cancer is found in 1 case out of 12 ("Med. Record," June 6, 1908). In the United States cancer causes 5 per cent. of the annual deaths. Kellogg ("N. Y. Med. Jour.," Sept. 2, 1911) claims that there are 300,000 cancerous people in the United States, that 75,000 die of it each year, and that in 1909, of women who died between the ages of forty-five and fifty-five, 1 in 6 died of cancer. Hoffman ("The Mortality from Cancer") is certain that in the United States at least 80,000 deaths a year are due to cancer. The Bureau of the Census has announced that in the registration area of the United States during 1920 there were 73,000 deaths caused by cancer. If the death-rate from cancer in non-registration areas is calculated and the result is added to the former figures we obtain a result of 89,000 deaths from carcinoma in the United States during 1920. During 1919 it is estimated there were 84,000 deaths from cancer in the United States. In England in 1909 there were over 34,000 deaths from cancer. In France in 1908 there were over 30,000 deaths from cancer. In the United States cancer stands fifth in the mortality list. (1) Tuberculosis. (2) Pneumonia. (3) Heart disease. (4) Kidney disease. (5) Cancer. It has been stated that of persons living above the age of thirty-five, that 1 woman in 8, and 1 man in 12, will die of cancer (Copeman, quoted by Brand, in "Lancet," Jan. 11, 1908). The returns of the Registrar-General for 1911 show "the chance that a man over thirty-five years of age will die of cancer is one in 9.7, and the chance of a woman above the same age is one in 7.4" ("The Mortality from Cancer," by Frederick L. Hoffman). Is cancer increasing? Of course, the number of cases increases with the increase of population. The apparent death-rate from cancer increases year by year. It was pointed out by W. Roger Williams that in England and Wales the mortality from cancer increased from 1 to 5646 in 1840 to 1 to 1306 in 1896, and the proportion to deaths from other causes rose from 1 to 129 in 1840 to 1 to 22 in 1896 ("Lancet," Aug. 20, 1898). Roswell Park commented on the increasing number of deaths from cancer in New York

[1] In considering statistics for the United States, remember that only 65 per cent. of the population is in the registration area. Outside of this area we rely on estimates.

State, and said if it continued for the next ten years the disease would kill more persons annually than phthisis, smallpox, and typhoid combined. Kellogg ("N. Y. Med. Jour.," Sept. 2, 1911) believes that the increase is enormous, and claims that in the United States the disease has increased 500 per cent. in sixty years. Bertillon, of the Statistical Department of Paris, believes that cancer is increasing in all countries. The increase is greater among men than women. In 1913 the cancer mortality in the United States was 79 per 100,000 of population, in 1900 it was 63 (J. Howard Beard in the "Scientific Monthly," Feb., 1916).

The cancer death-rate of Greater New York has increased during the last twenty years from 59 to 86 per 100,000 of population. In London the death-rate is 94, in Paris 109, in Berlin 107, and in Boston 107 per 100,000 of population (John Chadwick Oliver in "Annals of Surgery," May, 1916). In the Boroughs of Manhattan and the Bronx, the cancer death-rate during the last fifty years has increased from 24 to 86 per 100,000 of population—253 per cent. (J. C. Oliver, Ibid.).

Hoffman (Ibid.) says the facts of actual experience "prove beyond a doubt that the actual as well as the relative increase in the cancer death-rate in at least some of the more important countries continues progressively at the present time, and that for most of the civilized countries a maximum rate is far from having been reached." Such statements are truly alarming, and yet the reality of all of this apparent increase is doubtful. A part of the apparent increase is due to the greater frequency of exploratory operations for diagnostic purposes, to the greater frequency of postmortem examinations, to more correct diagnoses of obscure internal conditions, and to greater accuracy than was once either usual or expected in filling up death certificates. Neusholme says that just as deaths certified as due to old age grow apparently fewer every year, so other non-specific certifications grow fewer, and cancer gains as they lose. The diminution in infant mortality also causes a relative rise in the apparent cancer mortality. Further, more people than formerly live to reach the cancerous age, and people in general live longer than formerly, and in the later years of life cancer is common. In the United States over 80 per cent. of cancer deaths are in those over forty-five years of age. The above facts certainly account for a portion of the alleged increase, but we must also remember that we are curing many more cases by operation than we used to be able to, and hence that the death-rate from cancer is not the real and final measure of the incidence of cancer. The experience of most practical surgeons is that there is a real increase in cancer, but the extent of the increase cannot be ascertained with any accuracy.

Hereditary Influence.—This was referred to on page 293. It can be at most only tissue predisposition or a diminution of tissue resistance to the real cause of cancer, whatever that may be. Some previously quoted cases are too impressive to be regarded as coincidences. Williams ("Brit. Med. Jour.," May 9, 1908) points out that 24.2 per cent. of women with cancer of the breast have or had relatives with a history of cancer. Williams states that Butlin's estimate is 37 per cent.; Leaf's, 23 per cent.; and Nunn's, 29.3 per cent.

Slye maintains that mouse cancer can be bred in and out of strains as is desired ("Interstate Med. Jour.," 1915, xxii).

Immunity.—This was referred to on page 293.

It is known that mouse tumors which follow transplantation in some cases retrogress and undergo spontaneous cure, and that animals in which this has occurred are found to have become immune to a re-inoculation of a like tumor. Crile and Beebe present some studies on this interesting subject in the "Journal of Medical Research," June, 1908. Gaylord and Clowes found that the serum of an animal thus rendered immune tends to destroy tumor cells, and experimented with the transfusion of the blood of immune animals into animals with active tumors; 7 animals out of 10 were cured. The blood of an animal naturally immune to tumor inoculation is said to act similarly to that of an animal which has acquired immunity, as shown by retrogression of a tumor.

Sex.—Cancer is more common in women than in men. If we leave out of consideration cancer of the uterus and breast, men suffer from cancer more often than women. Men are most apt to get cancer of the lip, tongue, and digestive canal.

Distribution of Cancer.—It occurs in all climates and probably all races, though it is much less common in primitive people living under natural conditions than among highly civilized races. It has been asserted that Eskimos are not liable to it. We know that the disease is very rare in the Eskimos of Labrador and Alaska. We know it is much more common among civilized than barbarous people. It is

rarer among the black and yellow races than the white race. Before the Civil War the negro in the United States seldom got cancer. Since emancipation cancer has become more and more common among negroes in the United States. At present and according to population, the colored woman is more liable to uterine cancer than the white woman. The American Indians seldom suffer from it. It occurs in the lower animals far less often than in man, is more common in domestic than in wild animals, and in captive wild animals than in those free and at large. The highly domesticated and pampered dog is of all animals the most prone to develop cancer. Cancer can even occur in cold-blooded animals. Fish in aquariums are liable to cancer, but are more liable to sarcoma. Cancer is most common in the temperate zone. It is usually asserted that the disease is rare in the tropics, but Dudley denies that this statement is true of the Philippine Islands ("Jour. Amer. Med. Assoc.," May 23, 1908). Cancer is certainly less common in India than in England, and it is very rare in Greenland. It is almost unknown among the natives of Algeria. Dr. Lionel Sells, of the Uganda Medical Staff, examined for army porters 17,000 men of all tribes, and only saw one case of cancer (letter to "Brit. Med. Jour.," Nov. 24, 1923). The frequency of the disease among the Jews has been much debated. Lombroso says of Italian Jews that they suffer more often than the rest of the population. This is not true of most countries. The Jews are long lived, hence there are many of the cancerous age, yet in New York and Philadelphia cancer of the uterus is rare among Jewesses in spite of their usual fecundity and cancer of the breast is relatively rare. It would be interesting to determine the incidence of cancer among gypsies. Cancer is more common in cities than in the country. This is a general rule to which there are local exceptions. It is usually believed that cancer is most prevalent in low and marshy districts. It is less common at high altitudes and among the dwellers on soils of chalk and lime. Returns seem to show that the larger the city, the higher the cancer death-rate. There seems to be a blight in civilization. It generates poisons which threaten its own destruction. Material progress, its artificial conditions, its keen-edged strife, its anxieties and harassments, its fears and griefs, cast an ominous shadow, and in that shadow is cancer. I know not how or why, but I am sure it is the case.

Cancer Regions and "Cancer Houses."—Some regions show a remarkable frequency of cancer. In Brookfield, New York, during five years nearly 10 per cent. of the deaths were due to cancer.

Tynes (Ibid., March 21, 1908) reports that in Fisherville, Pennsylvania, in 265 families there were 105 deaths, and 18 of them were due to cancer. It is maintained by Haviland and others that certain houses become infected and that cancer appears in such houses again and again among successive families inhabiting them. Such houses are called "cancer houses," and many remarkable statements have been collected relating to them, statements which to some observers seem to prove contagion, but which to others merely serve as interesting examples of coincidence.

Leeson ("Practitioner," Feb., 1909) is of the latter opinion, and shows that there was not a cancer house in his district. He studied 248 cases of cancer and all but 4 of them were in different houses. As this author says: "If we are to accept such evidence as that on which the belief in 'cancer houses' is founded, we must believe in 'apoplexy houses,' 'liver houses,' etc."

Statements about cancer houses are, to use the words of Horace Greeley, "important if true." Imagination has run wild on the mysterious theme. The buildings pointed out as being under the curse are usually old, damp, dark and moldy, just such buildings as could be responsible for all sorts of impairment of health in the inmates. Nothing has been developed in the record of any such house to indicate whether or not the successive victims were of cancer age, followed provocative callings, were predisposed by heredity, or had causal habits. The thesis is unproved, fanciful, in fact, all but incredible.

Influence of Diet.—Some blame meat, some tomatoes, etc., for the development of cancer. Vernueil and Reclus, commenting on the fact that carnivora are much more prone to cancer than herbivora, suggested that the increase of cancer during recent years might be due to the increased consumption of meat by the poorer classes. There is no proof of the truth of the suggestion that a meat diet is causative. If it were true the recent increase in the cost of meat might be regarded as the work of philanthropists striving to prevent cancer. Certainly of late the poorer classes have been consuming far less meat, but the increase in cancer goes on just the same. In fact, Prof. Senn points out that the Eskimos seem immune to tumor formation; yet

they live on an exclusive animal diet, and, furthermore, are the healthiest people in the world.

Arsenic Cancer.—Sir Jonathan Hutchinson pointed out in 1887 that the administration of arsenic may lead to cancer. Dubreuilh, of Bordeaux, has collected 19 cases ("Annales de Dermatoses," Feb., 1910). It is highly important to find out if salvarsan can ever be responsible for malignant growth.

***x*-Ray Cancer.**—A number of *x*-ray operators who worked with the rays soon after Roentgen's discovery developed cancer. An *x*-ray operator in Philadelphia died of carcinoma of the hand. It led to axillary and mediastinal growths. I operated on him twice in vain. Another Philadelphia operator submitted to amputation of the arm and subsequently died. Another one died after the amputation of several fingers. The cells are repeatedly injured by the rays and, finally, normal repair becomes impossible.

Recurrence After Operative Removal.—This is usually due to the fact that all of the cells were not removed. It may be due to a new growth. Recurrence may be due to cutting across lymph-tracts and flooding the wound with carcinoma cells, which lodge and grow. The growth of cancerous nodules in the abdominal scar resulting from an exploratory operation for cancer of the stomach is observed now and then. It is probably due to contact invasion of the scar area, which area has a lowered vital resistance to cancer cells.

Murphy thinks that the same explanation holds when the stitch cicatrices become cancerous ("General Surgery" in "Practical Medicine Series for 1909").

Extension of Cancer.—Cancer is at first a local disease, but sooner or later it spreads. It remains local longer in the aged than in the young. It spreads by the lymphatics and rapidly involves the anatomically associated lymph-nodes. The greater activity of the lymphatic system in youth than in old age explains the rapid spread of cancer in youth and the slower spread in old age. In the nodes the migrating cancer cells are imprisoned for a time, and in this incarceration lies the hope of surgery. The adjacent glands are involved much more rapidly than we used to think. They are usually involved within a few weeks of the start of the growth, except in superficial epithelioma, in which cases they are not involved at all.

In a structure devoid of capsule (as the tongue, the mammary gland, etc.) Lockwood points out that involvement of related lymph-nodes is practically immediate.

Lymphatic involvement may result in the formation of a mass much larger than the parent growth. The ducts between the primary cancer and the involved glands are filled with carcinoma cells and their walls will become infiltrated. Hence in an operation the ducts should not be cut across or the wound will be flooded with fluid rich in cancer cells. The ducts should be extirpated as well as the glands. To flood the wound with fluid containing cancer cells is very dangerous, for some of them may adhere, multiply, and reproduce the disease. After a time the capsules of cancerous nodes rupture and periglandular tissue becomes involved. The cells are held in the first glandular stopping-place (the anatomically related glands) for a time, but sooner or later other and more distant glands become involved. In certain abdominal cancers (stomach, rectum, and uterus) the thoracic duct may become obstructed by cancer cells. Large glands may cause much trouble by pressure. When they soften and break down the skin becomes involved and dreadful sores form, oozing foul matter and blood. Death may be due to hemorrhage from a large vessel which has become infiltrated.

Several times I have been consulted by patients on account of glandular enlargements of the neck, the patients never having noticed a small primary lesion in the mouth, and yet the entire glandular disease was secondary to the limited oral trouble.

Dissemination, or Metastasis.—These terms mean the formation of secondary growths. These growths are formed by small fragments of cancer being broken off and carried to lodgment in distant structures. Such small fragments are called *cancer emboli*. Cancer emboli may be carried by lymph or blood. When cancer emboli lodge in a region favorable to their growth their constitutent cells multiply and produce secondary growths. A secondary growth is the histologic counterpart of the parent growth, and an examination of a secondary growth gives us accurate information as to the nature of the primary growth. In cancer of the rectum there may be secondary deposits in the liver or in bone. Such deposits contain structure resembling rectal glands. In cancer of the stomach secondary nodules in the skin may contain structure resembling the gastric glands. Secondary deposits are by no means as common in cases of squamous-cell cancer as in glandular cancer.

Another method of dissemination is observed in the abdomen. When cancer of a viscus breaks through the peritoneal coat the cells are spread widely by peristaltic movements and peritoneal fluid, and the peritoneum becomes extensively involved. This involvement is a form of contact cancer. Any structure may be the seat of a secondary growth. The lung is frequently affected, so is the liver, so are the bones. What is known as the *Krukenberg tumor* is probably a carcinoma of the ovary secondary to cancer of the gastro-intestinal tract. The tumor contains fibrous elements and Krukenberg in 1896 described it as a fibrosarcoma containing cells like cancer cells (Major in "Surgery, Gynecology, and Obstetrics," August, 1918). Any organ or tissue may become the host for secondary deposits of carcinoma. Cancer of the umbilicus is usually, but not always, a condition secondary to intra-abdominal or pelvic cancer.

Spontaneous Disappearance of Cancer.—This is an excessively rare event in human beings, but it does occasionally occur. Gaylord has collected 11 cases which he considers authentic, viz.: 2 epitheliomata (1 of the tongue and 1 of the lip), 1 scirrhous cancer of the breast, 1 malignant adenoma of the rectum, and 7 cases of chorion carcinoma ("Seventh Annual Report of the Cancer Laboratory of New York State Department of Health"). The same author also notes the spontaneous disappearance of two sarcomata. Spontaneous disappearance of Jensen tumors successfully inoculated in mice is quite common. It occurred in 23 per cent. of Gaylord's animals. Whereas it is common in mouse tumors resulting from inoculation, it is rare in spontaneous mouse tumors. Bashford finds spontaneous healing in less than 1 per cent. of the latter group. Spontaneous disappearance is not due to the fatty degeneration and necrosis so often found about the center of a carcinoma, but to deprivation of some or all of the vitality of the epithelial cells by an utterly unknown process. Some observers think spontaneous cure is brought about by the stimulation of an immunizing force. When spontaneous cure occurs cancer cells are gradually replaced by scar tissue, and the resulting scar may contain cancer cells immeshed in it. Hence, after apparent retrogression, growth may begin anew.

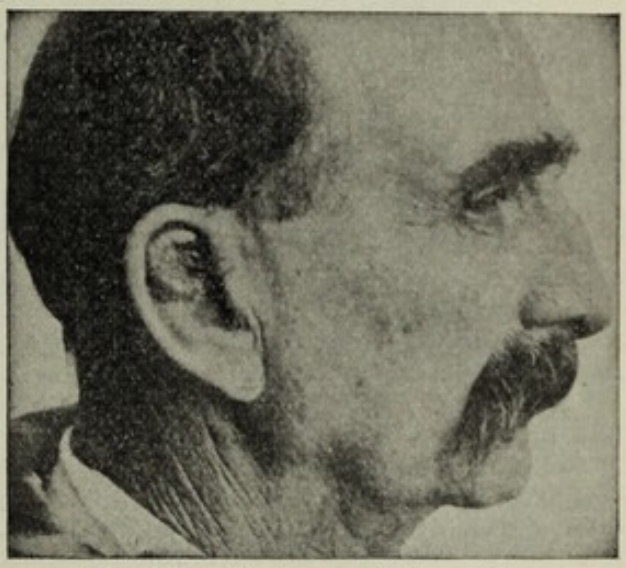


FIG. 187.—Carcinoma of the auricle.

Besides the apparently positively authenticated cases reported by Gaylord, there are numerous cases on record in which it is highly probable cancer disappeared spontaneously. These cases are collected in the Appendix to the previously cited report of Gaylord.

Blood Changes in Cancer Cases.—In early cases there is no notable change in either erythrocytes or hemoglobin. In more advanced cases as cachexia begins secondary anemia develops, fall of hemoglobin antedating diminution in erythrocytes.

The anemia may become so profound that it resembles pernicious anemia; in fact, some observers have asserted that pernicious anemia may arise. The anemia of cancer is not benefited by medical treatment.

In gastric cancer, because of vomiting, diarrhea, and deficient absorption of water, blood concentration may occur, the red corpuscles being 6,000,000 or even 7,000,000 per cubic centimeter.

The leukocytes may be normal, but are often increased. It has been claimed by Macalister and Ross ("Lancet," Jan. 16, 1909) that the blood of a patient with cancer contains a material in its plasma which is an excitant for the leukocytes of healthy persons. As previously stated (see page 328) the serum of the blood of a person with cancer contains agents destructive to the red corpuscles of healthy blood.

Elevated Temperature in Cancer Cases.—In any cancer case fever may occur when no complications exist to account for it. It may be sudden and brief or remittent and prolonged. It is especially common in cancer of the lung and the liver. It bears no relation to metastasis, but may to ulceration.

Classification of Carcinomata.—There are many forms of cancer: *Adenocarcinoma*, a growth in which glandular alveoli are imperfectly reproduced. *Papillary adenocarcinoma* springs from glands, mucous membrane, and skin. A *cystic carcinoma* may spring from a cyst wall or may form cysts of ducts or alveoli of a gland. *Fully developed carcinoma*, according to Ewing, may be in structure small alveolar, large alveolar, or tubercular.

Diffuse, *acute*, or *inflammatory carcinoma*, as it produces no tissue reaction leading to the formation of fibrous tissue, grows with frightful ferocity. It is seen notably in a lactating breast. *Fibrocarcinoma*, or *scirrhous cancer*, is accompanied by the formation of much fibrous tissue. It is the *hard* or *cicatricial cancer*. Embryonal carcinoma in structure resembles "that of the embryonal type of the organ from which it springs" (Ewing on "Neoplastic Diseases").

Epithelioma.—See below.

Clinically, we speak of rodent or Jacob's ulcer; *cuirass cancer*, a condition sometimes arising when the mammary gland is cancerous, and due to the infiltration of the cutaneous lymphatics with cancer cells and the formation in the skin of much fibrous tissue; *anilin worker's cancer* of the bladder and *paraffin worker's cancer* of the skin, if either of these occupations seems to have been causative; *cancer à deux*, a phrase used in France to signify that carcinoma has occurred in 2 persons of a household who are not blood relations, but have been in close contact; *contact cancer*, when cancer appears in an area which was in close contact with a cancerous area in the same or in another individual—for instance, when a cancer of the upper lip follows a malignant growth of the lower lip; when a carcinoma of the face follows a like growth of the hand; when a cancer appears on the penis of a husband whose wife has cancer of cervix uteri or vagina. *Chimney-sweep's cancer* was a cancer of the skin of the scrotum due probably to the arsenic contained in soot. The condition was discussed by Pott nearly one hundred and fifty years ago. A *melanotic carcinoma* is a form of encephaloid in which the cells contain melanin. *Marjolin's ulcer* is an epithelioma which arises from the epithelial edge of a chronic ulcer, a scar, or a sinus (see page 87, Figs. 42–45).

Epithelioma, or *epidermoid carcinoma*, springs from a surface covered with squamous epithelium. Ewing divides such growths into two classes, viz.: those possessing flat cells (*acanthomata*) and those exhibiting cells of the basal type (*basal-cell carcinomata*).

We speak also of *spheroidal-cell cancer*, *round-cell cancer*, *encephaloid* or *very soft cancer*, and *colloid cancer*.

Squamous-cell epithelioma (see Fig. 185) takes origin from the skin or from a mucous membrane covered with pavement-epithelium. It is especially apt to appear at the junction of skin and mucous membrane (as the lips) or the point of juxtaposition of different kinds of epithelium. Such a growth may arise in the anus or vagina; on the penis, scrotum, lips, or tongue; in the mouth or nose; on the skin, and other situations. There is an ingrowth of surface epithelium into the subepithelial connective tissue, colonies of cells growing inward and forming epithelial nests. It may arise without discoverable cause, it may follow prolonged irritation, or it may arise in a wart or fissure. In the nipple it is not very unusually, and in the scrotum, glans penis, and nose it is occasionally, preceded by a persistent dermatitis due possibly to psorosperms, and known as *Paget's disease*. Paget's disease is not true eczema, but is rather malignant dermatitis. A crust gathers on the part, and beneath this crust is a raw, red, and moist surface, the edge of which is slightly elevated and somewhat indurated. In the beginning there is a strong resemblance to eczema. The nipple is apt to retract. The parts are the seat of a constant itching and scalding sensation. The area may become cancerous in a few weeks, but may not for years. I have seen 2 cases of Paget's disease of the glans penis. Squamous epithelioma generally begins as a warty protuberance which soon ulcerates. A malignant or *true cancerous ulcer* (see Fig. 185) has a hard, irregular base, uneven edges, a foul, fungus-like bottom, and gives off a sanious or ichorous discharge. This ulcer is the seat of sharp, pricking pain, sometimes bleeds, and extends over a considerable area, embracing and destroying every structure. Epithelioma usually affects lymphatic glands early, but such infection may be long delayed. Epitheliomatous glands break down in ulceration, making frightful gaps and often causing fatal hemorrhage. Dissemination is not nearly so common as in other forms of cancer, but it does sometimes occur.

The so-called *cylindric-cell epithelioma* is in reality a *cylindric-cell adenocarcinoma*. This form of growth takes origin from structures covered with or containing cylindric epithelium, and it contains cylindric or columnar cells. It is composed of a stroma of fibers between which lie tubular glands lined with columnar epithelium

and containing masses of epithelial cells. Such tumors are found in the uterus and gastro-intestinal tract, and may begin from the surface epithelium or from the cells of tubular glands. In these tumors there is an acinus-like structure and the spaces are filled with proliferating epithelium. Cylindric-cell cancers may also arise from the mammary gland, liver, and kidney. One of the most common seats of cylindric-cell cancer is the rectum. Cancer of the rectum tends in many cases to occur at an earlier age than cancer elsewhere, being not uncommon between the ages of twenty-eight and forty. Cylindric-cell cancers are at first covered with mucous membrane, but they soon ulcerate and involve the submucous and muscular coats in the growth. They may grow rather slowly, usually but not always cause lymphatic involvement, and finally disseminate widely. They require in some regions from five to six years to cause death. In the rectum, however, growth is much more rapid and few victims of cylindric-cell carcinoma of the rectum, if unoperated upon, live beyond two years, and many of them die long before this period.

A *rodent* or *Jacob's ulcer*, *epithelioma exedens* or *cancroid* (Figs. 188–191), was called by the older surgeons *noli me tangere*, because they found that surgical interference (incomplete removal as we now know) was sometimes followed by very active growth. A rodent ulcer is scarcely ever met with except upon the face, though



FIGS. 188, 189.—Rodent ulcer (case of Dr. L. M. Raring, Denver, Colorado).

Jonathan Hutchinson saw one upon the forearm, and James Berry met with one upon the arm. It is especially common upon the nose and forehead. It begins usually between the ages of thirty and fifty as a little warty prominence which ulcerates in the center, the ulceration progressing at a rate equal to the new growth. The ulcer becomes deep; it is not crusted; its edges are irregular, hard, and everted; the floor is smooth and of a grayish color; the discharge is thin and acrid; and the parts about the sore contain numbers of visible vessels. Jacob's ulcer grows slowly, may last for years, does not involve the lymphatics, produces no constitutional cachexia, and is rarely fatal. In some cases, although growth is very slow, destruction eventually becomes very great because of ulceration, and there is great loss of tissue and horrible deformity (Figs. 188–190). A rodent ulcer is usually considered to be a malignant epithelial growth which springs from a sweat-gland, a sebaceous gland, or a hair-follicle, but Kanthack asserts that before ulceration the rete and the sweat-glands are normal, but the sebaceous glands are destroyed. The base and edges of the ulcer are hard, and this differentiates it from lupus; and, further, the bacilli of tubercle may perhaps be cultivated from the discharge or the margin of an area of lupus. A rodent ulcer may arise in an area of lupus (Fig. 191). Rodent ulcer begins below the surface epithelium, ordinary epithelioma begins in the surface epithelium, and a rodent ulcer contains no cell-nests. A rodent ulcer very rarely undergoes cicatrization, a fact which differentiates it from lupus. Occasionally, but very rarely, a small portion of the growth sloughs out and a temporary scar forms at this point.

Adenocarcinoma or Glandular Carcinoma.—In this growth the glandular acini from which the tumor arises are imperfectly reproduced. Ewing regards it as a partially developed form of cancer. As the growth develops it becomes gradually a typic cancer. Glandular carcinomata in structure resemble racemose glands. Such a cancer consists of a stroma of connective tissue and alveoli filled with proliferating epithelial cells. If the proportion between the fibrous stroma and the cellular elements is about the same as in a normal gland, the growth is called simple. When the cellular element is in excess the growth is soft (medullary), and when the fibrous stroma is in excess the growth is hard (scirrhous).

1. *Scirrhous carcinoma* is a white and fibrous mass which has no capsule, which infiltrates tissue, and which, by the contraction of its outlying fibrous processes, draws in toward it adjacent soft parts, thus producing dimpling, or, as in the breast, retraction of the nipple. It is composed of spheroidal cells in alveoli formed of connective-tissue bands. The commonest seat of scirrhus is the female breast. It occurs also in the skin, vagina, rectum, prostate, uterus, stomach, and esophagus. It is most frequent in women after forty. It begins as a hard lump which is at first painless, but which after a time becomes the seat of an acute, localized, pricking pain. This lump grows and becomes irregular and adherent, causing puckering of the soft parts. After the skin or mucous membrane above it has become infiltrated ulceration takes place and a fungous mass protrudes which bleeds and suppurates. The adjacent lymphatic glands usually become cancerous in from six to ten weeks, and constitutional involvement is rapid and certain.

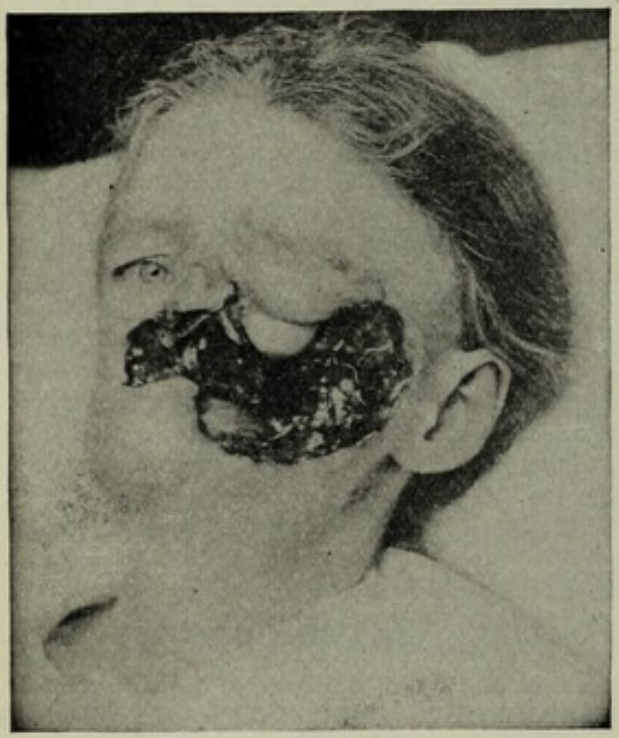


FIG. 190.—Rodent ulcer. Case in the author's wards in Philadelphia Hospital.



FIG. 191.—Rodent ulcer engrafted upon lupus. Woman of sixty (Dr. W. L. Clark).

2. *Medullary* or *encephaloid carcinoma* is a soft gray or brain-like mass. It is a rare growth, it has no capsule, and it may appear in the kidney, liver, ovary, testicle, mammary gland, stomach, bladder, or maxillary antrum. An encephaloid cancer often contains cavities filled with blood, and this variety is known as a "hematoid" or a "telangiectatic" carcinoma. These growths are soft and semifluctuating, they infiltrate rapidly and soon fungate, and they terminate life in from a year to a year and a half. If the cells of encephaloid become filled with melanin, the condition is called "melanosis" or "melanotic cancer."

3. *Colloid cancer* is extremely rare. It arises from either a scirrhus or an encephaloid when the cells or the stroma of such a growth undergo colloidal degeneration. On section there will be seen in the center of the growth a series of cavities filled with a material resembling honey or jelly; the periphery is frequently an ordinary scirrhus or encephaloid cancer. Colloid degeneration is most prone to attack carcinomata of the stomach, mammary gland, and intestine. The name colloid cancer is often given to glistening, gelatinous, malignant growths springing from the ovary, testicle, mammary gland, or gastro-intestinal tract. The condition is due to mucous degeneration of the connective tissue or of the epithelial tissue of a carcinoma. Only a portion of the tumor may degenerate or the entire mass may become gelatinous.

Syncytioma Malignum.—By this name is meant a malignant epithelial growth arising from the site of the placenta during pregnancy or the puerperal state. It resembles placenta in appearance and rapidly causes metastases by way of the blood-vessels. It is quickly fatal.

Treatment.—Cancer is so prevalent, is so dreadul in its nature and inexorable in its progress, tends so strongly to cause death in from one to five years, people are so afraid of it, and so many physicians are hopeless of curing it that multitudes seek relief from the obsessed Christian scientists or from vulgar criminal quacks. It cannot be too strongly insisted that in the beginning cancer is a local disease curable by early and radical operation, that early diagnosis should be made, and that prompt operation is imperative. Delay is not only disastrous, it is usually fatal. Certainly at least 30 per cent. of the cases of cancer I see are beyond radical operation when they are first brought to the hospital, they having sacrificed the golden moments during which cure was possible. Carcinomata demand early and wide excision, with removal of implicated glands. Anatomically related lymph-nodes must be removed even if they show no evidence of involvement. If operation is early and thorough, and if certain regions are involved, a considerable proportion of cases can be cured. Carcinomata of the lip, the skin, and the mammary gland can often be cured. The operation must be radical. That the tumor is small and recent is no justification for minimizing the extent of operation. That is the sort of case which may be cured by radical removal. Anything short of radical removal is bound to fail. Recurrence almost certainly means that cancer cells have been left behind. Unless a wide area is removed cancer cells are sure to be left. During removal the parts should be handled as little as possible so as not to squeeze malignant cells into the wound. Cancer cells in a wound soon become fixed and multiply. For the same reason tumor and glands are removed in one piece. The surgeon avoids cutting across lymph-vessels and thus planting cancer cells in the wound. After operation the *x*-rays should be used in hope of destroying cancer cells which may have remained in the tissues. To use the rays lessens the danger of recurrence. Czerny ("Deutsch. med. Wchnschr.," Nov. 2, 1912) is so impressed with the necessity of special effort to prevent recurrence that he leaves the operation wound open for two or three months, uses radium, the *x*-rays, or fulguration in the wound, and then, if everything seems to be going on well, he closes the wound by a plastic operation. A recurrent growth may be removed as a palliative measure to lessen pain and to relieve the patient from ulceration and hemorrhage, but such an operation is rarely curative. If a growth does not recur within five years after removal, a cure has very probably been attained; in fact, if there is no recurrence within three years, the case is probably cured. The three-year limit has been usually accepted since Volkmann's paper on the subject. A rodent ulcer should be excised or be curetted and cauterized with the hot iron or the Paquelin cautery or subjected to electric desiccation or to electrothermic coagulation. In cancer of the lower *lip*, remove the growth by Grant's operation (*q. v.*), or, if necessary, cut away the entire lip. In every case remove the glands beneath the jaw. In cancer of the *tongue*, excise this organ and also the lymph-nodes from beneath the jaw and in the anterior carotid triangles. In cancer of the *breast*, remove the breast, the pectoral fascia and the pectoral muscles, and take away the fat and glands of the axilla. In cancer of the *rectum* do the sacral resection of Kraske and then remove the growth. In cancer of the *esophagus*, perform gastrostomy; in cancer of the *pylorus*, perform pylorectomy or gastro-enterostomy; in cancer of the *bowel*, do resection, side-track the diseased area by an anastomosis, or make an artificial anus; in cancer of the *penis*, amputate the organ and remove the glands of the groin.

Treatment of Inoperable Cancer.—Erysipelas toxins are seldom of any service in carcinoma. In very rare cases they do good. It is justifiable to try them. Claims have been made that cancer can be benefited by the intravenous injection of material expressed from carcinomatous tumors. There are suggestions of the value of such treatment. The late Dr. Hodenpyl had charge of a case in which a cancer of the liver was undergoing spontaneous retrogression. When a cancerous individual was injected with ascitic fluid from this case a local reaction was observed in the tumor (swelling, redness, diminution in size, necrosis). It was assumed that the fluid contained a specific material which might cure cancer. The results of the study of such fluid have been negative (Richard Weil, "Jour. Med. Research," August, 1910). Serum from animals suffering from cancer is without therapeutic value. Pyoktanin, thiosinamin, trypsin, colloidal silver, lecithin, and many other materials have come upon the scene as remedies. They were like plausible confidence men, but each was soon exposed.

There is no drug and no serum, no globulin, no vaccine, and no toxin at present known to be capable of curing cancer. Honest investigators have at times been led into error by forgetting that at times the rate of growth of a cancer may temporarily lessen or that growth may for a time actually cease. (See Lewis S. Pilcher's address before the Surgical Society of Brooklyn in Feb., 1909.)

Fulguration has of late excited much interest. By this term we mean bombarding a part from a metal electrode with sparks flashed from a high-tension current. It was introduced as a treatment for cancer by De Keating-Hart in 1907. The sparks have no specific action on cancer cells. All the surface cells of an ulcerated growth are converted into an eschar and the connective tissue under and around the sore is stimulated to cicatrize. Sometimes after fulguration healing occurs over cancerous nodules. Fulguration cannot act through the unbroken skin. It is not a real cure, though it may retard the progress of a case or aid in preventing recurrence after extirpation of a growth. Application of sparks may be followed by grave or fatal sepsis. The early enthusiasm for fulguration in cancer has largely waned. No operable growth should be treated by it, as, at best, it has only a local effect and cannot act upon the involved lymph-nodes. The cautery at a cherry heat as used by the late Dr. Byrne is a valuable agent. At this heat there is no bleeding.

Electric desiccation finds some warm supporters. A monopolar electric current of high tension is used (the Oudin current). It is applied by means of a metal conductor. The tissues are dehydrated but not carbonized, and are removed later by sloughing or curetment (Clark in "Med. Council," July, 1915). This is particularly suited for superficial lesions (page 1468). In *electrothermic coagulation* heat generated in the tissues by their resistance to the passage of the electric current causes coagulation and destruction of the cancer. The high-frequency current of the d'Arsonval type is used (Pfahler in "Interstate Med. Jour.," 1917, vol. xxiv). (See page 1468.) I find that in some cases, obviously irremovable by the knife alone, a combined operation may be done with great benefit. The surgeon uses the knife. The electric expert applies desiccation. In one case I tied the external carotid artery before Dr. Clark desiccated the area. In another case I removed the upper jaw as a preliminary to desiccation. In another case I removed part of the lower jaw. The results were excellent. This combined operation permits of the removal of a glandular area. The failure to do this by electric methods alone has been a major indictment against them. I am convinced that a cancer removed by desiccation or by the knife followed by desiccation is decidedly less apt to recur than if the knife alone were used. If recurrence does take place, it will be later if desiccation has been used than if it has not been used.

Electrolysis destroys tissue by electrolytic action. Cataphoresis, or ionic surgery, is a modification of electrolysis. Percy employs a method by which the tissues are cooked for a considerable time. The heat is applied by an electrocautery controlled by a rheostat and the degree of penetration of the heat can be regulated rigidly ("Transactions of Western Surgical Assoc.," Dec., 1913). The *x*-rays are of distinct value in certain cases of carcinoma. Surface growths may be apparently cured, although, unfortunately, they are apt to return even after total disappearance. Deeper growths are seldom lessened in size and practically never cured, but the rate of growth may be diminished and pain be abated or abolished. The knife is to be preferred to the *x*-rays, except in very superficial skin cancer about the eyelid or nostril, and in inoperable cancer. The real curative power of radium is as yet undetermined. The *x*-rays and radium have a decided influence in lessening the horrible pain of recurrent or inoperable cancer. In lymphatic recurrence after operation thyroid extract may perhaps be of some value. In some cases of recurrent cancer ligation of the artery of supply or extirpation of the artery, as suggested by Dawbarn, notably retards growth. I have been able to confirm this statement. In cancer of the breast, oöphorectomy occasionally produces great benefit (Beatson's Operation, page 1435). In inoperable cases palliative operations may be justifiable to relieve some urgent discomfort or get rid of a foul or bleeding mass. Gastro-enterostomy, gastrostomy, and colostomy are palliative operations. In a malignant growth of the nasopharynx tracheotomy may be required, and in a malignant growth of the bladder it may be advisable to perform suprapubic cystostomy. In an inoperable case of cancer it may be necessary to relieve the pain by opium, giving as much as may be required to secure ease. Opium so used seems not only to relieve pain, but to retard the growth of the tumor and to favor the development of fibrous tissue in the stroma. Gay, of Boston, has long believed in the value of compound tincture of iodin in retarding cancer growth.

In some cases he gives also the bromid of arsenic ("Boston Med. and Surg. Jour.," March 11, 1909).

Chemotherapy of Cancer.—Wassermann has been able to cause mouse cancer to disappear by injecting into the veins of the animal negrosin, and also by injecting eosin and selenium. This proves that a chemical, as well as a parasite, may have an affinity for certain cells. The chemicals used by Wassermann attacked the cells of mouse cancer, and did not attack or only slightly influenced the other cells of the body. The world is seeking for a chemical agent to destroy cancer.

Wassermann desired to introduce selenium into the cancer cells. He found eosin (an anilin dye) to be the helping hand to put selenium into the cells. When the pink solution of eosin-selenium is thrown into the blood of a mouse the skin at once becomes pink. The pink color of the skin disappears in a few hours; the tumor remains deeply stained. Numerous injections will kill the mouse or cause the tumor to soften and slough, and the action is just as positive in spontaneous as in transplanted tumor.

This material is too dangerous to use in man, but the investigation suggests splendid possibilities for the future (E. F. Bashford in the "Lancet," Jan. 13, 1912). Colloidal solution of vanadium has been tried. It is stated that copper and tin have a greater affinity for cancer cells than selenium (Weil reviewed the subject in "Jour. Amer. Med. Assoc.," 1915, lxiv).

Malignant Growth from Congenital Pigmented Mole (Fig. 192).—As previously stated (pages 300 and 319), the embryonic origin of the pigment-producing cells is uncertain. Some regard a malignant growth of a congenital pigmented mole as cancer, others as alveolar pigmented sarcoma. Bloodgood thinks it is probably carcinomatous.

Malignant change seldom occurs before the fiftieth year, the growth rarely attains a large size, metastasis takes place very rapidly by the blood and lymphatics, and the patient seldom lives more than a year after malignant change begins. (See Bloodgood in "Progressive Medicine," Dec., 1907.)

Because of the danger of subsequent malignant change it is wise to remove large pigmented moles. Every pigmented mole which is irritated or begins to enlarge must be removed, and the associated lymph-nodes should also be removed. Bloodgood knows of no definite cure on record of a malignant tumor arising in a pigmented mole. Prevention is easily secured by extirpation before the onset of malignancy.

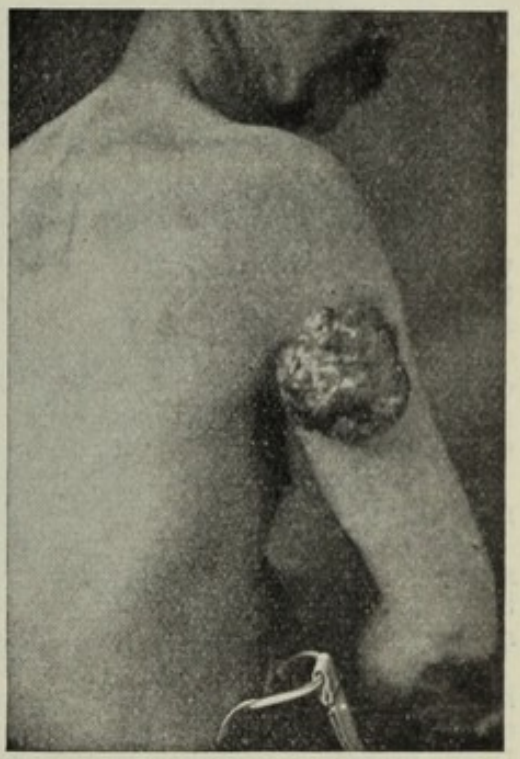


FIG. 192.—Melanotic growth, secondary to pigmented mole.

Cystomata.—A cystoma is a benign cystic tumor in which the cells of the cyst wall constitute the new growth. The cyst contents are derived from the cells of the wall. The tumor is the cyst wall; the cells of this wall are derived from the epiblast, the hypoblast, or the mesoblast, and are either epithelial or endothelial. The cells of the cyst wall adhere to connective tissue which seems to constitute a part of the wall. A thick wall contains much connective tissue, a thin wall very little. The nature of the contents is dependent on the character of the cells which constitute the tumor. Cysts lined by endothelium contain serous fluid; a cyst of the thyroid gland usually contains colloid material; a cyst lined by flat epithelial cells contains matter resulting from fatty degeneration, etc.

Cystomata may be congenital or acquired, and an acquired cystoma may arise after injury or follow inflammation. The cyst may increase in size progressively or its growth may be halted. The wall may become calcareous or even bony. When a cyst has one cavity, we call it monolocular; when there are several or many cavities it is called multilocular.

Varieties of Cystomata.—The chief varieties are: Traumatic epithelial; atheromatous; mucous; mesoblastic.

Traumatic Epithelial Cystomata.—These growths have been called traumatic

dermoids. Such a growth may arise after an injury which carries and deposits epithelial cells or a bit of skin deep into the connective tissue. For instance a punctured wound of the hand may be followed by an epithelial cystoma (Fig. 194). It may arise after a scalp wound, in the scar of a burn, or in the scar following a fistula operation or an operation for osteomyelitis. The cyst grows only to a certain size and then remains stationary. It is lined by pavement-epithelium and it contains products of the fatty degeneration of epithelial cells (page 344).

Treatment.—Extirpation of the wall of the cystoma.

Atheromatous Cystomata.—These growths, according to Senn, are met with particularly in the ovaries, in the orbital region, and at the base of the tongue, but they can arise almost anywhere. They may remain small or may attain a great size. Such a cystoma contains columnar epithelial cells which have undergone fatty degeneration and sometimes contains oil. An atheromatous cystoma is deep seated and is not connected with the skin, in contrast to a sebaceous cyst, which is superficial and is a part of the skin. An atheromatous cystoma is lined with epithelium, but not with skin. A dermoid cyst is lined with skin or other definite structure. An atheroma is due to the displacement of a mass of epithelial cells which was the matrix of the cystoma. "The displacement of the matrix of an atheroma occurred at a time prior to the differentiation of the epiblastic cells into the organs representing the appendages of the skin, while the matrix of a dermoid cyst points to a later displacement of the matrix" ("Pathology and Surgical Treatment of Tumors," by Nicholas Senn). Atheromatous cystomata may be congenital, but may not appear until puberty or even much later.

Treatment.—Extirpation of the wall of the cystoma.

Mucous Cystomata.—A mucous cystoma, like an atheromatous cystoma, is due to the displacement of epithelium, but in the former condition it is pavement-epithelium and in the latter it is columnar epithelium. A mucous cystoma is filled with a mucoid material and an atheromatous cystoma with a fatty débris. Such a mucous cystoma must not be confused with a retention cyst of a mucous membrane. Mucous cystomata are found particularly about the lips, mouth, and pharynx. They rarely attain any considerable size. Cystomata lined with ciliated epithelium may arise in the testicle, the liver, and the brain.

Treatment.—Incise, cauterize, and drain. The wall is so delicate that excision is rarely possible.

Mesoblastic Cystomata.—They are lined with endothelial cells. They contain serous fluid, often grow to a large size, and sometimes disappear spontaneously. Mesoblastic cystomata are probably distended lymph-spaces. They are congenital and are most common in the neck, axilla, and perineum.

Hadley regards certain retroperitoneal cysts as having a common origin with hydrocele of the neck ("Surgery, Gynecology, and Obstetrics," xxii, 1916). He says that the embryologic development of the lymph system passes through two stages. In the first stage primitive lymph sacs form from veins. In the second stage lymphatic vessels grow from the endothelial layer of the sacs. There are four primitive lymph sacs, viz., the jugular sacs in the neck, a sac back of the peritoneum and in front of the lower dorsal and upper lumbar vertebræ, and a sac in the pelvis. If development is arrested early a cyst will form. In one case seen by the author such a cystoma of the neck appeared late in life, but it is probable that it had existed in childhood, and after disappearing for a long time had reappeared. The most common form of mesoblastic cystoma is known as *hygroma* or *hydrocele of the neck* (Fig. 193). A hygroma contains numerous pockets. Some hygromata are very large, reaching from the clavicle to the lower jaw and from the middle line of the neck to the spine. Some pass into the axilla, others into the anterior mediastinum.

Treatment.—Excision is very difficult. In 1 case in which I assisted Professor Keen it was successfully accomplished and in another case I succeeded. The cyst should be injected with methylene-blue to make its outlines clear. The usual treatment is to tap frequently, and, after each tapping, to wash out with carbolic acid (2 to 5 per cent.) and to apply pressure. Recently I excised successfully a hygroma which passed down into the axilla.

Cystomata of bone, of the thyroid gland, of the mammary gland, etc., are considered in the sections on Regional Surgery.

Embryomata and Teratomata.—The teratomata contain tissues or higher structures derived from two or all of the blastodermic layers. The tumors we previously considered are derived from only one of these layers. The elder Senn, in his work on "Tu-

mors," thus defines a teratoma: "A teratoma is a tumor composed of various tissues, organs, or systems of organs which do not normally exist at the place where the tumor grows. The highest type of a teratoma is a fetus in fetu. In the simpler varieties the tumor is composed of heterotopic tissue, such as bone, teeth, skin, mucous membrane, etc. All teratoid tumors are congenital; that is, the tumor either exists at the time of birth or the patient is born with the essential tumor matrix. A teratoma never springs from a matrix of postnatal origin." According to Ewing, in an embryoma tissues and organs are arranged in an orderly imitation of a fetus. In a teratoma there is a lack of orderly arrangement and a chaos made up of bits of tissue and parts of organs. Any human structure may be found in a teratoma. Various fetal malformations belong to this group, as do also double monsters, in which one of the embryos is rudimentary. Teratomata are divided into *external* and *internal*. To the external teratomata belong the parasitic fetus and the suppressed fetus. A *parasitic fetus* is the result of fusion of two embryos, one having gone on to complete development, and the other developing partially, and obtaining nutrition from the fully developed embryo to which it is attached (an embryoma). A *suppressed fetus* is an irregular mass attached to the posterior surface of the sacrum, to the chest, or to the abdomen. It contains a conglomeration of tissues and fragments of organs, for instance, bone, cartilage, lung tissue, kidney tissue, a piece of intestine, or a portion of liver (a teratoma). In a case pictured by Sir J. Bland-Sutton a leg projects from the sacral region.

An *internal teratoma* may be found within the cranium, chest, abdomen, or pelvis. The internal teratoma consists of a conglomeration of the tissues and visceral fragments

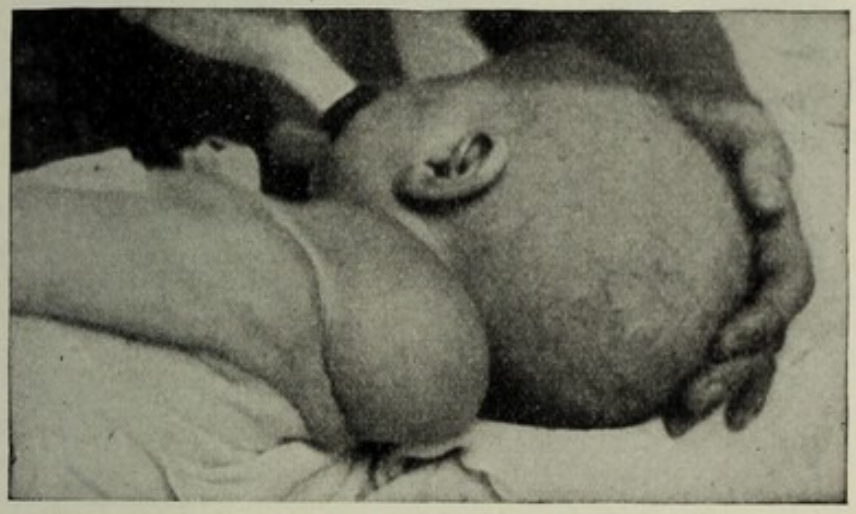


FIG. 193.—Hydrocele of neck in boy nine weeks of age.

of a suppressed fetus, but, unlike the external teratoma, it is surrounded by a cyst wall. The members of this group most often seen by the surgeon are *dermoid cysts*. Tumors, innocent or malignant, may spring from a teratoma.

Dermoid Cysts.—These cysts were first studied and described by Lebert. The name "dermoid" implies that the cyst contains skin, and it does contain skin or mucous membrane, the chief mass of the tumor being derived from proliferation of the cells of a portion of displaced epiblast or hypoblast, but it also contains mesoblastic derivatives. The true dermoid is the *sequestration dermoid*. The *tubulodermoid* is considered on page 344. In this section we speak of the first form. The second form is considered on page 346. A superficial dermoid is formed by the inclusion in mesoblastic tissues of a portion of the epidermis or mucous membrane. Superficial non-traumatic dermoids are situated in regions where the blastodermic layers were in contact. A deep dermoid is formed from a collection of epithelial cells completely separated from the epiblastic tissue from which they originated. When a cyst originates from epiblastic cells so immature that the skin appendages have not as yet been formed, it will contain only atheromatous material like that found in a sebaceous cyst. When a cyst arises from epiblastic cells after they have so matured that the appendages of the skin have been formed, it will contain atheromatous matter, sweat, sebaceous matter, and hair. The first form is known as an *atheromatous cystoma;* the second, as a dermoid. A deep-seated dermoid may contain also such structures as prove it must have taken origin from a displaced matrix representing different tissues. Such a dermoid may contain

portions of bone, cartilage, and teeth. A dermoid cyst may be defined as a heterotopic cyst, the wall of which is composed of connective tissue lined with epithelium and containing material formed by the proliferation of epithelium and often hair, teeth, or even bone. An injury may displace a bit of epithelium and lodge it in connective tissue and from this a traumatic dermoid may arise (Fig. 194). Traumatic dermoids are not true dermoids. Garrè called them *traumatic epithelial cysts*. They are most often encountered in the palmar surface of the hand or fingers. The skin above such a cyst is not adherent to it and often a scar is visible. The cyst wall is composed from without inward of connective tissue and epithelial cells, the stratum corneum being the inner layer (Leo Buerger in "Annals of Surgery," August, 1907). The cyst contains desquamated epithelium and often cholesterin. The causal injury is usually a puncture, but may be a laceration, a contused wound, or a bite. Sometimes a cyst arises in the track of a healed sinus. Pietzner collected reports of 73 cases ("Ueber Traumatische Epithelcysten. Dissert. Rostock.," 1905).

True dermoid cysts are most commonly found in the various regions where, during bodily development, the blastodermic layers come in contact; for instance, in the neck, the eyelids, the orbital angles, the lumbosacral region, the root of the nose, and the floor of the mouth. Such cysts are also found in the ovary, testicle, brain, eye, mediastinum, lung, omentum, mesentery, and carotid sheath.

A dermoid of the lumbosacral region may be mistaken for a spina bifida. Sarcoma may form from the connective-tissue elements of the wall of a dermoid cyst.

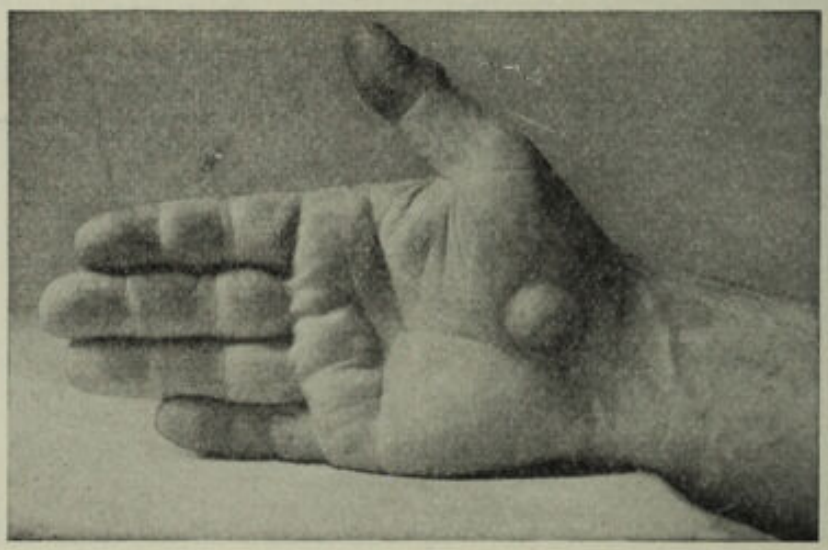


FIG. 194.—Traumatic dermoid cyst.

A dermoid cyst may become cancerous, or innocent epithelial tumors may originate from the cyst lining. The epithelial cells may become fatty and an oil-cyst may actually form. If the cyst epithelium was derived from mucous membrane, mucus may gather in the sac. A dermoid cyst may inflame or even suppurate. It is free from pain unless it suppurates, inflames, or develops into a malignant tumor; it grows slowly and rarely attains any considerable size unless it arises in the ovary. A subcutaneous dermoid may or may not fluctuate. It is not in the skin as is a sebaceous cyst, but the skin can be moved over it. A sebaceous cyst moves with the skin. Subcutaneous dermoids about the orbit are adherent to the underlying periosteum. The matrix of a true dermoid is congenital, but the cyst often does not appear until puberty or later. Teratoids and dermoids connected with the rectum require special consideration (see page 1166).

Treatment.—Complete extirpation. If any of the epithelium of the cyst wall is left, the cyst will re-form. A superficial dermoid should be removed in the same manner as a sebaceous cyst, and if it is adherent to underlying periosteum the portion of this membrane to which it adheres should also be removed. A deep dermoid ought to be removed as a tumor would be, if operation is feasible.

Branchial Cysts and Fistulæ.—When a branchial cleft fails to become completely obliterated, a branchial cyst may form. The branchial clefts are the analogues of the gill-slits of a fish. There are four of these clefts on each side of the neck. They are called clefts, but they are really grooves, and each groove on the skin has its counterpart in the mucous membrane of the pharynx. Each pharyngeal groove is covered

with hypoblastic epithelium; each cutaneous groove is covered with epiblastic epithelium, and the two grooves are separated by mesoblastic structures. When the sides of a cleft do not unite and openings form in the skin and mucous membrane, a *complete branchial fistula* (*complete congenital lateral cervical fistula*) results. When the sides of a cleft fail to unite and, although the mucous membrane is not perforated, the skin does not cover the cleft, a *branchial sinus* or an *incomplete branchial fistula* (*incomplete congenital lateral cervical fistula*) results. When the sides of a cleft toward the pharynx fail to coalesce, a *pharyngeal diverticulum* is produced. When the pharyngeal surface and the cutaneous surface both close, but the deeper part of a cleft remains open and epithelial cells are caught in mesoblastic elements, a *branchial cyst* is formed. Cysts lined by columnar epithelium seldom give rise to symptoms. (See "British Jour. of Surgery," April, 1923. Article on "Clinical Aspects of Branchial Cysts," by Hamilton Bailey.) Sinuses are more common than complete fistulæ or cysts.

The essential cellular element of a branchial cyst is epithelium, derived usually from the skin, rarely the pharynx; hence the branchial cyst is not a true dermoid, because its histologic elements are derived from only one of the blastodermic layers. Branchial cysts are most common in the triangle of election of the left side. Cysts are more common in males than in females, may be noted in early life, but are seldom observed until adolescence or later. Growth is slow. In most cases the cyst presents in front of the sternomastoid muscle and its center is opposite the greater cornu of the hyoid bone. I have never noted translucency. They are round, smooth, painless, and often fluctuating. Cysts lined by columnar epithelium contain clear mucus. Cysts lined by squamous epithelium contain fluid which may be colorless, but is usually thin and opaque, holding fatty débris, and the microscope shows cholesterol and epithelial cells. An abscess may form. The origin of a cyst or fistula is usually from the second branchial cleft, but I have operated on two cysts of the first branchial cleft, and Dr. Nassau also operated on one of like origin. Many cysts are placed just beneath the deep cervical fascia, some are adherent to the sheath of the internal jugular vein. Some by enlargement pass inward between the internal and external carotid arteries. Seldom the cyst springs from the pharyngeal wall (Bailey, Ibid.). There may be one, two, or three openings of a fistula. The openings of sinuses are sometimes, but seldom, bilateral. Hereditary tendency may be manifest in cysts. The cutaneous openings are always along the anterior margin of the sternocleidomastoid muscle. At the external orifice there is often an irregularly shaped bit of skin and cartilage, which is called a *cervical auricle*. A branchial cyst or sinus or epithelial remains in a cleft may become the seat of epithelioma. Such growths are rare, though more common than I used to think, and they are excessively malignant. They grow rapidly, extend widely, and soon ulcerate (*branchial carcinoma*).

Treatment.—In older children and in adults it may be possible to extirpate even a deep cyst or a fistula, although this is very difficult and often impossible. A ureteral catheter is introduced into the fistula, a circular incision through the skin is made about it. The incision leaves a disk of skin. An incision is then made along the anterior border of the sternomastoid, the muscle is drawn outward, the tract is dissected sharply to the carotid bifurcation, but from that point blunt dissection is practised. The patient's mouth is opened and traction on the tract will make a dimple below the tonsil or in the lateral wall of the pharynx. The neck of the tract is ligated and divided (Dowd, quoted by Tarnowsky in "Internat. Abstract of Surgery," Sept., 1916). Other methods employed are incision, cauterization with the electric cautery, and packing with gauze; frequent tapping and injection with iodin; incision and drainage, every antiseptic care being observed. In all young children and in some older persons with deep cysts the latter plan is the only one advised, and it will often fail, but may sometimes produce a cure.

Cysts.—A cyst is a cavity, abnormal or pathologic in character, lined by a membrane and containing material usually fluid or semifluid. It is necessary to bear in mind the distinction between a cystoma and a cyst. Hektoen and Riesman, in the "American Text-Book of Pathology," insist on this distinction. They say: "A *cystoma* is a true tumor, arising from active proliferation of a matrix destined to form cystic spaces; whereas a cyst is a secondary formation not primarily due to tissue proliferation." Cysts are divided into the following classes: retention cysts; cysts from softening; tubulocysts, and parasitic cysts (Ibid.).

Retention Cysts.—A retention-cyst is formed by blocking of the duct of a gland or by failure in the absorption of the proper amount of the secretion of a ductless gland. A few characteristic forms of retention cysts will be described.

Sebaceous Cysts (Wens).—A sebaceous cyst arises when the excretory duct of a sebaceous gland is blocked by dirt or occluded by inflammation. The orifice of the duct is often visible as a black speck over the center of the cyst. They are very common in the scalp, being known as *wens*, and upon the face, neck, shoulders, and back. There may be one, several, or a number (Fig. 195). Arising in the skin, and not under it, the skin cannot be freely moved over a sebaceous cyst. A sebaceous cyst is lined by epithelium and is filled with foul-smelling sebaceous material. A sebaceous cyst may suppurate. When a cyst ruptures and the contents become hard, a *horn* is formed. Another form of horn has been previously alluded to as due to horny transformation of a wart.

Treatment.—To treat a sebaceous cyst, incise the portion of skin above it and dissect the sac entirely away by scissors or a dissector, trying not to rupture the delicate wall. If even a small particle of the wall is left, the cyst will re-form unless the clinging bit of lining is destroyed by a cauterizing agent. If it rupture during removal and it is possible that some portion may remain, cauterize the interior of the wound with pure carbolic acid. If acid was not needed, close without drainage; but if acid was used, drain for twenty-four hours. If an abscess forms in a sebaceous cyst, open it, grasp the edges of the cyst lining with forceps, dissect out this lining by scissors curved on the flat, cauterize by pure carbolic acid, and drain for twenty-four hours.

Mucous Cysts.—A mucous cyst is due to the blocking of a mucous gland or a mucous crypt. Mucous cysts occur particularly in the mucous membrane of the mouth and genito-urinary organs, and are filled by thick, adhesive mucus containing numerous epithelial cells. Such a cyst is of spheric outline, and the epithelial membrane which lines it is strongly adherent to tissues beyond.

Treatment.—Incision, curetment, cauterization by pure carbolic acid, and packing or extirpation of a considerable part of the cyst, and curetment and cauterization of the part remaining.

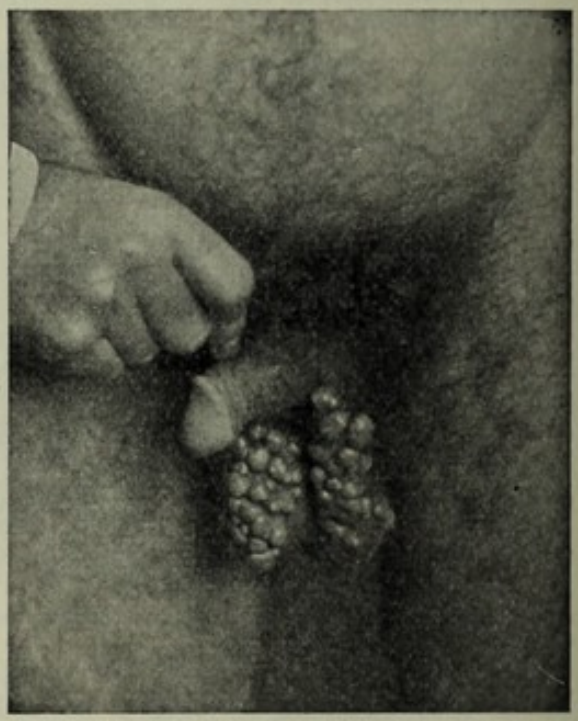


FIG. 195.—Dr. Weatherby's case of multiple sebaceous tumors of the scrotum.

Oil Cysts.—An oil cyst is due to fatty degeneration of the epithelial lining of a sebaceous cyst, or of a milk cyst of the breast. As previously noted, a dermoid may become an oil cyst.

Treatment.—Extirpation, as for sebaceous cysts.

Salivary Cysts.—A retention cyst of a salivary gland is known as a *ranula* (*q. v.*). These cysts are most common in the submaxillary or sublingual gland.

Lacteal or Milk Cysts (Galactocele).—Such a cyst occasionally arises in the mammary gland during lactation, and is the result of blocking of a lactiferous duct (see Cysts of Mammary Gland).

Among other forms of retention cysts, most of which are discussed in special sections of this book, we mention *hydrosalpinx*, a cyst due to blocking of a fallopian tube; cysts due to obstruction of the bile-ducts (the most common form is known as *hydrops*, which is a dilated gall-bladder the result of obstruction; cyst of the thyroid gland; cyst of the pancreas; and *hydronephrosis*, a condition produced by obstruction of the ureter.

Cysts from Softening.—These cysts are formed by the disintegration of degenerated tissues. For instance, after a hemorrhage into the brain, softening may follow and a cyst arise. Cystic changes of this sort are frequently observed in sarcomata and carcinomata. A cyst from softening has a wall of connective tissue, but there is no endothelial or epithelial layer.

Tubulocysts.—This name was given by Sir J. Bland-Sutton to cysts formed in certain remains of embryonal ducts—vestiges which ought to have been destroyed in the developed body. A small cavity is left unobliterated, and in this space fluid gathers. The source of the fluid is usually the lining cells of the cavity. Branchial

cysts are frequently considered under this heading. Among the commoner tubulocysts are cysts of the vitello-intestinal duct, cysts of the urachus, and thyroglossal cysts. Thyroglossal cysts and sinuses are considered on page 914.

Mesenteric cysts, not hydatid and not due to carcinoma, are embryonic developments from remains in the mesentery of the vitelline duct, the wolffian ducts, the wolffian bodies, and the müllerian ducts (Moynihan).

What are called "chyle cysts" of the mesentery are embryonal cysts placed in such close adjacency to lacteals that chyle enters into them (E. P. Baumann in "Lancet," May 7, 1904).

Cysts of the Vitello-intestinal Duct.—Such a cyst presents itself as a small, bright red, globular mass, which appears to arise from the umbilicus of a baby or a young child, and which usually has a distinct pedicle, but may be sessile. A cyst of this character forms when the vitello-intestinal duct atrophies from the gut toward the umbilicus, but a remnant at the umbilicus escapes obliteration, and from this remnant a cyst forms. The wall of such a cyst contains unstriped muscular fiber and is lined by mucous membrane. Occasionally the duct in the process of involution is not destroyed—its caliber is simply lessened—and the duct remains open in the navel and feces come from it. If the duct closes at the umbilical end but fails of obliteration at the intestinal end, a diverticulum remains at this point (*Meckel's diverticulum*).

Treatment.—A pedunculated cyst at the navel is treated by ligating its base and dividing the stalk beyond the ligature. A cyst with a thick base is dissected out. The surgeon must be careful to avoid confounding an umbilical hernia with a cyst of the navel.

Urachal Cysts.—The urachus is the obliterated allantois, and is a cord running from the summit of the bladder to the umbilicus. This structure is in the middle line of the abdomen and in front of the peritoneum. A portion of the allantois may not be obliterated at birth, and in consequence of this failure a cyst forms. It grows to a considerable size, may push the peritoneum away and reach the pelvis, may communicate with the bladder, may break through the umbilicus, or grow backward toward the spine.

Treatment.—Extirpation of the lining membrane, partial closure of the cavity by suture, and packing the unobliterated part. Complete extirpation of the cyst is seldom attempted. W. R. Weiser ("Annals of Surgery," Oct., 1906) collected 86 cases of cyst of the urachus. In 8 of these complete extirpation was performed, and Macdonald has since reported a successful complete extirpation (Ibid., August, 1907).

Parasitic cysts are due to the development of certain parasites in the tissues. The form most often encountered is known as the hydatid cyst.

Hydatid cysts are especially common in Iceland, and are frequent in Australia and South America, but are very rare in the United States. In the United States 91 per cent. of cases occur in foreigners (Lyon). Hydatid cysts are due to echinococci. The adult echinococcus is the tapeworm of the dog (Tænia echinococcus), and its ova or larvæ gain access to man's body by accompanying the food he eats and passing into the alimentary canal, from which situation they are transported to various organs by the blood. The cat also brings danger to man. Osler says the embryo (which has six hooklets) burrows through the wall of the bowel and enters the peritoneal cavity or muscles; it may enter the portal vessels and reach the liver, or may enter the systemic circulation and pass to distant parts. The danger depends on two factors: "the situation and the liability of the cyst to suppurate" (Sidney Coupland). The organs most usually attacked are the liver and lung. In 60 per cent. of cases the liver suffers, and in 12 per cent. the lung (Thomas). Lyon estimates that the liver is the seat of disease in 73 per cent. of cases. Cysts sometimes arise in the intestine, kidney, genito-urinary passages, brain, or spinal canal. When the embryo lodges, the hooklets disappear and a cyst is formed. This cyst is composed of two layers, an outer capsule (cuticular membrane) and an inner layer (endocyst). The cyst contains clear saline fluid. As the cyst grows, daughter-cysts bud out from the wall of the mother-cyst, the structure of the daughter-cysts being identical with that of the mother-cyst. From the lining membrane of all the cysts, after a time, growths arise known as scolices, which represent the head of the echinococcus and exhibit four sucking disks and a row of hooklets (Osler).

The fluid is not albuminous, is occasionally saccharine, is thin and clear, and may contain scolices or hooklets.

A hydatid cyst may calcify, may rupture, or may suppurate. In very rare cases spontaneous absorption occurs. If hydatid fluid is disseminated throughout the peritoneal cavity, it may or may not lead to the development of new cysts, but it is

almost certain to cause a febrile condition accompanied by urticaria and known as *hydatid toxemia*. Hydatid cysts are very firm, and seldom fluctuate. Palpation with one finger while percussion is practised with another may appreciate a distinct tremor (*hydatid fremitus*), but it is absent in a majority of cases. If the cyst can be safely reached, some fluid should be drawn and examined for diagnostic purposes. When a cyst suppurates, positive constitutional and local symptoms arise. Hydatid cysts of the brain and cord tend to produce death in the same manner as do tumors. A cyst of the liver may rupture into the pleural sac, into the belly cavity, into the stomach, or into the bowel, producing shock, hemorrhage, and probably death. In rare cases hydatid cysts rupture into the pericardium or into a great abdominal blood-vessel, or externally. Rupture into the bile-passages is usually followed by suppuration of the cyst. Suppuration of a cyst may follow unclean tapping. It has been pointed out that eosinophilia is noted in most persons suffering from hydatid disease.

Treatment.—An unruptured hydatid cyst of a superficial tissue should be incised and the sac wall should be dissected out. Hydatids of the brain have been successfully removed in Australia. A cyst of the kidney is removed through a lumbar incision. Omental cysts should be radically removed if possible; if this is not possible, open the abdomen, surround the cyst with gauze, evacuate through a trocar, stitch the cyst wall to the wound, incise, irrigate, and drain by gauze. Bond advocated evacuating the cyst, closing it by sutures, and dropping it back in the abdomen. Gardner says tapping is dangerous, as it may cause rupture of the cyst. In a hydatid of the liver the abdomen should be opened, the cyst should be surrounded by gauze pads, and tapped by a trocar and cannula. When the cyst is emptied of fluid it is grasped by forceps and pulled to the incision in the abdominal wall; it is sutured to this incision, the trocar opening is enlarged, and the endocyst is removed by irrigation.[1] This operation is called *marsupialization*. If the cyst is on the summit of the liver, it may be reached by a transpleural hepatotomy. If aspiration is performed to settle a diagnosis, operate at once after doing it, because of fear that the cyst may leak and disseminate the disease throughout the peritoneal cavity. Brewer ("Annals of Surgery," April, 1908), in operating on a case of hydatid cyst of the liver, wounded the portal vein and was obliged to tie it. The patient recovered. That there was no failure of nutrition Brewer attributes to the fact that the vein had been long pressed upon and the collaterals were dilated when ligation was performed. Before operating Kolbé gives an intravenous injection of salvarsan or neosalvarsan and waits for an elevation of temperature which should occur in about one week. A simple incision will liberate necrotic vesicles and turbid fluid, and, it is said, will cure the case.

XVII. DISEASES AND INJURIES OF THE HEART AND VESSELS

Rupture, Wounds, and Injuries.—Rupture.—A heart valve may rupture. The aortic and mitral valves most often suffer. Barie collected 38 cases, of which 10 were traumatic (Babcock in "N. Y. Med. Jour.," June 10, 1916). In this article rupture of the wall of the heart is considered. The heart may rupture and cause instant death, but rupture may not be instantly fatal. Curtin reported a case in which death did not occur for over twenty-four hours. Elsner reported a case of rupture in which life was prolonged for ten days. One case lived eleven days. In cases in which death does not occur rapidly the rupture must be so small that very little blood escapes. Rupture occurs in a damaged heart, a heart in which the muscular fiber is fatty, is fibroid, or is necrotic from suppuration, or which has softened because of occlusion of branches of the coronary artery. Aneurysm of the coronary artery may rupture. A tumor or a hydatid cyst of the wall may be responsible for rupture. Rupture may be traumatic, resulting from a fall or a blow upon the chest, or non-traumatic, following a great effort or strain, physical or psychical, which raises the blood-pressure greatly. When congenital narrowing of the isthmus of the aorta exists the heart is particularly exposed to the danger of rupture from elevated blood-pressure. A bullet which enters the chest but does not open the pericardium may cause cardiac rupture. If after rupture death does not at once take place the pulse becomes very rapid, there is precordial pain, dyspnea, cyanosis, feeble heart sounds, rapid respiration, great restlessness, collapse and syncope, and the development of a triangular area of dulness on percussion. Positive diagnosis is impossible. Meyer collected 36 cases of rupture of the heart reported since 1870. Death occurs from accumulation of blood in the pericardium making pressure upon the auricles. This acute compression of the heart due to

[1] John O'Conor, of Buenos Ayres, in "Annals of Surgery," May, 1897.

blood escaping from the heart is called **heart tamponade.** It is held by Franke, of Berlin, and others that in heart tamponade the pressure within the pericardium comes to exceed the pressure within the auricles, and that the pressure within the pericardium causes the symptoms of the injury, and finally death. Some would treat heart tamponade by puncture or aspiration. It would seem that either must be useless, as fresh blood is bound to replace what is withdrawn. Suturing must fail in non-traumatic cases because of the badly diseased myocardium. In traumatic cases it may possibly succeed.

Wounds of the Pericardium and Heart.—Severe wounds usually, though not always, produce death, but slight wounds may not prove fatal. It is a popular impression that the expression "stabbed to the heart" is another way of saying that instant death has occurred. This view was accepted even by surgeons during many centuries. During the sixteenth century sportsmen found now and then bullets and arrow-tips healed in the heart walls of animals they had slain. At this time the famous case of a duelist was published by Paré: a man received a sword thrust in the heart, but was able to run after his opponent many hundred feet before falling down in death. (See "An Experimental Investigation of the Treatment of Wounds of the Heart," by Charles A. Elsberg, in "The Journal of Experimental Medicine," Sept. and Nov., 1899.) From Paré's time until our own it has been recognized by surgeons that a wound of the heart does not of necessity produce immediate death, and may even be recovered from. In more recent years Rosenthal, Block, Del Vechio, and others proved by animal experimentation not only that cardiac wounds are not of necessity instantly fatal, and that in some cases they may be recovered from, but that the suturing of such wounds is possible and greatly enhances the chance of recovery.

In 1867 G. Fisher published a study of 452 cases of wound of the heart, and pointed out the surprising fact that from 7 to 10 per cent. of such cases recover. L. L. Hill ("Med. Record," Nov. 29, 1902) shows that although 90 per cent. of heart wounds are penetrating, only 19 per cent. are immediately fatal. Sudden death occurs always when Kronecker's co-ordination center is damaged. Kronecker and Schmey showed that a needle may be thrust into various parts of the ventricle without causing instant death. At one particular part of the ventricle a needle thrust instantaneously causes fibrillary contraction which is surely fatal. This spot is in the line of the septum at the lower border of the upper third (Howell's "Text-book of Physiology"). Those who maintain the neurogenic theory of heart action call this spot *Kronecker's co-ordination center.* Several times during postmortem examinations on human beings healed scars have been found upon the heart. The heart has been punctured a number of times accidentally or intentionally, and death has not ensued, yet until 1881 the profession of the world accepted the views of Billroth, who scoffed at the very possibility of operating upon the heart. John B. Roberts,[1] of Philadelphia, suggested in 1881 that it would be proper to try to suture wounds of the heart. In 1882 Block demonstrated upon animals the practicability of operating upon the heart.

In 1887 Dr. Harvey Reed, of Cincinnati, sutured a wounded pericardium and the patient recovered. In 1891 Dalton, of St. Louis, obtained recovery in a like case by a similar operation. In 1896 Farina, of Rome, did the first suturing operation upon the human heart. The patient had been stabbed in the right ventricle and he died of pneumonia on the sixth day. In 1896 Rehn, of Frankfort, performed the first successful cardiorrhaphy. After suturing he packed the pericardial cavity with iodoform gauze.

Symptoms.—A wound of the heart causes hemorrhage, which is usually copious, but owing to the interlocking of muscular fibers the hemorrhage may be slight. There may or may not be serious external bleeding. Fatal concealed hemorrhage may occur. Bleeding may take place into the pericardial sac in some cases where the pericardium has been injured and the heart has escaped. Such an injury is occasionally inflicted by the sharp end of a fractured rib. The wound is rarely at or near the apex of the sac. In most heart wounds the pleural cavity is also opened and severe hemothorax occurs. The lung may or may not be injured. A wound of the pericardium or heart causes profound shock. The pulse if detectable is irregular and very weak. The respiration is shallow and often sighing. There is severe cardiac pain. In most cases attacks of syncope occur. Dyspnea is severe. There is usually vomiting. The face is cyanosed. There is a low and usually rapidly falling blood-pressure, and an increase in the area of cardiac dulness when blood gathers in the pericardium (*hemopericardium*). The heart sounds are feeble and there are occasional splashing sounds. In some cases

[1] "Annals of Anatomy and Surgery," Dec., 1881.

the sounds are clear, in other cases they are marked. In some no heart sounds are audible. The apex-beat may be undiscoverable. If air enters the pericardial sac a tympanitic percussion note replaces normal cardiac dulness (*pneumopericardium*). The position of the wound and the evidences of hemorrhage may aid in making the diagnosis. Death is apt to occur suddenly from shock, hemorrhage, inability of the heart to contract because of the severed fibers, or inability of the heart to dilate because of the presence of blood in the pericardial sac. Blood in the pericardium if present in large amount compresses the auricles and finally arrests the circulation (*heart tamponade*). If a wound of the pericardium or heart does not cause death during the first day or two, inflammation follows (traumatic pericarditis or carditis) and the patient may die of suppurative pericarditis or of empyema.

Treatment.—Wounds of the pericardium and heart should be sutured. In every clear and in every suspected case give at once a hypodermic injection of atropin in order to lessen pneumogastric inhibition. Do not give stimulants until the bleeding has been arrested. To do so would increase hemorrhage. The moment the sutures have been tied and the bleeding has been arrested use every method to rouse from shock. We should explore if, from the location of the wound and the symptoms, we suspect a cardiac wound. I agree with Vaughan, that if there is a wound in the cardiac region and if the symptoms threaten life, exploration should be performed at once. In a doubtful case exploration should be made by enlarging the wound, and this may be done under local anesthesia. Every wound which is on the surface of the cardiac region does not of necessity involve the heart. Murphy saw 4 cases in each of which the wound of entrance of the bullet suggested strongly that the heart must have been hit, yet in these cases the only cardiac disturbance was manifested by slow pulse and in but one of them was there a friction sound (Leslie in "N. Y. Med. Jour.," 1916, civ). In operating for a heart wound the cutaneous surface should be rapidly disinfected with iodin. It is wiser, in most cases, to give a general anesthetic than not to give it. Local anesthesia is slow and unsatisfactory. Without an anesthetic the patient will probably struggle, and struggling is very dangerous, as it loosens clots and permits hemorrhage to begin again (L. L. Hill in "Med. Record," Sept. 19, 1908). Chloroform is the anesthetic used by many. I would prefer ether. If the patient is unconscious and the corneal reflex is abolished, no anesthetic should be given. The heart may be exposed by resecting several ribs. In a knife-wound of the right pleural cavity and right side of the pericardium, Barth, of Danzig, removed 1 inch from each of three right costal cartilages (fifth, sixth, and seventh), close to the side of the sternum, and removed also the ensiform cartilage and 1 inch of the sternum. The same surgeon, in the case of a man stabbed in the fourth left intercostal space, removed the fourth and fifth left costal cartilage and part of the sternum ("Deutsche Zeitschrift für Chirurgie," Bd. lxix, No. 1). Schwerin, of Berlin, in a stab wound of the chest exposed the heart by resecting the fourth and a portion of the fifth left ribs ("Proceedings of German Surgical Congress," 1903). Wilms ("Centralblatt f. Chirurgie," Leipzig, vol. xxxiii, No. 22), in a case of gunshot wound, obtained access to the anterior and posterior surfaces of the heart by a simple intercostal incision. Parrozzani makes a trap-door in the chest, the hinges of the door being the rib cartilages. In exposing the heart Giordono enters along the wound, removing any obstacles that intervene. It is needless to try to avoid opening the pleura if a flap with an internal hinge is used; it has usually been opened by the accident, and in any case can very seldom be avoided. Matas advises Spangaro's intercostal incision. The mammary vessels are tied and the width of the intercostal space is greatly increased by strongly retracting the ribs and cartilages. If more space is needed, the incision is carried upward at the junction of the cartilages and sternum. The heart is exposed, clots are removed from the pericardial sac, and the sac is irrigated with hot saline fluid. The bleeding may be furious. A non-penetrating wound of the ventricle may bleed so profusely during systole as to resemble a penetrating wound (Sherman). A penetrating wound may bleed most during diastole. The motions of the chest make manipulation difficult. Some surgeons use traction sutures to lift the organ toward the operator. In cases with severe hemorrhage it is better to take the heart in the palm. The bleeding, as pointed out by Rehn, can be completely controlled temporarily by making pressure upon the venæ cavæ just before they enter the auricle (Zur Chirurgie des Herzens und Herzbeutels. Verhandl. d. deutsch Gesellsch. f. chir., xxxvi, 2, 1907).

Babcock advises us to take the heart in the palm of the hand and compress the veins between the ring and middle fingers ("N. Y. Med. Jour.," June 10, 1916). This pressure can be maintained for three minutes without destroying life or causing dam-

age to the cells of the cerebral cortex. How much longer it could be continued is not known. We do know that if the cortex is entirely deprived of blood the cells perish in seven minutes. A wound in the heart is sutured with interrupted sutures of China silk, which are passed by means of a round, curved needle, and if a cavity of the heart is open each suture includes the whole thickness of the heart wall except the endocardium. It has been said that the sutures should be tied during diastole, otherwise they are apt to cut out. Profs. Gibbon and Stewart and Drs. Nassau and Jones tell me that in their cases such a procedure was impossible because of the very rapid action of the heart. As few stitches are used as will efficiently close the wound. Numerous stitches cause extensive degeneration of muscular fiber and stitch-holes may permit leaking. The pericardium is sutured with silk or, as was done in one successful case (Rehn), the sac is packed with iodoform gauze. It is better to avoid draining the pericardial sac. Clots are removed from the pleural sac by irrigation with hot saline solution, pulmonary bleeding is arrested by the suture or by packing, and a wound in the lung, especially if it communicates with the air-passages, is sutured if the patient's condition justifies prolonging the operation.[1] Primary drainage of the pleural cavity is seldom practised. Later drainage may become necessary.

After such an operation the patient is in great danger and every effort should be made to save him from shock. In performing operations upon the heart the pleura is almost always opened, and if it is open there is always pneumothorax and much danger of pulmonary collapse and overwhelming shock.

Frazier ("Progressive Medicine," March, 1913) collects 218 cases of operation for heart wounds. The mortality in the series was 55.5 per cent. This estimated mortality is probably much too low. Many operators have reported a single successful case each. For instance, Santy successfully sutured a ventricular bullet wound ("Presse Méd.," July, 1922). It is reasonable to believe that many unsuccessful cases have not been reported. It is eminently desirable to have the reports of a number of consecutive cases. We have here such a record. Hesse (Bruns, "Beiträge," 1911, lxxv) reports 21 cases, with a mortality of 71 per cent. We believe this represents about the average mortality of heart wounds subjected to operation. So many cases have been reported that it is now scarcely possible to present them all with the names of the operators. There have been 14 cases of heart suture in Philadelphia and 6 recoveries. Stewart had 5 cases and 3 recoveries; Gibbon, 2 cases and 1 recovery; Nassau, 1 case, which recovered, and Jones, 2 cases, with 1 recovery and 1 death. I have never operated for a wound of the heart. According to Hill, the right ventricle is most often, the left auricle least often, injured; wound of the auricle is generally considered to be more dangerous than wound of the ventricle; and wound of the apex is less dangerous than either. Peck points out, however, that there are 11 reported cases of auricle wounds, with 4 deaths, a mortality of 36.3 per cent., while the general mortality of heart wounds is about 64 per cent. ("Annals of Surgery," July, 1909). Chibolian and Marchals estimate the mortality of auricle wounds after operation as 50 per cent. ("Progrès Médical," Jan. 31 and Feb. 7, 1914). Wounds of the left ventricle give a better prognosis than of the right ventricle; wounds of the right auricle a better prognosis than of the left auricle. A needle puncture rarely causes serious bleeding from a ventricle, but is very apt to cause severe bleeding from an auricle. A wound received during diastole is less dangerous than one received during systole. Wounds of the right heart bleed more than wounds of the left heart. Wolff points out that ligation of one coronary artery can be done and recovery follow; wounds of the left ventricle give the best prognosis because the wound is closed by thick edges of muscle. In 37 operations for heart wounds the left pleura was opened, in 3 the right pleura, and in 2 the pleura was uninjured. In bullet wounds death usually occurs before operation can be done (Wolff, "Deutsche Zeitschrift für Chirurgie," Bd. lxix, No. 1). Bircher reports a case of gunshot wound of the heart in which there was no operation, yet the patient recovered. He believes that a gunshot wound by a small bullet should not be operated upon, but he would operate for wounds by large bullets and for stab wounds ("Arch. klin. Chir.," 1912, xcvii). Manteuffel reported 7 cases, occurring during the war in Manchuria, in which recovery followed gunshot wounds of the heart which were treated expectantly. Without operation the mortality of heart wounds will be at least 90 per cent.; with operation it will be about 60 to 70 per cent.

Matas ("Southern Med. Jour.," Aug., 1908) discussed 160 cases of heart wounds, with 43.83 per cent. of recoveries. In 134 cases the wound was sutured, with 49 re-

[1] The author, on "Suture of the Heart," in "Progressive Medicine," 1899, vol. i.

coveries. In 11 cases it was exposed, but was not sutured, and 5 recovered. In 5 cases foreign bodies were removed with success.

In Peck's table ("Annals of Surgery," July, 1909) there are 69 wounds of the right ventricle, with 48 deaths (69.6 per cent.); 74 of the left ventricle, with 45 deaths (60.8 per cent.); 5 of the left auricle, with 2 deaths (40 per cent.); 6 of the right auricle, with 2 deaths (33.3 per cent.); and 7 miscellaneous cases, with 5 deaths (71.5 per cent.), a total of 160 cases, with 58 recoveries and 102 deaths, a mortality of 63.7 per cent.

The immediate dangers of the operation are hemorrhage, shock, and the entrance of air. The late dangers are pericarditis, empyema, and pneumonia (Vaughan). Traumatic carditis or pericarditis is treated in the same way as idiopathic cases. Pus in the pericardial sac should be evacuated by resection of the fourth left costal cartilage and incision of the pericardium (von Eiselsberg's case). Pool reviewed the subject of heart wounds in the "Annals of Surgery," April, 1912.

Wounds in War.—Most heart wounds in war are instantly or rapidly fatal, a comparatively small number reach the evacuation hospital. Out of 123 wounds of the chest passing through an Evacuation Hospital there was but one wound of the heart (Dixon and McEwan in "Brit. Med. Jour.," May 27, 1916). Fewer still reach the base hospital, although there are a number of astonishing records of men going about weeks or months after such injuries. Few bayonet wounds and few wounds by fragments of explosive shells survive to be operated upon. The surgeon sees injuries by shrapnel, rifle bullets, and grenade fragments. Gunshot wounds of the heart are more surely fatal than ordinary stab wounds, but much can be done for cases which survive for a time.

Le Fort has removed 11 foreign bodies from the heart by 9 operations, in two from a heart cavity. But one patient died ("Lancet," Sept. 7, 1918).

A bullet may pass through the body including the heart in its journey. It may enter the body but show no wound of exit, having lodged in the anterior wall of the pericardium, the pericardial sac, the heart muscle, a cavity of the heart, the posterior sac of pericardium, or the tissues beyond or around. A bullet may hit the heart tangentially without making a wound in that organ. If circumstances admit the military surgeon operates in the same way as does a surgeon in a civil hospital.

Early operations are performed usually for hemorrhage. If the projectile is seen it is removed, but there is seldom time or opportunity to use the *x*-rays.

If a lodged projectile has not been removed at the operation or if the man has not been operated upon, but has recovered from the hemorrhage, the problem of extraction must be faced in the Base Hospital.

In such a case there are usually symptoms. The patient complains of dyspnea on exertion and chest pain and the pulse is rapid ("British Jour. of Surgery," 1916, iv). Yet cases are on record in which lodged projectiles caused practically no symptoms. In Silvan's case a projectile was lodged in the heart wall and penetrated the cavity and yet there were no symptoms ("Riforma med.," 1916, xxxii). See also the case reported by Lobligeois in "Bull. Acad. de méd. de Par.," 1916, lxxvi. In any case the projectile is shown and located by the *x*-rays. In one case a man walked a mile and a half after being struck, yet the *x*-rays showed a bullet in the heart wall and moving with it (Leslie in "N. Y. Med. Jour.," 1916, civ).

When a surgeon operates for a lodged foreign body and not for hemorrhage he takes the route which would seem to be the most accessible and least dangerous.

This point of view is set forth by Villeon ("Bull. et mém. Soc. de Chir. de Paris," 1916, xlii).

In one case a projectile was lodged against and behind the left ventricle. It was extracted by a transpleural operation. In another case the projectile was against and below the left ventricle. It was removed by the abdominal and transdiaphragmatic route. In still another case the projectile was against the left and anterior surface of the heart. It was removed from in front, the surgeon looking through the screen of the fluoroscope.

In operating the surgeon asks himself in each case—"should I drain?" In wound from a rifle bullet the answer is—"no!" In wound from a shell fragment the right answer is doubtful. In view of the fact that bacteriologic studies have shown gas bacilli and other dangerous bacteria on shell fragments removed from the chest I am forced to feel that drainage is called for in such cases.

Tolerance of Heart to Lodged Foreign Bodies in the Walls or in a Cavity.—Some striking cases have been reported showing extraordinary tolerance of the heart to a lodged foreign body. In some of these cases the missile had been lodged for many

months and yet there were no symptoms. Lobligeois reported a case of a shrapnel bullet in the cavity of the left ventricle which had been there for several months without producing any symptoms. An *x*-ray examination was made to locate the bullet, as there was no exit wound. The fluoroscope proved that the bullet was in the cavity ("Presse Médical," Nov. 9, 1916). Le Fort successfully removed from the cavity of the left ventricle a fragment of hand grenade which had been there for nearly ten months (see "Lancet," Sept. 7, 1918). Beaussanat records the following case: Four months before a fragment of a grenade entered the right ventricle. Shortness of breath developed. The patient suffered pain which was aggravated by movements and by attempts to speak. The ventricle was incised and the fragment removed. It weighed 1.5 gm. The patient recovered ("Bull. Acad. de med.," 1915, lxxiii). Gray removed a bullet from the interior of the right ventricle. Death followed in four days, but not from operation.

Arthur Keith (quoted in "Progressive Med.," Sept., 1917, from "British Med. Jour.") has seen records of 8 cases of bullets lodged in the heart cavity, and in each case the foreign body was coated with fibrin. The bullet may enter by means of a heart wound or it may enter the heart from a venous trunk, the wound being, perhaps, far away. It was known long ago that intravenous emboli could migrate. It is something new to find out that bullets can. Migration may be with the blood current, or directly against it by the influence of gravity. Keith knows of no case of a bullet having been swept from the ventricle into the pulmonary artery. In three specimens which are in the Royal College of Surgeons Keith shows that there is not a heart wound in any, and yet in every case there is a bullet in the heart cavity.

A curious fact is that a bullet may enter a great vein and the victim recover without grave signs of hemorrhage.

Grandgérard's case is very interesting and important ("Paris Méd.," Jan. 13, 1917; quoted in "Practical Medicine Series," vol. ii). The bullet was first located by *x*-rays in the right auricle, it was next seen in the right groin, and finally over the base of the sacrum. Keith says this case proves that a loose bullet in the right auricle or ventricle may shift its position and may by gravity be brought to a region favorable for operation.

In Lyle's cases of migration the shell fragment entered the right femoral vein. Death occurred on the fifth day when the fragment was removed from the right auricle ("Annals of Surg.," Dec., 1916). Several other remarkable cases are on record (see "Practical Medicine Series," vol. ii, edited by A. J. Ochsner).

Pericarditis is an infectious condition that may be traumatic or non-traumatic. If pericarditis follows an open wound, it is obvious how the infection must have entered; if it follows a bruise or a contusion, the injury has rendered the pericardium a point of least resistance. In some few cases, which are known as primary pericarditis, it is impossible to determine how the micro-organisms gained entrance. The ordinary form appears as a complication of certain infectious diseases, such as septicemia, pneumonia, rheumatism, and tuberculosis. It may be secondary to some adjacent infection, such as an empyema. A tuberculous abscess may break into the pericardium, and an abscess, even from a considerable distance, may burrow into it. It may arise secondary to a distant infection, as a suppurating wound, osteomyelitis, middle-ear suppuration, pyorrhea, furunculosis, abscess of the mastoid, tonsillitis, abscesses anywhere, peritonitis, and gastric ulcer. It sometimes follows gastro-enterostomy and may arise in an individual with Bright's disease. In a recently born child infection of the stump of the umbilical cord may cause pericarditis. A pericardial effusion in a newborn child is invariably purulent and in a young child it is usually purulent. In children the condition is usually associated with pulmonary disease (Poynton in "Brit. Med. Jour.," Aug. 15, 1908). A great variety of bacteria may be responsible for pericarditis (pneumococci, staphylococci, colon bacilli). The exudation may be serofibrinous; this is an evidence of its being a mild infection, and such an exudate may undergo absorption. On the other hand, the exudate may become purulent, and in such a case cure will never be obtained by absorption of the pus. In pericarditis there is usually some pain in the region of the heart, and this pain is apt to extend into the left arm. Epigastric pain is a common symptom. The heart is overacting, the heart sounds are indistinct, the pulse is strong and very rapid, there is an increased area of cardiac dulness, and the patient complains of dyspnea. The temperature is elevated and a double friction-sound may be made out upon auscultation.

Treatment.—Ordinary pericarditis, without pus formation or extensive effusion, is managed by the physician; but when there is extensive effusion with symptoms

of dangerous compression it is advisable to open the pericardium, and if there is purulent effusion the pericardium must be opened. The procedure usually practised in the past to relieve pericarditis with marked effusion was puncture or aspiration. This, however, is dangerous. The heart is not, as was formerly taught, pushed back and up by the pericardial effusion, but is lifted upward and forward, and may be pushed to the right or left if there are adhesions between the pericardium and heart; and it is impossible to select any place for aspiration that assures us that there will be no danger of puncturing the heart. A coronary vein may be injured, the pleural cavity may be entered, and a dry tap is usual from blocking of the needle. Brentano has shown that tapping cannot completely empty the sac. Many surgeons, however, do not fear puncture, and explore by inserting a fine needle in the fourth or fifth interspace of the left side close to the sternum. In cases of extensive pericardial effusion, and also in cases of suppuration within the pericardium, I believe that *pericardiotomy* should be performed. An inch or more of the cartilage of the fourth rib of the left side should be removed or 2 inches of the fourth rib itself, and the pericardial sac should be exposed and, after exploratory puncture, formally incised. In this operation it may be necessary to tie the internal mammary artery. In pyopericardium the pleural cavity is very seldom invaded, because the pleural space in front of the pericardium has usually been obliterated by the spread of the inflammation. The pericardial sac is opened as directed above, is cleared of purulent material and fibrinous masses by irrigation, the edges of the pericardial wound are sutured to the edges of the superficial wound, and gauze drainage is introduced. Incision is safer and more certainly curative than aspiration; for whereas aspiration might be curative in pericardial effusion of a serous nature, it cannot be so if the effusion is purulent. In 41 cases of purulent pericarditis (Roberts' table of 35 cases and Ljunggren's 6 cases) operated upon, 16 recovered. Prof. Ochsner states ("Practical Medicine Series," vol. ii, 1918) that out of 86 operations 41 died (47.7 per cent.). Local anesthesia is safer than general anesthesia.

Phlebitis, or Inflammation of a Vein.—Acute Phlebitis.—Phlebitis may be *plastic* or it may be *infective*. Plastic phlebitis, while occasionally due to rheumatism, to gout, to advanced phthisis, to a febrile malady, or to some other constitutional condition, usually takes its origin from a wound or other injury, from the extension to the vein of a perivascular inflammation, or, in the portal region, from an embolus. Varicose veins are particularly liable to phlebitis, but emboli are rare. When phlebitis begins a thrombus usually forms (see Thrombosis, page 116) because of the destruction of the endothelial coat of the vessel, and this clot may give rise to emboli, may be absorbed, or may be organized. An aseptic clot organizes and the vein becomes permanently narrowed or blocked. A septic clot is apt to soften and break up. In the lower extremities *paraphlebitis* is common with slight involvement of coats, and a clot may not form. Clot formation causes edema. Infective phlebitis is a suppurative inflammation of a vein arising from infection, perhaps from suppurating perivascular tissues (*infective thrombophlebitis*), perhaps from the blood-stream or in the portal system, perhaps from infective embolism. It is not unusually met with in cellulitis or phlegmonous erysipelas, may arise in the lateral sinus as a result of mastoid suppuration, or in the liver from appendicitis or from phlebitis of the rectal veins. Sometimes as the convalescence from pneumonia begins, phlebitis due to pneumococci arises. If a septic thrombus forms, the vein wall suppurates, is softened and in part destroyed, and the infected clot softens and gives rise to emboli. No bleeding occurs when the vein ruptures or is opened, as a barrier of clot keeps back the blood-stream. The clot of suppurative phlebitis cannot be absorbed and cannot organize. Septic phlebitis causes pyemia, and the infected clots are disseminated.

Postoperative phlebitis of the iliac, femoral, or saphenous veins is not uncommonly the result of a mild or attenuated infection, toxins in the blood probably attacking the vein. As a rule, the toxins are non-pyogenic. It may follow an abdominal operation when there is no evidence of infection. According to Cordier, it occurs in 2 per cent. of abdominal operations. It is called, as is the like puerperal condition, *milk-leg*, or *phlegmasia alba dolens*. Nearly always the femoral vein is the one which suffers first. Strange to say, it is most apt to attack the left iliac, femoral, or saphenous veins; it matters not upon which side the operation has been performed. In over 90 per cent. of cases the left femoral or left saphenous veins are attacked (Cordier in "Jour. Amer. Med. Assoc.," Dec. 9, 1905). One theory regards the pressure of the right common iliac artery upon the left common iliac vein as a predisposing cause. Another theory attaches importance to the pressure of a loaded sigmoid. It is most common in anemic subjects, especially when anemia results from blood loss. It may be due to toxins

damaging the inner coat of the vein, but feeble circulation is a powerful factor in its production. I believe, with Clark, that powerful traction on the sides of an abdominal wound may be responsible for it (see Thrombosis After Abdominal Operations, page 118). Vanderveer reported 4 cases in which sepsis was positively absent ("American Medicine," July 13, 1901). It occurred in the left iliac vein of a woman on whom I had operated for carcinoma of the left breast six days before. There was no obvious infection of the wound. I have seen it occur in the left iliac vein after an interval operation for appendicitis. Phlebitis may arise in the vein of one extremity, a clot may form, and this may be absorbed or may organize. The other extremity may be involved afterward or simultaneously (horseshoe form). It may come on seven or eight days after operation, many days, or several weeks. It usually is ushered in by chilly sensations or slight chills and elevated temperature. There is always pain in the limb. The pain may be dull or acute; it is made worse by motion and by pressure over the involved vein. The entire extremity swells from edema. It is probable that marked edema signifies associated lymphangitis or else an extensive clot running into many venous branches. The edema is seldom characterized by very distinct pitting on pressure. The skin is white and looks stretched and shiny. The inguinal glands are usually enlarged. Sensation is impaired except over the vein. Paresthesia is common. The involved veins feel like cords to the touch.

In mild cases the symptoms disappear in a few days. Severe cases continue for several or many weeks or even months. Involvement of the deep veins causes prolonged swelling. There is seldom any disposition to gangrene.

In some cases there is extensive muscular atrophy, in some there are trophic disturbances, in some muscular contractures. Postoperative phlebitis is sometimes responsible for embolic pneumonia and cerebral embolism. Not a few postoperative pneumonias are due to this cause.

The *symptoms* of plastic phlebitis are pain, tenderness in and around a vein, discoloration over it, and edema below the seat of the disease. Suppurative phlebitis, besides these conditions, causes the constitutional symptoms of pyemia (see page 129). Any thrombus, if it loosens, forms emboli. It is said that the clot resulting from pneumococcic phlebitis forms so rapidly that it adheres slightly and is peculiarly apt to loosen and give rise to emboli (Pierre in "Gazette des Hôpitaux," Sept. 3, 1904). Septic thrombi are apt to cause septic pneumonia.

The *treatment* of plastic phlebitis of an extremity comprises rest in bed for from four to six weeks, slight elevation of the part, the use of cold for the first twenty-four hours, and then the application of external heat and a flannel bandage. If the patient is gouty or rheumatic, appropriate remedies should be given. A clot does not always form in an inflamed vein, but if one forms there is danger of embolism; hence massage and both active and passive movement are dangerous until the clot becomes absolutely firm. When a vein is involved in a suppurative process and septic thrombophlebitis exists, we should operate when the situation makes operation possible. Ligate the vein (compress a sinus by packing) above and below the clot, open the vessel, and wash out the infected clot, or, if dealing with an accessible vein, extirpate the involved portion. This plan of treatment is always to be applied in infective thrombophlebitis of the lateral sinus and of the internal saphenous vein. The constitutional treatment is that of pyemia.

Chronic Phlebitis.—This rare condition is known as *phlebosclerosis*, and it is a chronic inflammation of the wall of a vein, producing a fibrous change in the vascular coats. It may arise in a part the seat of chronic venous engorgement, but its most frequent cause is syphilis. It is often associated with arteriosclerosis.

Varicose Veins; Phlebectasis, Phlebectasia, or Varix (Figs. 196 and 197).—**Definition and Causes.**—Varicose veins are unnatural, irregular, and permanently dilated veins which are elongated and pursue a tortuous course. This condition is very common, and 20 per cent. of adults exhibit it in some degree in one region or another. In many cases the condition is not sufficiently severe to be disabling. Out of those with varicose veins examined for service in this country during the World's War 25 per cent. were accepted. Some facts indicate hereditary predisposition. In over 80 per cent. of cases the trouble begins before the age of twenty-five. The causes of varicose veins are said to be obstruction to venous return and weakness of cardiac action, which lessens the propulsion of the blood-stream. A. Pearce Gould says obstruction is not a cause, because in pregnancy varicose veins may be seen early, before the womb is much enlarged. The real cause is probably a predisposition to the growth of vein tissue, which leads to valve failure and perhaps regurgitation of blood from the deep

veins into the superficial venous channels (A. Pearce Gould in "Lancet," March 1 and 15 and June 7, 1902). As Billroth said forty odd years ago, sudden obstruction causes edema and gradual obstruction a free collateral circulation. Neither sudden nor gradual obstruction causes true varicosity unless the veins are predisposed by a tendency hereditary or acquired.

Varicose veins may occur in any portion of the body, but are chiefly met with on the inner side of the lower extremity, in the spermatic cord, and in the rectum. Varix in the leg is met with most commonly during and after pregnancy and in persons who stand upon their feet for long periods and in those who make great muscular effort. It can occur as a result of phlebitis. It is especially common in the long saphenous vein, which, being subcutaneous, has no muscular aid in supporting the blood-column and in urging it on. The deep as well as the superficial veins may become varicose. Verneuil maintained that varix of the superficial veins is almost always secondary to varix of the deep veins, a radical view which seems improbable. The deep veins are seldom varicose. It is certain, however, that after contusions of the leg it is not very unusual for the deep veins to become filled with clot and for the superficial veins to

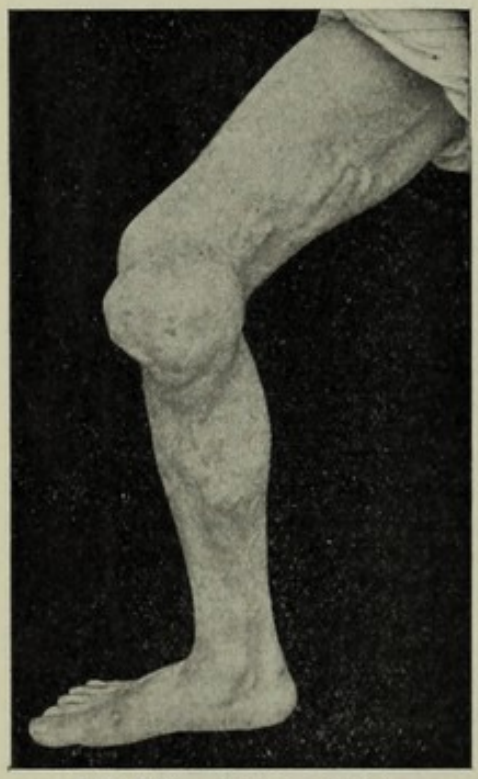


FIG. 196.—Varicose veins.



FIG. 197.—Varicose veins.

dilate notably. The veins which join the deep veins to the superficial veins may become varicose and incompetent, they are particularly apt to after phlebitis. If they do become incompetent blood will flow from the deep veins into the superficial veins instead of as normally in the other direction. By the term "*caput medusæ*" is meant dilated veins radiating from the umbilicus. The veins of the esophagus may become varicose, and this malady is commonly unrecognized clinically. Varicose veins are in rare instances congenital, but they are very often seen in the elderly, and usually are first observed between the ages of twenty and forty. They are more common in women than in men, owing, it is believed, to the influence of pregnancy. They are most common in large and heavy persons.

Varix of the spermatic cord is known as *varicocele*. It is apt to appear about the time of puberty, and most adult men have at least a slight varicocele. Varix is more likely to appear in the left spermatic vein than in the vein of the right side, because the left spermatic vein has no valves (see page 1385).

Varicose tumors of the rectum constitute *hemorrhoids* or *piles*. Piles are caused by obstruction to the upward flow in the hemorrhoidal veins, either by obstructive liver disease, enlargement of the uterus or prostate, or the presence in the rectum of fecal masses in a person habitually constipated (see page 1177).

A vein under pressure may dilate more at one spot than at another, the distention being greatest back of a valve or near the mouth of a tributary. The valves become incompetent and the dilatation becomes still greater. Callender has pointed out that varix of the lower extremity is apt to begin where the deep vessels join the superficial veins. At this point Treves says three forces meet: the blood column above, the valve below, and the force of the blood-current. At the spot where the pressure is greatest the vein wall dilates, and from this dilatation the blood-current is deflected and causes another dilatation higher up and on the opposite side of the vessel. The blood is again deflected and causes another dilatation, and so on. The vein wall may become fibrous, but usually it is thin and sometimes it ruptures. The veins not only dilate, but they also become longer, and hence do not remain straight, but twist and assume a characteristic form. It seems probable that the first step in the process is a growth of new venous tissue (A. Pearce Gould), and then follow lengthening, tortuosity, incompetence of the valves, and dilatation of the vessel.

Delbet[1] points out that varicose veins of the leg, which begin in the thigh, result from valvular incompetence. Varicose ulcers arise from variations of venous pressure due to valvular incompetence. The incompetence of the valves does harm by allowing the intravenous pressure to equal the pressure in the arterioles, a condition which arrests capillary circulation, causes congestion, and greatly lowers tissue resistance. Incompetent valves also favor ulceration by developing a *vicious venous circle*, first described by Trendelenburg. Blood passing through this circle loses nutritive elements. Trendelenburg has described the vicious circle as follows: Blood in the saphenous vein flows toward the periphery instead of toward the center, because of incompetent valves—it passes into the veins which connect the superficial veins with the deep veins and then enters the tibial and peroneal veins. It passes from the tibial and peroneal into the popliteal and femoral veins, and some blood leaves the femoral vein and again enters the saphenous.

The skin over varicose veins in the leg is often discolored by pigmentation due to red blood-cells having escaped from the vessel and broken up. The tissues around a varicose vein become atrophied from pressure, and it is not unusual to meet with a very large vein whose thin walls are in close contact with skin. In this condition rupture and hemorrhage are probable. When the vein wall forms a pouch-like dilatation the condition is spoken of as a *vein cyst*. Varicose veins are apt to inflame, and thrombosis frequently occurs. When a thrombus forms, emboli may be broken off and carried into the circulation, especially if the patient walks about. The formation of emboli is not nearly so common as a result of thrombosis in a varicose vein as in thrombosis in an undistended and unelongated vessel. In varicose veins of the thigh, however, the chance of embolism following thrombosis is much greater than when the veins of the leg alone are involved. In some elderly people a thrombus actually effects spontaneous cure. When a thrombus organizes, more or less calcification is apt to ensue, and a *vein-stone* or *phlebolith* is formed. After middle life many varicosities remain stationary or cease to give trouble. The chief complications of varicose veins of an extremity are thrombosis, edema, violent hemorrhage from rupture, phlebitis, eczema, and chronic ulceration.

Treatment of Varix of the Lower Extremity.—The treatment of varix of the leg may be *palliative* or *curative*, but whichever plan is followed, the surgeon should endeavor first of all to remove the exciting cause. An essential part of palliative treatment is to attend to the general health, to keep up the force and activity of the circulation, and to prevent constipation. Massage is useful, especially alcohol frictions, if eczema and thrombi are absent. *Cold* baths are always forbidden (Bennett). The patient should exercise regularly in the open air and should lie down for a time, if possible, every afternoon. Instead of lying down for a time during each day, he may sit down and elevate his legs, resting them on a table, and thus assuming a position supposed to be peculiarly American. If there is no pain, distinct discomfort, or edematous swelling, a support is unnecessary, but if these conditions exist it is needed. If a support is required in varix of the leg, use a flannel roller or a perforated rubber bandage applied over a long stocking. Such a bandage supports the veins and drives the blood into the deeper vessels, which have muscular support. The use of a rubber pad filled with glycerin and applied over the saphenous vein, so as to support the blood column and act as a valve, has been recommended. A purely local varix should be excised, because there is always danger of injury, and consequently of hemorrhage or thrombosis. If the superficial veins have dilated because of thrombosis of the deep veins and edema

[1] Delbet, "Sem. méd.," Oct. 13, 1897.

exists, ligation or excision is contraindicated, as its performance might lead to permanent edema. If an elastic bandage worn for one week gives comfort we may conclude that the deep veins are competent (the Mayo Clinic). Very marked capillary dilatations about the inner malleolus strongly suggests that the deep veins are incompetent. If the disease involves the leg only, operative treatment is seldom required and may even do harm. Such cases are operated upon if there are cyst-like dilatations, if thrombi form, and, as Bennett points out, if a thin-walled vein crosses the tibia, and is thus exposed to the danger of injury and thrombosis.[1]

If the leg is involved in the process, and the internal saphenus in the thigh is also varicose, operation should be performed.

If a thrombus forms in a superficial varicose vein, tie the vein above and below the clot, divide the vessel in two places, and remove the vein and the clot within it. Thrombosis of a varicose vein is not so apt to lead to emboli as thrombosis in a non-varicose vein, but it may do so, and the condition has some elements of danger.

If edema is marked, and increases in spite of properly applied bandages, etc., it probably signifies clot formation, and the patient should remain in bed until this question is determined. Hemorrhage from a ruptured varicose vein of an extremity is usually readily arrested by compression and elevation.

The radical treatment of varix of the leg often does good, often relieves some annoying condition, but rarely absolutely cures (W. H. Bennett). There are several methods of operation. (See Operations Upon Vessels.)

Local Traumatic Vasomotor Spasm or Traumatic Arterial Stupor.—After a wound near or a contusion about a large vessel the pulse nearly or entirely disappears for a number of hours. All surgeons have noticed at times that an exposed artery may cease to beat. Years ago I heard the elder Gross mention this as an occasional embarrassment to the surgeon during the operation of ligation. In local traumatic vasomotor spasm the vessel is patent, but does not pulsate. The limb is pallid or bluish, movement is impossible or is slow and clumsy, and sensation is impaired or destroyed.

If thrombosis does not occur and if the condition is not due to direct injury of the artery, the pulse will return in a few hours. Some suppose the condition to be due to irritation of the vasoconstrictors of the sympathetic. Others think it results from irritation of the muscular coat of the artery. The particular importance of the condition is that one might carelessly assume that the vessel was destroyed and that amputation was necessary.

For a long time afterward there may be attacks of burning pain in the limb.

Treatment.—As the condition is temporary no operation is indicated. Use local heat and massage and administer atropin. If pain is severe and persistent consider periarterial sympathectomy (page 423).

Nevus.—(See Tumors.)

Hereditary Hemorrhagic Telangiectasia.—In this condition there is a hereditary abnormality of the vascular system. The capillaries and venules in local areas dilate. The lesions are particularly common in the skin of the face and the mucous membrane of the nose and mouth. In such a case bleeding from the mucous membrane is not uncommon.

Thomas Fitz-Hugh ("Amer. Jour. Med. Sci.," Dec., 1923) says: "Among 30 families affected with this disease which are reported in the literature, there are found 57 undoubted and fully detailed cases, and 155 other probable cases which are only incidentally mentioned. In addition to these, 212 cases occurring in 30 clearly affected families there have been reported a number of isolated, apparently non-hereditary cases which conform so closely to the disease under consideration that one is forced to class them in the same group."

The same author points out that in spite of the commonly held view a generation may be skipped. There have been reported definite cases of atavism. Atavism is at the bottom of the so-called non-hereditary cases. Fitz-Hugh (Ibid.) found 7 cases of atavism in 4 families. Of course the diagnosis is clear when the family history is definite. The condition has been confused with hemophilia, but should not be. The blood coagulation time is not prolonged in hereditary telangiectasia. It may be confused with purpura hæmorrhagica, but Fitz-Hugh points out a simple test between the two. Pressure upon a glass slide laid upon the region causes an area of telangiectasia to disappear, but has no effect upon a purpuric spot. Furthermore, the

[1] W. H. Bennett, "Lancet," Oct. 15, 1898.

purpuric areas disappear after a time, whereas it is very seldom that an area of telangiectasia undergoes spontaneous disappearance.

The same author points out the important fact that in any obscure hemorrhage the condition should be thought of. It may be responsible for bleeding from the mouth, the nose, the throat, the stomach, the intestines, the uterus, or the cortex of the brain. As far as it is known hematoma does not occur.

The most common condition of hemorrhage is epistaxis. Repeated or severe hemorrhages may greatly weaken the individual. Although death is very seldom caused by it directly, Fitz-Hugh points out that recurrent epistaxis in 70 per cent. of the patients was exhibited in children. It is seldom that telangiectasia are discovered on the face until after twenty years of age.

If nasal examinations were made of such children lesions would undoubtedly be found. Bleeding is due to mechanical factors. Treatment is to destroy the lesion by heat or chemicals, diathermy being of great value. Radium may perhaps be of value in cutaneous lesions.

Arteritis, or inflammation of an artery, may be *acute* or *chronic*.

Acute Arteritis.—Slight inflammation is by no means unusual, but severe arteritis is decidedly rare. It may follow direct injury or arise secondarily to a perivascular inflammation. An artery is very resistant to the spread of inflammation, but we sometimes encounter suppurative arteritis in a suppurating area. Arteritis may arise in the course of an infective malady, being produced by bacteria, but it is also found in intoxications, and is then due purely to toxins. It may occur in the eruptive fevers, influenza, typhoid fever, acute rheumatism, gout, syphilis, diphtheria, septicemia, and septic intoxication. Ford points out that acute arteritis developing during acute or chronic infections is particularly apt to arise in the lower extremities (Ford, "Thèse de Paris," 1901). Toxins or bacteria usually reach the artery in the main blood-stream, but may be lodged in the vessel wall by the lymph or the flow in the vasa vasorum. The inner coat of a portion of an artery becomes lined with inflammatory exudate and the coats are infiltrated with small cells. Often parietal thrombi form. Sometimes, though rarely, the vessel is completely blocked by thrombosis. In acute suppurative arteritis pus accumulates in the arterial wall, a clot forms in the lumen, and the coats of the vessel undergo necrosis and give way. Violent hemorrhage may thus arise, but often, in thrombo-arteritis as in thrombophlebitis, rupture does not cause hemorrhage. Acute arteritis, if non-bacterial in origin, is usually recovered from with slight structural change. Infective arteritis is recovered from if the causative germ is not very virulent or if the toxin is not present in excessive quantity. Acute arteritis may terminate in arterial obstruction with or without gangrene, permanent dilatation, arterial rupture, or chronic arteritis.

The *symptoms* may be merged with those of an acute or chronic intoxication or infection, or with those of a local perivascular inflammation. In arteritis arising during infections the symptoms appear abruptly and the onset is marked by great pain. Ford studied 18 cases in influenza. He says it attacks particularly persons over thirty years of age, occurs in one leg or both, arises most commonly during convalescence, but may not begin until the individual is apparently well. There are pain and tenderness over the vessels, low surface temperature, paresthesia, and mottled skin (Ford, "Thèse de Paris," 1901). The artery may be obstructed, and if a large vessel is blocked, the pulse below the clot is lost. The block may be temporary or persistent. Gangrene may follow. Ford points out that if the artery only is blocked, the gangrene is dry; but if the vein also is occluded it may be moist. I have seen 2 cases of dry gangrene of the foot following influenza.

Treatment.—Probably the wisest plan if a large vessel is involved is to open the vessel and remove the clot (page 387). If this is refused, the surgeon must adopt a conservative plan. Secure rest in bed; elevate the extremity slightly, relax it, smear the skin over the inflamed vessel with ichthyol ointment or mercurial ointment, or follow Ford's advice and apply methyl salicylate or an ointment of salicylic acid, turpentine, and belladonna. Wrap the part in cotton and surround it with bottles or bags filled with warm water. If a patient is very restless, a splint must be used. It may be necessary to give morphin for pain, and any infection or toxemia must be combated with appropriate remedies.

If gout, rheumatism, or syphilis is regarded as causative, proper remedies must be given. It is most important to maintain the secretion of the kidneys. If abscesses form in a septic case, they must be opened and drained. If a large artery of one of the lower extremities becomes occluded, and we use heat and elevation, raise the foot

2 inches, wrap the foot and leg in cotton-wool, apply a flannel bandage from the toes up, and surround the limb with bags of warm—not very warm—water. Very warm water would take more blood to the region of the block than could be distributed. If gangrene occurs, amputation is necessary.

Chronic Endarteritis (Arteriosclerosis, Atheroma, Arteriocapillary Fibrosis, Cardiovascular Degeneration).—By these terms we mean thickening of the walls of the arteries, limited in area or wide-spread, due to inflammation or degeneration of the middle coat, the media undergoing hypertrophy and the intima fibrous hyperplasia (Wm. Russell, "Brit. Med. Jour.," June 4, 1904). Atheroma is used to designate the disease when it attacks the large vessels and is characterized by advanced degeneration. Chronic endarteritis is due to increase of blood-pressure. Hypertension precedes sclerosis and causes it. Hypertension is detected and measured by the sphygmomanometer. Increase of blood-pressure means increase of arterial tension, because the lumen of the vessels is lessened and the heart works more strongly to urge the blood along, and finally hypertrophy of the middle coat occurs. The persistence of arterial contraction which causes increase of blood-pressure may be brought about by kidney disease, hard work, violent strains, heart disease, care and anxiety, worry and mental strain, alcoholic or venereal excesses, habitual gluttony, syphilis, gout, rheumatism, lead-poisoning, diabetes, and acute infections like typhoid fever and influenza. It may arise in an old man who has not suffered particularly from any of the above-named causes, or may occur prematurely from toxemia or heredity. It is a true saying of Cazalis that "A man is as old as his arteries," and a young man debilitated by syphilitic disease or alcohol may have diseased arteries, and hence be really older than a healthy man of sixty. Heredity may be commonly traced in heart disease due to diseased coronary arteries, and cerebral hemorrhage due to disease of the middle cerebral arteries. The aorta, of all vessels, is most prone to suffer. The large vessels are more apt to be diseased than the small, but even the arterioles can be involved. The arteries of the stomach, liver, and mesentery are rarely sclerotic. In arteriosclerosis connective tissue is substituted for the normal elements of the vascular wall, and this tissue undergoes hyperplasia and subsequent contraction and induration. If the mass of proliferating fibroblasts undergoes fatty degeneration, *atheroma* is said to exist, and an atheromatous vessel may be calcified by deposition of lime-salts. When fatty degeneration occurs the endothelium is destroyed, the vessel wall is damaged, and the blood may obtain access to the deeper coats. Atheroma is a frequent cause of thrombosis, aneurysm, senile gangrene, and apoplexy.

A sclerosed artery is rigid, non-contractile, and inelastic, and the parts it supplies are cold, congested, ill nourished, and often edematous. When the caliber of arteries remains narrowed because of persistent contraction or of arteriosclerosis there is marked accentuation of the second aortic sound. The valve or door which opened during systole is slammed shut during diastole by the peripheral resistance. The heart is obliged to overwork and in consequence undergoes hypertrophy. The hypertrophied heart finally dilates. If a hypertrophied heart exists with diseased arteries, apoplexy or aneurysm is apt to occur (Nammack, "Med. Record," Oct. 26, 1901). Syphilitic arteritis is characterized by an enormous growth of granulation tissue from the inner coats of arteries of small size (*obliterative endarteritis*). Calcification of an artery may be secondary to fatty change, or may occur primarily from deposit of lime-salts in the middle coat. *Periarteritis* is inflammation of the sheath and outer coat. An acute arteritis is always local, but a chronic arteritis may be general. If angiitis with thrombosis arises in the arteries of a limb, the veins are almost certain to become involved. For this condition of veins and arteries Buerger suggests the term "thrombo-angiitis obliterans" (see page 92).

Treatment.—In treating chronic arteritis, endeavor to antagonize the dangers to which the patient is obviously liable. Forbid alcohol as a beverage, though a little whisky may be taken at meals. Maintain the activity of the skin by daily baths, and of the kidneys by diuretic waters. A daily bowel movement should be secured. The diet is to be plain and is to contain a minimum of nitrogen. If the patient has had syphilis, occasional courses of iodid of potassium are to be given. If the arterial tension at any time becomes inordinately high, administer nitroglycerin. One danger to which the patient is liable is apoplexy, hence excitement and violent exercise are to be avoided. Another danger is senile gangrene; hence the patient should wear woolen stockings, put a bottle or bag of warm water to the feet at night, and be careful to avoid injuring his toes or feet, especially when cutting his corns. A bag of *very* warm water is dangerous and may actually excite gangrene. When a patient with atheroma has dyspnea and

is of a livid color, or when the arterial tension is very high, a moderate blood-letting (16 to 18 oz.) does good, and may prevent or arrest edema of the lungs. Still another danger is aneurysm, which may appear suddenly from rupture or gradually from progressive distention.

It has been suggested that endarteritis threatening gangrene of the foot should be treated by an anastomosis between the common femoral artery and the femoral vein, in order that the blood may be directed from blocked to open channels, and hence may still nourish the extremity. The operation is never to be thought of unless pulsation is absent in the tibials, the femoral high up seems normal, and the deep veins are patent (see page 94).

Buerger suggests the following test of the patency of the deep veins ("Jour. Amer. Med. Assoc.," April 24, 1909): "I allow the limb to hang, watch for the advent of the erythema, and wait until a fair degree of cyanosis has become established. This may take considerable time—five to ten minutes. The veins are then obliterated above the knee by means of a Martin bandage properly applied. The limb is then raised high and the bandage loosened just enough so as to remove pressure from the deep, but not from the superficial, veins. If the cyanosis is slow in disappearing or fails to disappear, it may be concluded that the function of the deep veins is impaired."

An **aneurysm** is a pulsating sac containing blood and communicating with the cavity of an artery, and formed partly or entirely by the arterial walls, or is a fusiform dilatation of an artery. Some restrict the term "true aneurysm" to a condition of dilatation involving *all* the coats of the vessel. We shall consider, with Heath, a *true* aneurysm to be one in which the blood is included in one or more of the arterial

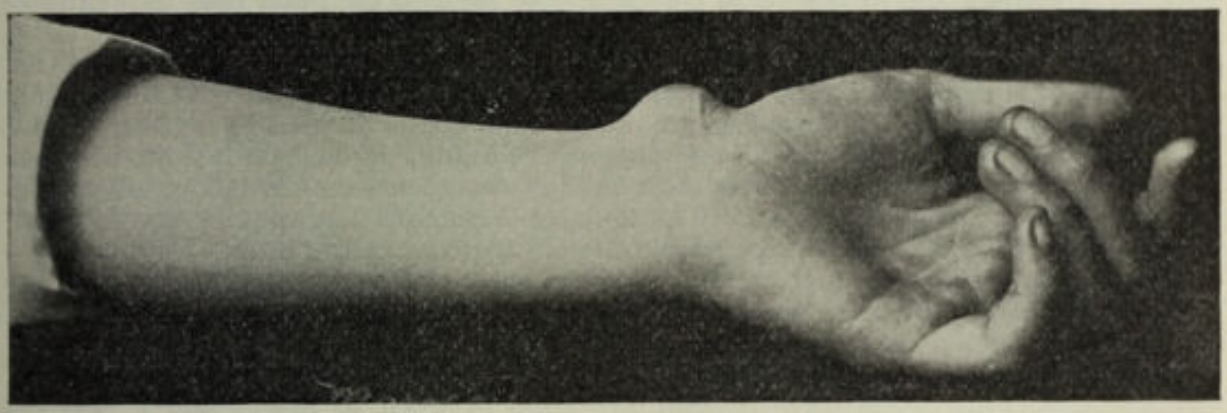


FIG. 198.—Traumatic diffused radial aneurysm following incised wound of wrist (Prof. W. Wayne Babcock).

coats, and a *false* aneurysm to be a condition in which the vessel has been wounded, has ruptured or has atrophied, and the aneurysmal wall is formed by a condensation of the perivascular tissues.

Forms of Aneurysm.—The following forms of aneurysm are recognized:

1. *True aneurysm*—one whose sac is formed of one or more arterial coats.

2. *False aneurysm*—one whose sac is formed of condensed perivascular tissues and contains no arterial coat.

3. *Traumatic diffused aneurysm* (*traumatic arterial hematoma*, Fig. 198)—a false aneurysm due to a wound or traumatic rupture of a blood-vessel. At first the blood is widely diffused and unlimited by any sac or capsule, later a limitation or encapsulation may occur by the condensation of tissue, any wound being healed. A traumatic diffused aneurysm may follow a puncture or an incised wound of an artery, the injury causing the aneurysm directly. It may follow an effort or a strain, the injury indirectly causing the aneurysm by acting on a diseased vessel. As Barwell says, the term "traumatic diffused aneurysm" is an extremely bad one, as the term "aneurysm" conveys the idea of some sort of a sac. In this condition there is no true sac and blood is either unlimited or limited by condensed tissue only.

4. *Diffused aneurysm*—a term used to mean a ruptured aneurysm, the blood being diffused in the tissues and either unlimited or limited by condensed tissue only. The term should be limited to conditions in which the effusion of blood is slow and trivial. If the effusion is large and rapid, the term *ruptured aneurysm* is preferable.

5. *Consecutive aneurysm* results from the rapid growth of a sacculated aneurysm. At a certain portion of the sac of a true aneurysm the arterial coats give way com-

pletely, and at this point blood is limited only by clot and by condensed perivascular tissue. The blood is not diffused, but is encapsuled, partly by the old sac, partly by condensed tissues, aided it may be by bone and fascia.

6. *Fusiform* or *tubulated aneurysm*—a variety of true aneurysm, the sac being spindle-shaped and formed, as Matas states, "at the expense of the artery," the artery dilates, the continuity of the parent artery is interrupted for a variable length, and is lost in the sac, to be restored once more as a normal vessel at the outlet of the aneurysm ("Trans. Amer. Surg. Assoc.," 1905). Such an aneurysm has, of course, two openings. This form, according to Matas, comprises 66.6 per cent. of all aneurysms.

7. *Sacculated aneurysm*—a common form of aneurysm, in which the dilatation is like a pouch, arising from a part of the arterial circumference and joining the lumen of the vessel by a single aperture. As Matas points out, the parent artery is involved in but a portion of its circumference, the continuity of the vessel is not lost, the arterial caliber is maintained at a nearly normal diameter, and "the sac is simply grafted or attached to the artery by a narrow neck, forming a sort of diverticulum of variable shape and dimensions" ("Proceedings of Amer. Surg. Assoc.," 1905). Such a sac has but one orifice. The opening from the artery into the sac is called the *mouth;* around and just above the mouth is the *neck;* the balance of the sac is much larger than the neck and is called the *body*. A sacculated aneurysm may arise from an artery of normal size, from a dilated artery, or from a fusiform aneurysm. A sacculated aneurysm of unknown cause is called a *spontaneous aneurysm;* one which is due to injury is called a *traumatic aneurysm*. The first step in the formation of a sacculated aneurysm is stretching or giving way of an area of the middle coat (media), followed by a gradually advancing stretching and dilatation of corresponding areas of the outer coat (adventitia) and the inner coat (intima).

8. *Dissecting aneurysm* (*Shekelton's aneurysm*)—a pouch-like dilatation of an artery due to the blood-stream, which has gained access to the middle coat through an atheromatous ulcer or a minute rupture of the inner coat. It used to be taught that the blood flows between the media and adventitia; we now know that it flows between the layers of the middle coat. The outer wall of the aneurysm consists of adventitia and a portion of the middle coat. The unnatural channel may or may not join the lumen of the artery at another point by a fresh aperture in the intima. Practically, the dissecting aneurysm is met with in the aorta only. It is most common in the thoracic aorta. About 80 cases have been reported.[1]

9. *Arteriovenous aneurysm*, which is divided into aneurysmal varix, or Pott's aneurysm, when there is direct communication between a vein and an artery; and varicose aneurysm, when there is communication between an artery and a vein by means of an interposed sac.

10. *Acute aneurysm*—a cavity in the walls of the heart, which communicates with the interior of this organ, and which is due to suppuration in the course of acute endocarditis or myocarditis.

11. *Aneurysm by Anastomosis.*—(See Angiomata.)

12. *Aneurysm of bone*—an inaccurate clinical term used to designate a pulsatile tumor of bone.

13. *Circumscribed aneurysm*—when the blood is circumscribed by distinct walls.

14. *Cirsoid aneurysm*—a mass of dilated and elongated vessels shaped like varicose veins and pulsating with each heart-beat (page 380).

15. *Cylindric aneurysm*—a dilatation which maintains the same dimensions for a considerable space.

16. *Embolic* or *capillary aneurysm*—dilatation of terminal arteries due to emboli.

17. *Spontaneous aneurysm*—non-traumatic in origin.

18. *Miliary aneurysm*—a minute dilatation of an arteriole.

19. *Secondary aneurysm*—one which, after apparent cure, again pulsates, the blood entering by means of the anastomotic circulation.

20. *Verminous aneurysm*—one containing a parasite. This form of aneurysm is met with in the mesenteric artery of the horse.

21. *Bilateral aneurysm*—aneurysms of two corresponding arteries are very rare. In 120 subclavian aneurysms two-thirds were of the right side and "in only two instances were the lesions bilateral" (Lothrop in "Boston Med. and Surg. Jour.," April 10, 1913).

The sac of a sacculated aneurysm is at first composed of at least two of the arterial coats, reinforced by the sheath and perivascular tissues. After a time the blood-pressure distends the sac, and the inner and middle coats either stretch with inter-

[1] Coleman in "Dublin Jour. Med. Sciences," Aug., 1898.

stitial growth or—what is more common—are worn away and lost. When all the coats are lost and the blood is sustained only by the sheath and surrounding tissue, a true aneurysm becomes a false or consecutive aneurysm, the limiting tissues and sheath being condensed, thickened, and glued together. This limiting process is deficient in the brain, hence cerebral aneurysms break soon after their formation. When all the arterial coats are lost, the blood-pressure, acting on the tissues, finds some spots less resistant than others, the blood follows the lines of least resistance, the aneurysm grows with great rapidity, and soon ruptures externally or into a cavity.

An aneurysm may rupture into a cavity (pleural, pericardial, or peritoneal), into the perivascular tissues, or through the skin. Rupture into the tissues may produce pressure-gangrene. When rupture occurs through the skin the hemorrhage is not often instantly fatal, but during several days recurs again and again in larger and larger amounts. The pressure of an aneurysm causes atrophy of tissues, hard and soft, bones and cartilages being as easily destroyed as muscles and fat. Sometimes the perivascular tissues inflame and suppurate, and the sac is opened rapidly by sloughing. An aneurysm usually progresses toward rupture, the slowest in this progression being the fusiform dilatation, which may exist for many years, but which finally is converted into the sacculated variety.

In some rare instances there takes place spontaneous cure, which may result from laminated fibrin being deposited upon the walls of the sac as the blood circulates through it. The laminated fibrin is known as an "active clot," and eventually fills the sac. The weaker and slower the blood-stream, the greater is the tendency to the formation of an active clot, hence any agent impeding, but not abolishing, the circulation aids in the deposition. The weakening and slowing of circulation may be brought about by great activity of the collateral circulation diverting most of the blood from the area of disease. Sometimes a clot breaks off from the sac wall and plugs the artery beyond the aneurysm, and the anastomotic vessels, enlarging, divert the blood-stream. A large aneurysm, falling over by its own weight upon the vessel above the mouth of the sac, may, in very unusual cases, diminish the blood-stream. The development of another aneurysm upon the same vessel nearer to the heart weakens the circulation in and may cure the older one. Inflammation occasionally forms a clot. I saw an aneurysm of the subclavian undergo spontaneous cure from clot formation in the brachial which gradually extended up until the aneurysm became blocked. The brachial clot was apparently due to embolism. The tissues about an aneurysm tend to contract when arterial force is lessened, hence tissue-pressure may more than counteract blood-pressure when the circulation is feeble. Clotting of the blood contained within a sac, circulation through the aneurysm having ceased, causes a "passive clot." A passive clot, which occasionally induces cure, may arise from a twist of the neck of the sac preventing the passage of blood, from the lodgment of a clot in the mouth of the sac, or from inflammation. Spontaneous cure is, unfortunately, very rare.

Causes of Aneurysm.—Gradual distention of arterial coats which are in a condition of arterial sclerosis, or of coats whose resisting power is lowered because of atheroma, may cause aneurysm. Hence, the causes of sclerosis and atheroma are also causes of aneurysm. The principal cause of aneurysm is increased blood-pressure. This increase may be brought about by severe labor; by sudden strains, as in lifting; by violent efforts, as in rowing in a boat-race; by chronic interstitial nephritis; by hypertrophy of the heart; by alcoholic excess, and by syphilis. Arterial disease is commonest in the larger vessels, and in the aged, but it may occur in youth. When an aneurysm follows a strain, it may be due to laceration of the media and loss of resistance at a narrow point. The intima may lacerate, permitting the blood to come in contact with the media or causing blood to diffuse between the coats (dissecting aneurysm). When an embolus lodges in an artery the vessels may become aneurysmal on the proximal side of the clot. The embolus, if infective, causes softening, and if calcareous causes laceration (Osler). Colonies of micrococci may cause aneurysm.[1] The parasite *Strongylus armatus* causes aneurysm of the mesenteric arteries in horses. Suppuration around a vessel weakens its coats and tends to aneurysm by inducing acute arteritis and softening. Sometimes an individual develops multiple aneurysms the origins of which are absolutely unknown. A bruise of a vessel may be followed by aneurysm. A cut or puncture of a healthy artery may lead, after the surface wound heals, to the development of an aneurysm. Such an aneurysm does not differ in symptoms or treatment from the other form.

[1] See Osler on "Malignant Endocarditis."

The *constituent parts of an aneurysm* are: (1) the wall of the sac; (2) the cavity; (3) the mouth, and (4) the contents.

Symptoms of Aneurysm.—The formation of an aneurysm, when sudden, is occasionally, though rarely, appreciated by the patient, and is described by him as a feeling of something having given way. In most instances the feeling of beating and the discovery of the lump are the first intimations that anything is wrong. An oval or globular, soft, elastic, and pulsatile protrusion develops in the line of an artery. It is usually quite evident to the touch that the sac contains fluid, but sometimes in old aneurysms the sac seems firm or even hard, because of the deposit of fibrin upon its inner surface. In a partially consolidated aneurysm pulsation may be slight or even inappreciable. The protrusion instantly ceases to pulsate and almost disappears on making firm pressure on the artery above. On relaxing the pressure the pulsatile enlargement at once reappears. Direct pressure upon the tumor may cause it to almost disappear. Pressure upon the artery below causes the lump to enlarge. The pulsation is expansile—that is, the sac expands in all directions during every cardiac contraction—and if an index-finger be laid on each side of the tumor so that the points nearly touch, each pulsation not only lifts the fingers, but it also separates them. It is important to remember that a *large* intrathoracic aneurysm which is in contact with the chest may not exhibit expansile pulsation, but simply transmit pulsation from the blood-stream (Sidney Lange in "N. Y. Med. Jour.," Nov. 21, 1908). On placing a stethoscope over the aneurysm there is imparted to the ear a distinct bruit which is systolic in time, and is usually harsh, rather than soft and blowing in character. Seldom is the bruit transmitted any considerable distance along the artery or the blood-current. In some cases bruit is absent (when a sacculated aneurysm has a very small mouth, when the circulation is tranquil, or when the sac is full of blood and clot). When

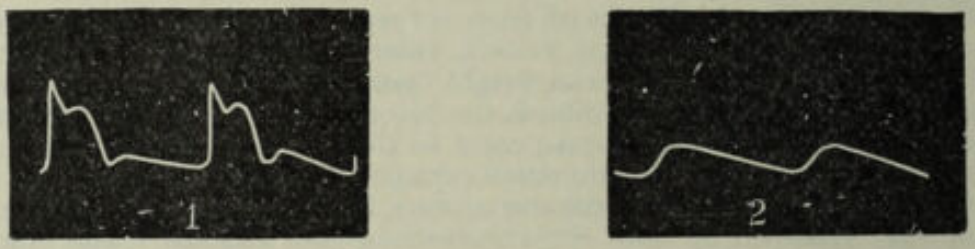


FIG. 199.—Radial pulse-tracings in aneurysm of right brachial artery: 1, Left radial pulse; 2, right radial pulse (after Mahomed).

bruit is absent, it may sometimes be developed by muscular exercise or raising the affected limb (Halloway). In rare cases there may be a double bruit. Occasionally, in fusiform aortic aneurysm linked with aortic regurgitation, a diastolic bruit exists. A bruit is arrested by pressing upon the artery between the aneurysm and the heart. A patient who has an aneurysm of an extremity complains of a sensation of beating, of weakness or stiffness of the limb, frequently of pain in a nerve, a feeling of fatigue in the muscles, and edema and dilated veins are apt to develop because of pressure upon large veins and loss of *vis a tergo* in the circulation. The skin over an aneurysm may be normal, may be discolored, may ulcerate, or even slough. The pulse below an aneurysm is weaker than the pulse of a corresponding part of the opposite limb. This is well shown by sphygmographic tracings (Fig. 199). The tracings taken below an aneurysm are rounded without a sudden rise or an abrupt fall. In internal aneurysms pressure symptoms are marked. Thoracic aneurysm causes intercostal pain; iliac aneurysm causes pain in the thigh. Abdominal aneurysm is very rare. It is most common near the diaphragm. It is more apt to be sacculated than fusiform. As a rule, it distends forward; if it distends backward it may destroy the vertebræ and press upon the cord. Pain practically always occurs, usually in the back, sometimes in the abdomen. Expansile pulsation and bruit make the diagnosis clear. The *x*-rays are valuable in establishing the diagnosis. Aneurysm of the thoracic aorta pressing upon the pneumogastric nerve causes spasmodic dyspnea, and upon the recurrent laryngeal causes hoarseness, which may be associated with loss of voice, cough, and laryngeal spasm, and is due to unilateral abductor paralysis. Pressure upon a bronchus or the trachea causes dyspnea or dysphagia from obstruction, and cough from laryngeal spasm. Pressure upon the cervical sympathetic first causes dilatation and later contraction of the pupil of the same side. A thoracic aneurysm may erode the ribs, sternum, or vertebræ. The *x*-rays are of great value in diagnosticating thoracic

aneurysm (Fig. 200). An aneurysm in the neck may interfere with the cerebral circulation and produce vertigo and even attacks of unconsciousness. Leaking of blood from a ruptured aneurysm into the tissues causes a diffused aneurysm. The evidences of a diffused aneurysm of an extremity are loss of distinctness of outline and increase in area of the swelling, weakening or disappearance of pulsation which may later appear, weakening or alteration of bruit, absence of pulse below the aneurysm, severe pain, edema, and coldness of the surface. Only when the swelling is rapid because the bleeding is profuse are there constitutional symptoms. External hemorrhage may arise; the tissues may become extensively infiltrated with blood; sloughing or gangrene may ensue. Violent external hemorrhage causes shock, syncope, and probably death unless a surgeon is at hand. Only in very rare cases does spontaneous cure take place. Rupture of a large aneurysm into a cavity causes intense pallor, advancing weakness, syncope, and death.

Diagnosis.—A cyst or abscess over a vessel may show transmitted pulsation which is not expansile, and the swelling does not disappear when pressure is made upon the

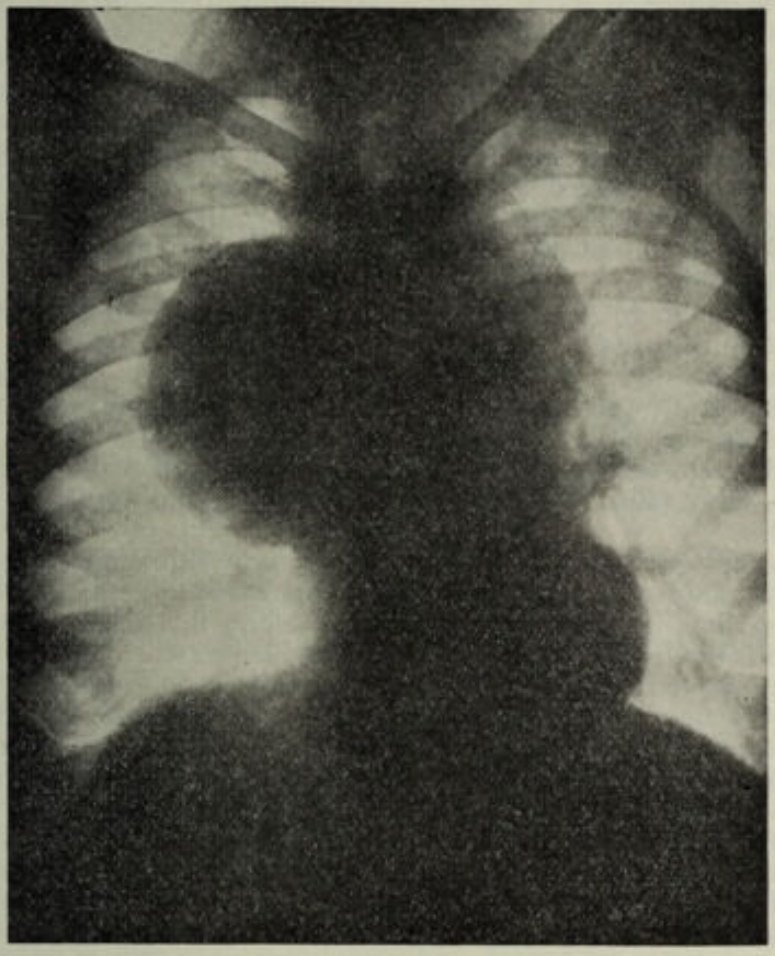


FIG. 200.—*x*-Ray of aneurysm of thoracic aorta.

vessel above it. The pulsation ceases when the growth is lifted off the vessel. There is no true bruit, and the history is widely different. A growth under a vessel may lift the vessel and simulate an aneurysm, but the pulsation is not noted in the entire growth, the growth does not disappear on proximal pressure, and there is only a false, and never a true, bruit. The larger the growth under a vessel, the less is the pulsation, because of pressure narrowing the caliber of the vessel. A sarcoma, especially a soft sarcoma attached to the bone, and also a nevoid mass, pulsate and often have a bruit; the tumor never disappears from proximal pressure, though it may slowly diminish in size, to enlarge gradually again when pressure is withdrawn. These growths do not feel like fluid, and are rarely circumscribed. In aneurysm there is a systolic bruit seldom transmitted along the blood-current. In arteriovenous aneurysm the bruit is continuous, though accentuated during cardiac systole, is purring in sound, is transmitted far along the veins above and below, and is accompanied by a thrill. An aneurysm may cease to pulsate from consolidation leading to cure or from rupture. Rupture of a large aneurysm into a cavity induces deadly pallor, syncope, and rapid death.

Rupture of an aneurysm of an extremity into the tissues is made manifest by a sensation of something breaking, by pain, by sudden increase in size, by diminution or absence of bruit and pulsation, by absence of pulse below the aneurysm, by swelling and coldness of the limb, and, if bleeding is rapid, by shock. The *x*-rays are valuable in diagnosticating thoracic aneurysm and abdominal aneurysm.

Treatment.—(For the history of the evolution of the treatment of aneurysm, see "Studies in Aneurysm," by James G. Mumford, "Cleveland Med. Jour.," Feb., 1908.) In inoperable aneurysms, *general*, *medical*, and *dietetic* treatment must be tried. A chief element in treatment is rest in bed to diminish the rapidity and force of the circulation and favor fibrinous deposit. Valsalva long ago suggested rest, occasional bleeding, and a diet just above the point of starvation. Tuffnell's plan is to reduce the heart-beats by rest and mental quiet, and to restrict rigidly the diet so as to diminish the total amount of blood and render it more fibrinous. Liquids are restricted in amount, and the patient lives through each twenty-four hours upon 4 oz. of bread, a very little butter, 8 oz. of milk, and 3 oz. of meat. This plan is pursued for several months if possible, or it is employed for several weeks, intermitted for short periods, the rigid diet again returned to, and so on, over and over again. There can be no doubt that Tuffnell's treatment sometimes cures aneurysm by decidedly lowering the blood-pressure. Many who suffer from aneurysm may be permitted to go about, taking their time about everything and avoiding work, worry, and excitement. The diet should be low and non-stimulating, and the bowels must be maintained in a loose condition.

Even in an operable case diet and rest are of importance. Often a patient is kept in bed for a number of days before operation, the daily diet consisting of 10 or 12 oz. of solid food with a pint of milk. If the circulation is very active, use aconite and allay pain by morphin.

Iodid of potassium in doses of 20 gr. undoubtedly does good in aneurysm and even in non-syphilitic cases. It seems to lower the blood-pressure. Balfour taught that it thickened the walls of the sac. Osler says it relieves the pain. Iron, acetate of lead, and ergotin are prescribed by some. Digitalis is contraindicated, as it raises the blood-pressure. S. Solis-Cohen has used with some success the hydrated chlorid of calcium. Morphin and bromid of potassium are occasionally useful to tranquilize the circulation, allay pain, and secure sleep. Aconite and veratrum viride have long been employed.

Lancereaux and others claim that hypodermic injections of gelatin at some indifferent point may cure aortic and subclavian aneurysm. In 1896 Dastres and Floresco proved that gelatin injected into the blood increases coagulability. Later, Lancereaux and Paulesco showed that injections into the subcutaneous tissue act similarly. Carnot pointed out that gelatin applied to a wound may arrest bleeding. How gelatin acts is uncertain, but that it does increase blood coagulability seems proved. The value of injections of gelatin for aneurysm is in dispute. Lancereaux warmly advocates its use for sacculated aneurysm, and says that after the first dose the aneurysm is seen to shrink and the pulsation is observed to lessen. He injects it slowly and with aseptic care into the subcutaneous tissue of the thigh, using normal salt solution containing from 5 to 10 per cent. gelatin given at the temperature of the body. He never injects less than 5 gm. of gelatin. He gives an injection every tenth to fifteenth day and administers from ten to twenty injections. But the treatment is not free from danger; several deaths have taken place, and several persons have died from tetanus. Care must be taken not to inject gelatin into a vessel, and it must never be thrown about the aneurysmal sac. It irritates the kidneys and its use is contraindicated in renal disease. The injections cause much pain, and it is very doubtful if they do any real good in aneurysm. The dangers are definite, the benefit is doubtful, and I no longer use it.

Other expedients sometimes used in the treatment of aneurysm are: the kneading of the sac to release a clot, in the hope that it will plug the mouth of the sac or the artery beyond it—this is dangerous; electricity; electrolysis; the injection of an astringent liquid; the insertion of a fine aspirating needle and the pushing through it into the sac of a large quantity of silver wire, in the hope that it will aid in whipping out fibrin. Some physicians have inserted needles and others horsehair.

Treatment by Pressure.—In a case of subclavian aneurysm in my ward spontaneous cure followed clotting distal to the aneurysm. In this patient a cervical rib existed. I have never seen personally an aneurysm cured by any method of pressure, although I have observed several which by it were diminished in size. *Instrumental pressure* is made by applying two Signorini tourniquets or some specially devised apparatus

to limit the flow of blood through an aneurysm without entirely stopping it, the aneurysmal sac being felt still to pulsate slightly. In some situations Lister's abdominal tourniquet is applied; in other regions we may use Tuffnell's compress, which is like a spring truss and is strapped in place. A heavy body suspended over the artery and resting part of its weight upon the vessel has occasionally brought about cure. Compressing instruments can be worn for from twelve to sixteen hours at a time; usually they are removed to permit sleep and are reapplied the next day, and so on for several days. Before applying the compress be sure the sac is full of blood, and render this certain by applying for a few minutes distal compression. This method may possibly cure, but it is very painful. It aids in the formation of an active clot. It cannot be used successfully in treating aneurysm of the axillary, subclavian, or carotid artery.

Digital pressure, made with the thumb aided by a weight, and maintained for many hours by a relay of assistants, has cured some cases. This method may be used alone or may be used as an accessory to instrumental pressure. Its chief field is in the treatment of aneurysm for which other methods are inapplicable (orbit and some aneurysms at the root of neck). It entirely cuts off the blood and promotes the formation of a passive clot. If cure does not take place in three days, abandon pressure. It must often be abandoned far earlier because of pain.

Direct pressure upon the sac has been used in aneurysm of the popliteal artery, the pressure being obtained by flexing the leg; and in aneurysm of the brachial artery, pressure being applied at the bend of the elbow by flexing the elbow. The pressure of a hollow rubber ball has been used in aneurysm of the subclavian.

Rapid pressure completely arrests the passage of blood through the sac for a limited time, and is applied while the patient is under the influence of an anesthetic. Take, for example, a case of popliteal aneurysm: the patient is placed under the influence of ether; two Esmarch bandages are used, one being applied to the limb from the toes

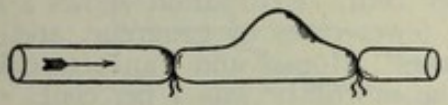


FIG. 201.—Old operation of Antyllus for aneurysm ("Amer. Text-book of Surgery").



FIG. 202.—Anel's operation for aneurysm ("Amer. Text-book of Surgery").

up to the lower limit of the aneurysm, and the other from the groin down to the upper limit of the sac, and the Esmarch band is fastened above the aneurysm. This procedure stagnates the blood both in the veins and in the arteries, and the sac remains full of blood. Pressure is thus maintained for three or four hours, and on removing the Esmarch apparatus a tourniquet is put on the artery above the aneurysm and partly tightened in order to limit the amount of blood passing through and thus prevent the washing away of clot. This method of rapid pressure sometimes cures by forming a passive clot, but it sometimes results in gangrene. It was devised by John Reid.

Operative Treatment.—In the vast majority of cases of aneurysm an operation is called for. When an aneurysm threatens to rupture or when there is infection immediate operation is demanded imperatively. Either condition is a surgical emergency. In any operable case of aneurysm operate reasonably early. Don't delay needlessly. Early operation means that we deal with a thin sac. Before operating on an aneurysm of an extremity test the activity of the collaterals. If they are active, operate promptly. If they are inefficient take means to develop them (see Matas's views on page 373). Before operating on an aneurysm of the neck, if possible (page 372), test the brain circulation by partially occluding the common carotid with a band (page 375).

Operation by the Ligature and by Sutures.—Ligation of the main artery was the operation employed by most surgeons until the Matas operation was introduced. The methods of ligation are: (1) the method of Antyllus; (2) extirpation of the sac; (3) the method of Anel; (4) the method of Hunter; (5) the method of Wardrop, and (6) the method of Brasdor.

Aneurysmotomy, the *method of Antyllus* (Fig. 201), a Roman successor to Galen, who lived in the third century, A. D., is usually described as a method involving a direct attack upon the sac itself. The artery is ligated immediately above and below the sac, the sac is opened and its contents turned out, or the sac is extirpated. As a matter of fact, Antyllus advocated applying a ligature on each side of the sac and

opening the sac in order to evacuate its contents, but he distinctly opposed extirpation because of its danger. All we know of Antyllus is found in writings of Oribasius, who lived in the fourth century and was the physician of Julian the Apostate. Syme maintained many years ago that incision of the sac was the proper operation for aneurysm of the gluteal, iliac, carotid, and axillary arteries, but Syme's method is productive of fearful hemorrhage, and the plan of Antyllus is vastly better. Syme opened the sac, inserted his finger, and plugged the artery toward the heart until a ligature was applied and tied. He then packed the sac with lint. The method of Antyllus may be a good plan for a false aneurysm.

Aneurysmectomy (*extirpation of the sac*), if practised, should be carried out after applying a ligature on each side after the method of Antyllus. It was originally practised by Philagrius and was reintroduced by Purmann of Brandenburg in 1699 (Moynihan in "Annals of Surgery," July, 1898).

Extirpation finds warm advocates in Delbet, Littlewood, and Moynihan. Moynihan claims that, as compared with distal ligature, there is a greater chance of recovery, no chance of recurrence, less risk of gangrene, and complete recovery from troubles due to nerve interference (Ibid.). Extirpation is regarded by some surgeons as the best operation for traumatic aneurysm, but if the vessel is seriously diseased near the sac some other method should certainly be employed. It would seem that excision must destroy collaterals which would be of much value if retained intact. In aneurysm of the common carotid after extirpation (as after ligation) there is grave risk of cerebral embolism, and it has been thought better by some surgeons to attempt a re-establishment of the circulation by circular suture of the two ends of the divided vessel, or, as Lexer did in the axillary artery, autoplasty with a piece of the internal saphenous vein. It seems certain that the safest plan in carotid aneurysm is to apply the removable aluminum band of Halsted. In the extremities there is less danger of gangrene after Matas's operation than after extirpation. Monod and Vanverts ("Rev. de Chir.," 1910, xli and xlii) collected 205 cases of excision. Of these, 90 per cent. were cured. Relapse occurred in 1½ per cent. Direct operative mortality was 3 per cent. Gangrene occurred in 4 per cent. Extirpation shows a higher percentage of cures, a lower rate of mortality, fewer cases of gangrene, and fewer relapses than any operation except that of Matas. Monod and Vanverts collected 138 cases of ligation by different methods. The mortality was 7 per cent. There were 12 per cent. of relapses and 6½ per cent. of gangrene. The cures numbered 74 per cent. Extirpation requires a very free incision. In the limbs an Esmarch band controls bleeding. In other regions the artery is clamped on each side of the aneurysm. On removing the sac, ligate the veins and arteries above and below. Nerve trunks are apt to be found adherent to the sac.

The Method of Anel.—Anel, of Toulouse, devised and performed this operation in 1710. In Anel's method the artery is ligated above the sac, and so close to it that there are no anastomotic branches between the sac and the ligature (Fig. 202). It is used chiefly for traumatic aneurysms, and is never employed when the vessel is diseased on the cardiac side of the aneurysm. Either extirpation or Matas's operation is preferable to Anel's operation.

The Method of Hunter.—This operation, which is the modern method of ligation, was devised by the illustrious John Hunter, and was first employed by him in January, 1786. He is said by Sir Everard Home to have recognized the fact that the vessel adjacent to an aneurysm was apt to be diseased, and he discovered the anastomotic circulation. Putting together these two facts, he devised the operation which goes by his name. It consists in applying a ligature between the heart and the aneurysm, but so far above the sac that collateral branches are given off between it and the point of ligation (Fig. 203). This operation, which is done upon a healthy portion of the artery, does not permanently cut off all blood, but so diminishes the force and frequency of the circulation that an active clot forms within the sac. Thus are lessened the dangers of secondary hemorrhage and gangrene. According to Stimson ("New York Med. Jour.," July, 1884), Hunter really builded better than he knew, for he sought only to tie the artery without opening the sac and at a healthy point, but said not a word about the necessity of having branches between the sac and the ligature or about the desirability of diminishing the flow of blood instead of cutting it off completely (Moynihan in "Annals of Surgery," July, 1898). Hunter tied the femoral artery in the region now known as Hunter's canal. Scarpa introduced the custom, which we still follow, of tying it in Scarpa's triangle. The hunterian method was for many years regarded by most surgeons as the proper operation for aneurysm in the majority of cases.

In some cases pulsation does not return in the aneurysm after tightening the ligature; in most cases, however, it reappears for a time after about thirty-six hours, but is weak from the start, constantly diminishes, and finally disappears permanently. Previous prolonged compression by enlarging the collateral branches permits strong pulsation to recur soon after ligation, and thus militates against cure; hence, it is a bad plan to use pressure in cases admitting of ligation and in which the success of pressure is very doubtful. Proximal ligature alone is now seldom regarded as the best method for false aneurysm. If the aneurysm is at the root of the neck and is very large it may be the desirable method. Hunter's operation is best suited to true aneurysm. Occasionally after Hunter's operation the sac suppurates, producing symptoms like those of abscess. Suppuration may occur between the first and the thirty-second week after ligation.[1] When pus forms, open freely, as we would open an abscess, and if no blood flows, treat as an abscess, but have a tourniquet loosely applied for several days after drainage ready to screw up at the first sign of danger. If hemorrhage occurs, tie the vessel above and below the aneurysm, open the sac, and pack with iodoform gauze. If bleeding recurs, there is no use reapplying the ligature and there is little use tying higher up. If dealing with the upper extremity, try the application of a ligature higher up; if dealing with the lower extremity, amputate at once.

Distal Ligation.—When an aneurysm is so near the trunk that Hunter's operation is impracticable, or when the artery on the cardiac side of the aneurysm is greatly diseased, distal ligation may be employed. Distal ligation forms a barrier to the onflow of blood, collateral branches above the aneurysm enlarge, the blood-current is gradually diverted, and a clot may form within the aneurysm. Distal ligation is used in some

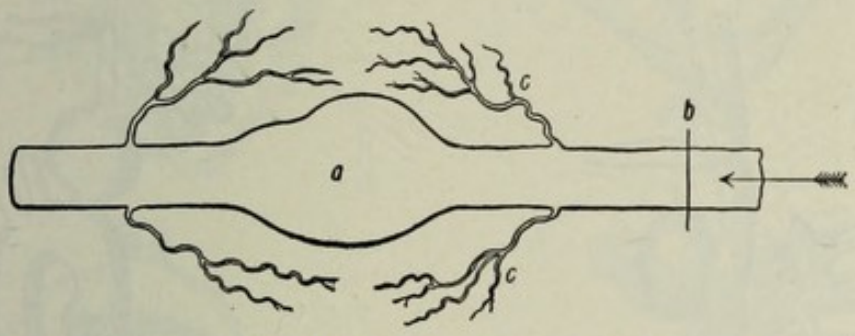


FIG. 203.—Hunter's method of ligating for aneurysm: *a*, The aneurysm; *b*, point of ligation; *c*, the branches between the aneurysm and the ligature. The arrow shows the direction of the blood-current.

aneurysms of the aorta, iliac, innominate, carotid, and subclavian. It occasionally causes rupture of the sac of the aneurysm. I have obtained two notably successful results in aneurysms of the innominate artery by ligation of the common carotid and subclavian of the right side. In each of these cases I tied both vessels at one séance, tying the carotid first. In one case I tied the third part of the subclavian and in the other the first part. The first patient returned to his work as a blacksmith and died over a year and a half later from rupture of a secondary aneurysm of the carotid at the point where the ligature had been applied. The second case was living and apparently well over five years after the operation (the author in "Surg., Gyn., and Obst.," June, 1910). Distal ligation was suggested by the French surgeon Pièrre Brasdor (1721–97) in 1760. At the present time we usually tie the main trunk below an aneurysm or both branches below the first bifurcation distal to the aneurysm.

The *operation of Brasdor* consists in tying the main trunk some little distance below the aneurysm (Fig. 204). It completely arrests circulation in the sac.

The *operation of Wardrop* consists in tying one of the branches of the artery beyond the aneurysm (Fig. 205). James Wardrop of London originally advocated ligation at a point where there is no intervening branch between the sac and the ligature. Later, he advocated ligation at a point where there is an intervening branch. In 1809 Wardrop ligated the carotid distally and successfully for carotid aneurysm. He published his well-known article in 1825. In 1827 he ligated the subclavian for innominate aneurysm ("Lancet," 1827, xii). It is the custom to consider Wardrop's operation to be the ligation of one branch beyond the aneurysm, as shown in Fig. 205. The circulation is but partially arrested by Wardrop's operation. An *x*-ray picture should be

[1] See the case described by Sir Astley Cooper.

taken in every case of aortic aneurysm. Such a picture may aid us in coming to a conclusion as to which vessel or vessels to tie.

Matas's Operation (*Aneurysmorrhaphy*).—This procedure is the greatest advance in the surgery of the arterial system since the observations of John Hunter. It was devised and first practised by Rudolph Matas of New Orleans in 1889 on a negro suffering from traumatic aneurysm of the brachial artery in the middle of the arm. The operation was a complete success. In 1900 Matas began again to use this method, and in 1902 described it to the profession ("Trans. Amer. Surg. Assoc.," 1902; "Annals of Surg.," Feb., 1903; "Trans. Amer. Surg. Assoc.," 1905).

One procedure, applicable to ordinary fusiform aneurysms, is called *obliterative endo-aneurysmorrhaphy without arterioplasty* (Fig. 206). "No attempt is made to reconstruct the parent artery (arterioplasty), and the arterial orifices are simply obliterated by suture." By sutures applied within the incised sac the sac is cut off from the circulation without disturbing adjacent collaterals and without interfering with the nutrition of the sac walls. After this operation there is very seldom secondary hemorrhage, gangrene, or relapse.

A modification of the above operation applied to sacculated aneurysms in which there is one orifice of communication with the artery is called *endo-aneurysmorrhaphy with partial arterioplasty* (Fig. 206). The sac is opened, clots are washed away, the opening of the aneurysm into the artery is closed by a continuous suture passing through all the coats of the sac at the edge of the opening into the artery. Blood is thus excluded from the sac; the lumen of the artery is not, however, obliterated, and

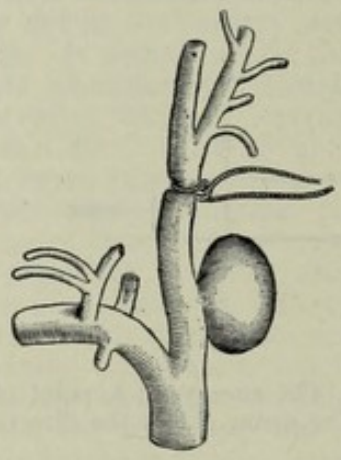


FIG. 204.—Brasdor's operation (Holmes).

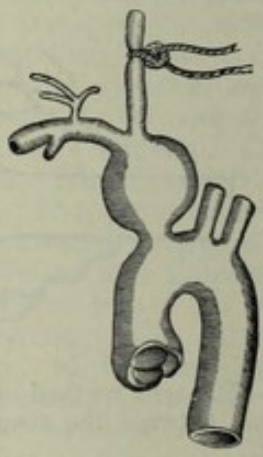


FIG. 205.—Wardrop's operation (Holmes).

the blood-supply of parts beyond is not interfered with. After closing the cut in the arterial wall the sac is obliterated by rows of sutures inserted in its walls. Matas reports 4 cases operated upon successfully by this plan. In a fusiform aneurysm with a firm and resisting sac wall, and in which there are two openings near together on the floor of the sac, *endo-aneurysmorrhaphy* with complete *arterioplasty* may be performed (Fig. 206). This operation restores arterial continuity, a new channel being made out of the sac walls "by simply holding these over a rubber guide (tube or catheter) and suturing them firmly together so as to restore the continuity of the artery lost in the sac." The catheter is withdrawn before the final sutures are tied. This operation has been performed successfully by Morris, Craig, and others. Some surgeons are fearful that such an operation will be followed by relapse, and a very few of the reported cases did relapse. Matas says that preservation of the arterial lumen is "only indicated positively in the sacciform aneurysms with a single opening where the parent artery already exists as a formed vessel, and in which the closure of the fistulous opening can be accomplished with the greatest facility and simplicity" (address delivered at the Medical Assoc. of Alabama, April 22, 1906). Some surgeons think it improbable that the artery remains patent long, because the seat of aneurysm is a diseased vessel and it would seem reasonable to expect that vascular disease would probably cause clotting, but even a temporary restoration of circulation if followed by *gradual* abolition gives time for the enlargement of collaterals and so prevents gangrene. Matas maintains that after the purely restorative operation the artery "remains pervious permanently or for an indefinite time." This has been proved by certain necropsies on successful cases, made after the operation, death having been caused by secondary condi-

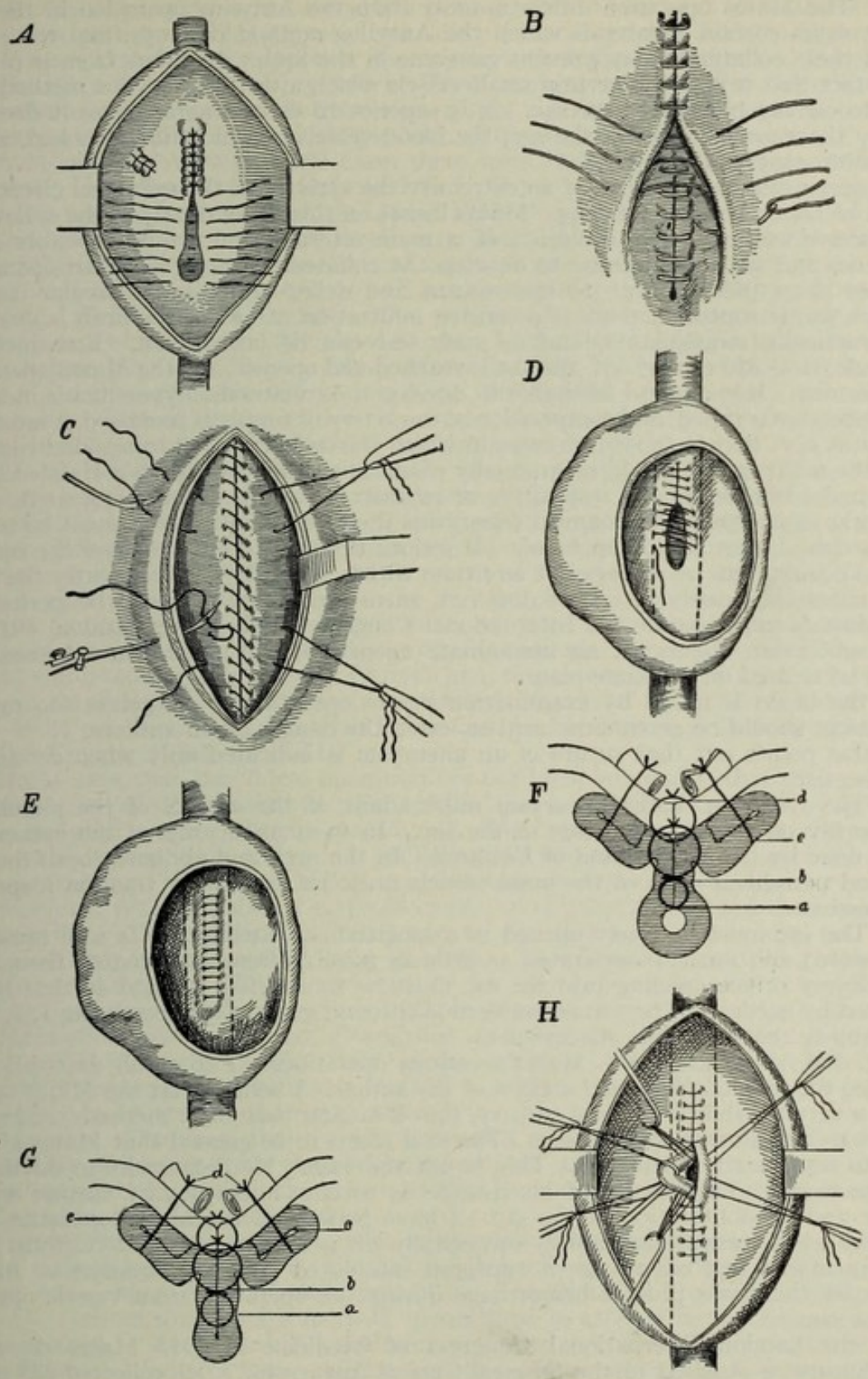


FIG. 206.—The radical cure of aneurysm by aneurysmorrhaphy (Matas): *A*, First tier of sutures in a fusiform aneurysm; *B*, second tier of sutures, some of which are tied; *C*, sutures to approximate the walls of the aneurysm; *D*, suturing the opening in a sacculated aneurysm—the main artery is not obliterated; *E*, opening completely closed; *F*, diagram of cross-section of parts after complete obliteration of sac, but with restoration of blood-channel; *G*, diagram of cross-section of parts after complete obliteration of sac and blood-vessel; *H*, operation for fusiform aneurysm when we wish to restore the blood-channel—sutures applied over a rubber tube, most of the sutures tied, tube withdrawn, and remaining sutures tied.

tions. The Matas operation differs notably from the Antyllus operation in the fact that it saves certain collaterals which the Antyllus method destroys, and the retention of these collaterals may prevent gangrene in the limb. It differs from it further in the fact that it occludes certain small vessels which after the Antyllus method continue to convey blood into the sac. It is superior to extirpation because it does not destroy the vascular walls of the sac, the blood-vessels of which, if unblocked, aid in preventing gangrene of the limb.

In every case of aneurysm of an extremity the activity of the collateral circulation should be tested before operating. Matas insists on this being done. If the collaterals are inactive we know that occlusion of a main arterial trunk would probably cause gangrene, and we adopt means to develop the collaterals before doing an operation. In most cases there is time to take means and delay brings no particular danger. But if a sac is ruptured, there is extensive infiltration of blood, the limb is cyanotic and practically strangulated, and no such test can be undertaken. Free incisions are made, clots are turned out, the sac is reached and opened, and the Matas operation is performed. If it is found advisable to develop the collaterals, hyperemia is induced, blood-pressure is raised, and compression of the artery of supply is practised at intervals.

Matas says that in those rare cases in which the collaterals fail to respond to treatment the main artery should be gradually obliterated near the sac by a Halsted band. If gradual occlusion fails, a restorative or reconstructive operation is indicated.

Matas insists that in all carotid aneurysms the cerebral circulation must be tested. This is done by an aluminum band. If serious cerebral symptoms arise the band is removed, and it can be removed at any time within three days. Frequently the band alone cures the aneurysm. If it does not, aneurysmorrhaphy should be performed. (See Matas's paper before the International Congress of Medicine, London, 1913.)

A subclavian aneurysm, an innominate aneurysm, and an iliofemoral aneurysm should be treated on the same plan.

If the blood is found by examination before operation to coagulate too rapidly the patient should be given citric acid to lessen the danger of thrombosis.

Matas points out that suture of an aneurysm is indicated only when certain essentials exist:

1. The situation of the aneurysm must admit of the control of the circulation temporarily on the proximal side of the sac. In most aneurysms of the extremities this is done by the elastic band of Esmarch. In the neck and abdomen both the cardiac and peripheral sides of the main vessels must be secured by traction loops and compression.

2. The sac must be freely opened in a longitudinal direction. Its wall must not be dissected and must be separated as little as possible from surrounding tissue.

3. Every orifice opening into the sac must be thoroughly exposed so that it can be closed by sutures. The suture material is chromic gut, the number being 1, 2, or 3, according to the size of the aneurysm.

Fig. 206, *A* to *H*, shows Matas's various operations. For a full description of them see the previously quoted articles of the author. I believe that the Matas operation is a very notable advance in surgery, that it is safer than older methods, and much less apt to be followed by gangrene. The idea seems to be general that Matas always seeks to restore arterial lumen. This is not the case. He only seeks to do this in suitable cases. The essence of his method is to cure aneurysm by sutures within the sac and by obliteration of the sac. I have performed the Matas operation (obliterative endo-aneurysmorrhaphy) successfully on a case of ruptured fusiform popliteal aneurysm and on a case of ruptured sacculated popliteal aneurysm. In the latter case there was profuse hemorrhage during the operation from vessels opening into the sac.

At the London International Congress of Medicine in 1913 Matas discussed "The Suture as Applied to the Surgical Cure of Aneurysm." He collected 225 cases. There were 19 deaths (8.4 per cent.). He eliminated 9 deaths in no way due to this particular operation (for instance, 1 death from the anesthetic, 1 from tetanus, 1 from nephritis, 1 from pyelonephritis, 1 from erysipelas, 1 from septic arthritis of the knee, 1 from pulmonary embolism, 1 from a supposed air embolism, 1 from heart disease). This elimination and the exclusion of the 4 aortic cases give a mortality of 6 cases in 221 (2.7 per cent.). In the upper extremities there were 23 cases and 1 death; in the lower extremity, 194 cases and 12 deaths; in the neck, 4 cases and 2 deaths; in the abdominal aorta, 4 cases and 4 deaths. In 150 obliterative operations there were 16 deaths (10.6 per cent.). The 4 aortic cases are in this list. So are 2 accidental deaths. There

were 9 cases of gangrene and 1 secondary hemorrhage. There were 50 total restorative operations, with 1 case of gangrene, 1 secondary hemorrhage, and 2 deaths (4 per cent.). There were 25 total reconstruction operations with 1 case of gangrene, 1 secondary hemorrhage, and 1 death (4 per cent.). There were no relapses after the obliterative and restorative operations, but there were 3 after the reconstructive operations.

Success is obtained in about 90 per cent. of cases and relapse is very rare.

In Monod and Vanvert's 103 cases there were 89 cures. Relapse occurred in 1.5 per cent. Gangrene occurred in from 3 to 5 per cent. of the cases. Direct operative mortality was 3 per cent. ("Rev. de Chir.," 1910, xli and xlii).

The operation has been performed upon the abdominal aorta, the external iliac, the subclavian, the popliteal, the femoral, the internal carotid, the axillary, the common carotid and the external carotid, as well as upon smaller vessels. Munro, Martin and Parham, Lilienthal, Pringle, and Lozano performed endo-aneurysmorrhaphy for subclavian aneurysm (Eliot in "Annals of Surgery," July, 1912). Matas has collected 350 cases including his own 59 ("La Presse Mèdicale," No. 10, Feb. 3, 1923). It is certain that this method gives the lowest mortality, the highest percentage of cure, and the lowest percentage of gangrene (See Gibbon in "Annals of Surgery," Sept., 1924, and Matas in "Supplementary Volume of Keen's Surgery," 1921).

The So-called Ideal Operation (*Circular Angiorrhaphy*).—This operation was first advocated by Goyanes, of Madrid, and Lexer, of Jena. The sac of the aneurysm is extirpated, and vascular continuity is restored by circular suturing or by the introduction and suturing of a graft from a vein or an artery to fill the gap. Matas says of this operation (Ibid.) that "it combines all of the objections that can be brought against extirpation, and, in addition to its traumatizing quality, is complicated by the great uncertainties of a circular suture, or, what is worse, the interposition of a vascular graft." Even in the laboratory experiments the results have been poor. In 352 end-to-end anastomoses by Carrel's plan there were 24.92 per cent. failures from thrombotic occlusion—in 8.12 per cent. marked stenosis of the lumen followed and in only 49.84 per cent. was a full-sized lumen obtained and retained (Sofoteroff in "Centralb. f. Chirurg.," Jan. 28, 1911).

Matas says that the "ideal operation" is not ideal surgically, that it is uncertain and liable to failure, and that as good results "can be obtained by a far more simple, and, clinically, a more efficient procedure." There is no doubt that lateral suturing for a small wound in an artery is a valuable plan and that in many cases thrombosis does not occur. The case is different with end-to-end suturing or vascular grafting. In the World War a number of surgeons employed circular sutures and the results were scarcely fair. The technic is difficult and in war thorough asepsis may fail. Jeger maintains that suture protects from gangrene. Von Eiselsberg and Bier both use it. Delorme opposes it. Tuffier uses suture for lateral wounds of the femoral and popliteal arteries. Most surgeons will not do angiorrhaphy if there is infection.

Halsted's Method by Partial, Progressive, and, Finally, Complete Occlusion by Metal Band.—This method is applied only to the aorta and other very large arteries. A number of surgeons have sought a method to occlude the abdominal aorta gradually and safely in order that they may attempt to cure aneurysm of the aorta or of the iliac arteries. The usual thought was to leave a metal instrument fixed to the aorta, the handle projecting from the abdominal wound, and a metal clamp or a snare of silk or catgut being around the vessel, so that by means of a screw arrangement pressure could be gradually increased.

Halsted showed that by this plan sepsis almost certainly occurs along the track of the instrument. (See W. S. Halsted in "Johns Hopkins Bulletin," 1905, xvi, 346; "Jour. Amer. Med. Assoc.," 1906, xlvii; "Jour. Experimental Medicine," 1909, vol. xi, No. 2.) Halsted sought for a method "permitting, in each entre-act, complete closure of the wound." He uses a band of aluminum curled in cylinder form about the vessel. This material admits of easy readjustment at a future operation, and it is tightened by the fingers (Fig. 207A).

Halsted's band, when used to occlude partially, seldom causes macroscopic alteration in the wall of the vessel; when used to completely occlude, the vessel may undergo atrophy. A diseased vessel may atrophy and rupture. Ideal closure is when the lumen has been nearly but not quite occluded, spontaneous obliteration having arisen, the arterial wall embraced by the band having undergone conversion into "a solid cylinder of living tissue." The arteries may become mere fibrous cords.

Matas's Plan for Testing Collateral Efficiency ("Jour. Amer. Med. Assoc.," lxiii).—Matas considers:

1. *The Sign of Quénu and Muret.*—To obtain this the main artery of the limb is compressed and while the compression is maintained a puncture is made at the periphery. If no bleeding follows, the collaterals are regarded as inefficient; if bleeding follows, they are regarded as efficient. This test Matas rejects.

2. *The Sign of Delbet.*—When an aneurysm forms on a main artery it is often found that the pulse below it disappears abruptly or gradually. When, in spite of absent pulse below the aneurysm, the nutrition of the part is well preserved, the collaterals are active. Matas regards this sign as most valuable.

3. *The Sign of Henle and Coenen.*—This sign is only made manifest during an operation. If blood is seen to flow from the peripheral lumen of the aneurysm when the proximal end is compressed the collaterals are active.

4. *The Signs of Von Frisch.*—They are three in number.

(*A*) When pressure is applied to the proximal side of an aneurysm the peripheral part of the limb retains the color of life.

(*B*) The sign of Henle and Coenen.

(*C*) When the main vein is compressed venous stasis arises below.

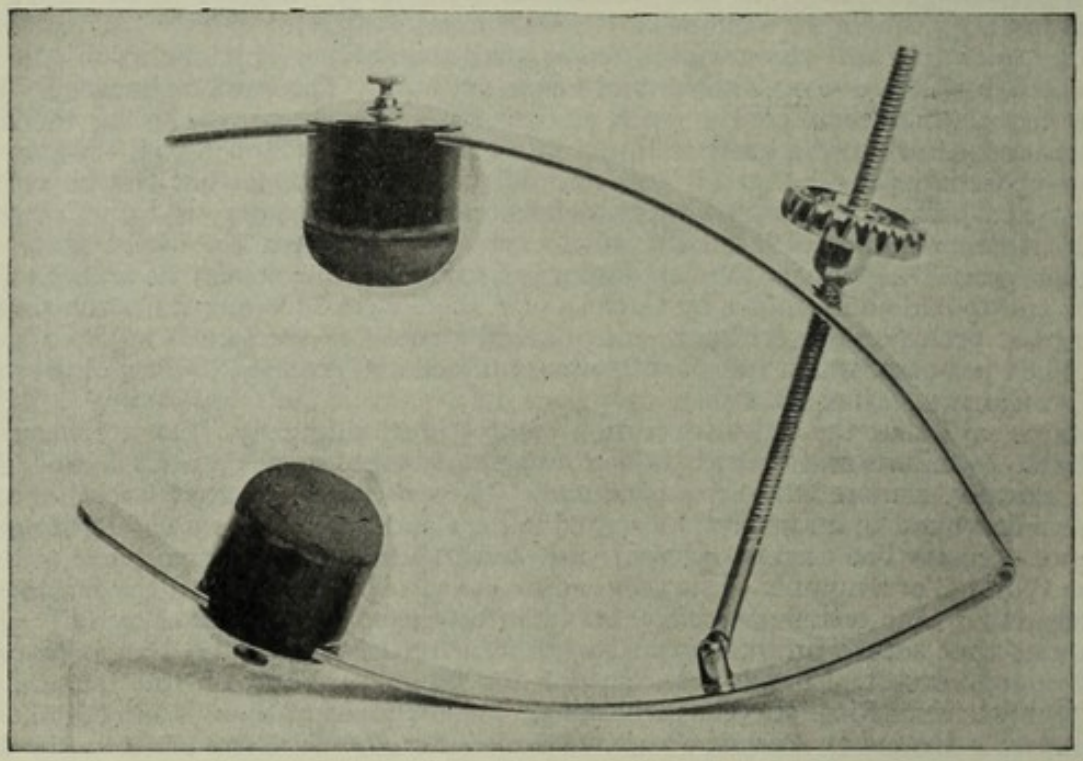


FIG. 207.—The Matas mechanical compressor for testing the collateral circulation in the extremities. The main artery of the limb can be compressed without materially interfering with the circulation in collaterals ("Keen's Surgery").

5. *Korotkow's Test.*—This is made by estimating blood-pressure at the periphery while the main arterial trunk above the aneurysm is being compressed. If the blood-pressure is fairly high the collaterals are active.

6. *Pachon's Test.*—This is also a blood-pressure test made in a different manner from No. 5.

7. *The Test of Tuffier and Hallion.*—If the main artery and vein are compressed, the veins of the foot will swell only if a considerable amount of arterial blood is taken to the periphery by the collaterals.

8. *Stewart's Test.*—In this test the amount of blood passing through a part in a definite time is estimated by means of a calorimeter.

9. Matas uses two methods:

(*A*) The hyperemic reaction advised by *Moszkowicz*, of Vienna, in 1907. This test is applied to an extremity if the main artery can be compressed. The limb is elevated. Esmarch's bandage is applied from the periphery to the lower border of the aneurysm. A Matas compressor is applied to the main artery above the aneurysm to cut off all pulse below (Fig. 207). After compression has been acting from six to ten minutes the elastic bandage is removed. It is removed while the compressor is still in place. At once a flush of hyperemia appears below the compressor and descends the limb quickly. Even when

the collaterals are active the digits remain of a waxy hue for some seconds. The longer the time required for the digits to become hyperemic, the poorer is the collateral circulation. When the collaterals are impaired ten minutes or more will be required. In cases of great impairment thirty or forty minutes may be necessary.

If collaterals are found inefficient they may be developed by making pressure upon the artery above the aneurysm. The pressure should not entirely cut off the circulation, several séances a day should be held, and each séance should last fifteen or twenty minutes. The séances are held until collateral circulation improves or it becomes evident that it is not going to do so. If collaterals refuse to distend, partly close the artery by means of an aluminum band.

(*B*) Preliminary partial closure of the main artery with a removable aluminum band.

In a huge iliofemoral aneurysm Halsted partially occluded the left external iliac, using a band. He cut off the pulse, but not the stream of blood. Sixteen days later he excised the aneurysm. The patient was cured ("Jour. Am. Med. Assoc.," 1914, lxiii). If an aneurysm of the aorta is not cured by partial closure, a secondary operation should be performed in order to permit further closure, complete closure, or perhaps ligation (Halsted in "Arch. f. klin. Chir.," 1914, cv).

The band should eventually be removed from the aorta. On any other large artery, if healthy, the band can be left permanently. By being careful to refrain from cutting off the blood-stream entirely the danger of gangrene is obviated. In constricting the aorta it does not do to abolish the pulse. In other large vessels, if the condition of the

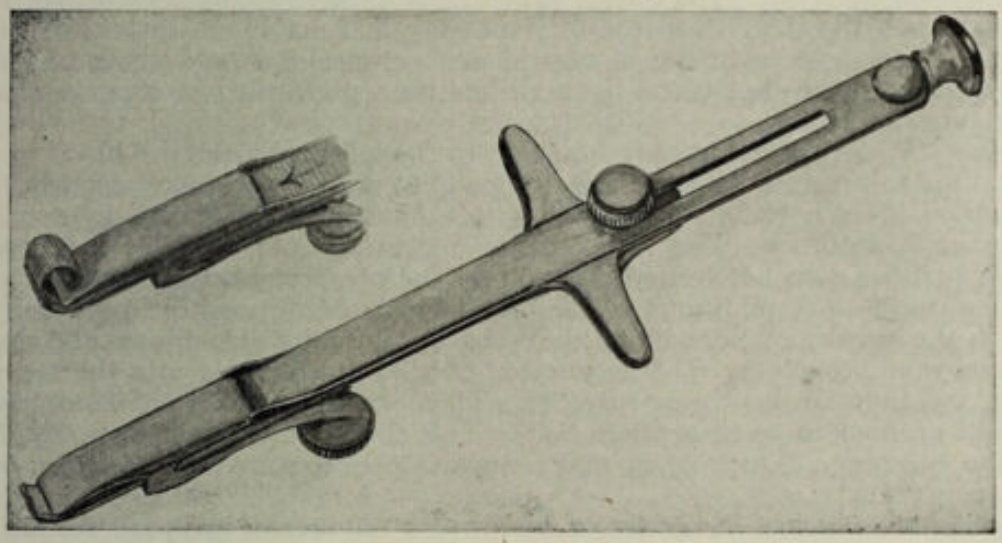


FIG. 207A.—Halsted's improved band roller: The instrument shown in full length is unloaded; in the abbreviated cut the band is about to be expelled from the roller (Halsted).

heart permits, the pulse may be abolished, but even then a small amount of blood continues to flow through the constricted area. In certain cases of cardiac disease even this degree of occlusion is not admissible (Halsted, Ibid.).

In a more recent study ("Jour. Exper. Med.," 1916, xxiv) Halsted maintains that the intimal surfaces brought into gentle contact by a band or ligature do not unite. The arterial surfaces under the band atrophy because they are deprived of blood. The arterial wall dies, and necrotic tissue is organized or substituted, blood-vessels entering both ends. Absorption of the necrotic wall is proceeding during the vascularization.

If an artery be occluded partially by a band it may develop a circumscribed dilatation distal to the seat of constriction. This will not happen if the artery be either very slightly or completely occluded. A like condition may develop in the subclavian in a case of cervical rib. Halsted ("Jour. Exper. Med.," Sept., 1916) studied the reports of 716 cases of cervical rib and found that in 27 or more of them dilatation existed. Animals tolerate gradual occlusion very well indeed.

Halsted has made numerous experiments on dogs and has used the band with encouraging results on the human being (partial occlusion of the innominate, twice; common carotid, four times). In a case of aneurysm of the abdominal aorta Halsted partially occluded the aorta near the diaphragm. Seventeen days later he placed another band on the aorta below the aneurysm. The patient lived twenty-four days after the second operation. The operation checked the growth of the aneurysm and

arrested pain ("Trans. Amer. Surg. Assoc.," 1909–10). In another case of abdominal aneurysm Halsted put a band on the aorta above the renals. Seventeen days later Finney inserted wire into the aneurysm. The patient lived forty-five days after the first operation (Ibid.).

In preparing the band for application it is rolled by means of the instrument shown in Fig. 207A. It is well to fasten the band with a silver ligature after application. The ligature prevents unrolling (Ibid.).

Treatment After Operation for Aneurysm.—After operating for aneurysm of an extremity by excision, by the ligature, by sutures or by a band, elevate the limb slightly, keep it warm by wrapping in cotton and surrounding with bags of warm water. The old plan was to give arterial sedatives to allay arterial excitement which was feared might loosen the ligature. To lower blood-pressure lessens the activity of the collaterals, and the less active the collaterals, the greater the danger of gangrene. So arterial sedatives are not to be given. When gangrene of a limb follows ligation, await a line of demarcation, and when it forms, amputate. Rupture of the sac after ligation may produce gangrene or be associated with suppuration, the first condition demanding amputation; the second, incision for drainage.

Other Methods of Treatment of Aneurysm.—*Injection of coagulating agents* into the sac (ergot, perchlorid of iron, etc.) is very dangerous and is to be utterly condemned. It may lead to suppuration, gangrene, rupture, or embolism.

Manipulation to break up the clot was suggested by Sir Wm. Fergusson and has been practised by some. The object aimed at is to have a fragment of clot block up the vessel upon the peripheral side of the artery and act like a distal ligature. The method is dangerous, especially in carotid aneurysm, and should never be employed.

Amputation, instead of distal ligation, has been performed in some perilous cases of subclavian aneurysm.

Electrolysis.—An attempt may be made to coagulate at once the blood in the sac, or from time to time an endeavor may be made to produce fibrinous deposits, but the first method is the better. Pulsation is for a time abolished, but usually recurs as the gas present is absorbed. Use the constant current. Take from 3 to 6 cells which stand in point of size between those used for the cautery and those used for ordinary medical purposes. A platinum needle is attached to the positive pole and a steel needle to the negative pole, each needle being insulated by vulcanite at the spot where the tissues would touch it. The asepticized needles are plunged into the sac where it is thick, and they are kept near together. The current is passed for a variable period (from half an hour to an hour and a half). This operation is not dangerous. Pressure stops the bleeding. Electrolysis may ameliorate and sometimes greatly improves aortic aneurysms.

Acupuncture consists in the introduction of a number of ordinary sewing needles partially into an aneurysmal sac and in leaving them in it for five or six days or more. Professor Macewen introduces a needle, and with it irritates the interior of the sac of an aneurysm, hoping thus to cause deposition of leukocytes, thickening of the sac, and clot formation.

Introduction of Wire.—This operation is performed by inserting into the sac a hypodermic or small aspirating needle, and pushing in through the needle or cannula a considerable quantity of aseptic gold and platinum wire, which is allowed to remain permanently. Wiring is used for aneurysms otherwise inoperable. Electrolysis should be combined with the introduction of wire. Wiring was first proposed by Moore, of London, in 1864. The details were improved by Corradi in 1879. Loreta and Barwell both inserted wire into an aneurysm before Corradi, but Corradi inserted wire and also used electricity. The first American wiring operation was performed by Ransohoff in 1886. Corradi's operation can be used when distal ligation cannot be carried out, and can be used even when the vessel is extremely atheromatous. It finds its chief use in aneurysms of the thoracic aorta and innominate. In some cases of abdominal aneurysm the belly has been opened and the operation carried out. It is used for sacculated, never for fusiform, aneurysms. The operation has not many elements of danger. Sepsis would inevitably cause death. If the wire is carried on into the aorta and heart, death will follow. A cause of death is embolism. In one of Finney's cases gangrene of the arm resulted from embolism. Too strong a current may cause sloughing of the aneurysmal wall. The wall of the aneurysm may rupture because of deviation of the strong blood-current in another direction. Some cases have been notably improved. The operation is performed with aseptic care. If the thoracic aorta is to be operated upon, an anesthetic is not required. If the abdominal aorta is to be wired,

the patient must be anesthetized because the abdomen needs to be opened. The wire used must have been previously drawn, so that it will easily pass through a hypodermic needle and will coil up spirally within the sac. The best wire is of platinum and gold. A special reel is used to keep the wire from getting kinked. It is a great mistake to introduce a large quantity. Stewart decided that a globular sac 3 inches in diameter required from 3 to 5 feet, and a sac 5 inches in diameter required from 8 to 10 feet. A hollow needle, insulated up to $\frac{1}{4}$ inch of the point, is carried into the interior of the aneurysm through a fairly thick portion of the sac. The shoulder of the needle is not insulated and must not be permitted to touch the skin, because if it did so it would cause a burn by electrolysis. The required amount of wire is introduced. The wire is attached to the positive pole of the battery. The negative pole is fastened to a large flat piece of clay or a pad of moistened absorbent cotton, and the negative electrode is placed upon the back or abdomen. The current is turned on gradually until the necessary strength is obtained (40 to 80 ma.). When ready to terminate the operation the current is lowered gradually to zero, the needle is withdrawn, the wire is cut off close to the skin, the end is pushed under the skin, the puncture is covered with iodoform collodion, and pressure is applied to keep blood from gathering in the tissue. Such a hematoma might cause the formation of a slough. The entire operation requires from three-quarters of an hour to one and a half hours. A clot forms with considerable rapidity and expansile pulsation may lessen or cease. It requires from a number of days to several weeks for the clot to become hard. The operation can be repeated if necessary. Subcutaneous injections of gelatin, made at a distant point after wiring, may be beneficial. Rest is imperative for months after wiring.

Notable improvement is common, but genuine cure is not obtained. As Hare says, "adjacent tissues of the vessel sooner or later give way, because the effort is like an effort to mend a rotten hose; though mended at one spot it breaks at another." One of Jones's cases remained well for six years and then pain recurred. The operation causes prompt and marked diminution of pain, an amelioration usually spoken of by the patient before he leaves the operating table. In 2 of my cases pain, which had been severe, disappeared completely during the operation. "Dyspnea is also benefited and just as rapidly" (H. A. Hare in "Therapeutic Gazette," April, 1908). Finney ("Annals of Surgery," May, 1912) reported 23 cases (mostly thoracic, some abdominal). Of these cases only 2 were known to be living at the time of the report.

Treatment of Diffuse Aneurysm (Ruptured Aneurysm).—In the neck and subclavian region, extirpation. In the limbs, Matas's operation or extirpation. In such a case the surgeon works on a diseased artery, and an angiorrhaphy is not applicable.

Diffused Traumatic Aneurysm (*Traumatic Arterial Hematoma*).—This condition has been called *pulsating hematoma*. There is no true or complete sac. A diffused traumatic aneurysm is caused by a wound in an artery, blood flows into the tissues. Wounds of healthy arteries causing diffused aneurysm are due to stabs or bullet wounds and are particularly common in war. Vessel injuries were common in the World War and a considerable number of cases of diffused aneurysm were operated upon. Wounds from pointed bullets constitute the chief cause. Shell fragments are causal much less commonly. In these cases there is no true sac, but the false sac is composed of blood-clot, compressed muscle, fascia, and inflammatory exudate. There may be one small opening in an artery, there may be two, there may be a longitudinal wound, a transverse wound, or a complete division. The vein may also be wounded or destroyed. Blood flows into the tissues and separates them. In some cases the flow is slight and it occasionally though seldom happens that the arterial wound closes and heals. In nearly all cases the hemorrhage continues. In some cases it is profuse, separating the tissues widely and perhaps even stripping up the periosteum. In most cases the hemorrhage from the surface wound is moderate or even trivial. There is much danger of secondary hemorrhage.

In a typical case pain is severe—there is swelling and coldness of the extremity below the wound—absence of pulse at the periphery—an oblong, fluctuating, and pulsating swelling now forms and increases in size progressively. On auscultation a bruit is detectable.

The skin at first is of a natural color, but later becomes thin and purple. Blood may trickle, flow, or even pour from the surface wound. Many cases reported in the World War deviated far from the above description. In many cases swelling is very slow in forming and pulsation is a late but not an early symptom. Auscultation may afford the only sign of the nature of the injury. Hence the rule is imperative

that auscultation must be used in every doubtful case. In battle this study is made in the first dressing station or in the field hospital.

Treatment.—The operation is seldom one of emergency. It must be if bleeding is dangerously severe and increasing or if there is infection. Infection is rare unless there is lodgment of a shell fragment, a bullet, or bit of clothing.

The limb must be immobilized for transportation to the base.

The best period for operation in most cases is the end of the third week. The collaterals are then, as a rule, at their best. Later, as the aneurysm increases, the collaterals will become less efficient. Test the collaterals before operating (page 373). If dealing with an extremity, empty the limb of blood by applying an elastic bandage up the lower border of the aneurysm, apply an Esmarch band above, make a free incision into the aneurysm, and turn out the clots. It may be possible to suture the wound in the artery. If the wound is small, it should be done. If sutures greatly constrict the arterial lumen, they should not be used. Some military surgeons advocate resection of the damaged area of the artery and end-to-end suture, or, if the space between the ends is too extensive, grafting in of a piece of resected vein (see the Ideal Operation, page 373). If lateral sutures are not applicable most American surgeons prefer to do a Matas operation, or, to tie the artery on each side of the tear, open the sac, and pack it (the operation of Antyllus), but Matas's operation is the preferable procedure. Some surgeons prefer to tie the vessel on each side of the rupture and excise the intervening portion. If the main vein is also ruptured, suture the vessels if possible. If suture is impossible, apply ligatures. In some complicated cases of grave injury amputation is necessary. In a few cases gangrene results and amputation becomes necessary, but as the wounded artery is healthy and the collaterals of youth are active gangrene among soldiers from this cause has been rare.

If a bullet or bit of clothing is lodged, the foreign body must be removed and the wound treated as an infected wound. In a diffused traumatic aneurysm of the iliac, the subclavian, or the carotid, it seems possible that extirpation is the preferable operation.

Arteriovenous aneurysm was first described by Wm. Hunter in 1757. By this term we mean an unnatural passageway between a vein and an artery or an artery and a dural sinus (pulsating exophthalmus), through which passage blood circulates. There are two forms: (*a*) *aneurysmal varix*, or *Pott's aneurysm* (arteriovenous fistula), a vein and an artery directly communicating (Fig. 209); and (*b*) *varicose aneurysm*, a vein and an artery communicating through an intervening sac. These conditions arise usually from punctured, bullet, or stab wounds, the instrument passing through one vessel and into the other, blood flowing into the vein, the subsequent inflammation gluing the two vessels together, and the aperture failing to close (aneurysmal varix, Fig. 209). After the infliction of the wound the two vessels may separate; the blood continuing to flow from artery into vein, and the blood-pressure, by consolidating tissue, forming a sac of junction (varicose aneurysm, Fig. 210). Wounds produced by small pointed bullets not infrequently result in arteriovenous aneurysm. Out of 102 cases of war aneurysm reported by Bier 56 were arteriovenous ("Internat. Abstract of Surgery," Oct., 1915). Aneurysmal varix is a less grave disorder than varicose aneurysm. Arteriovenous aneurysm used to be most frequent at the bend of the elbow, the vessels being injured during venesection. The condition may occur in the neck, the axilla, the extremities, or the groin. I assisted Professor Keen in an operation upon an aneurysmal varix of the common carotid and internal jugular vein, and assisted Professor Hearn in operating on a varicose aneurysm involving the external iliac vessels. I operated successfully on a case involving the popliteal vessels. Quénu operated on an arteriovenous aneurysm of the common carotid artery and jugular vein and collected 17 cases from literature. Sir Frederick Treves operated on a case involving the internal maxillary vessels. Very rarely an arteriovenous aneurysm forms spontaneously. Spontaneous arteriovenous aneurysm is most frequent between the aorta and vena cava. There is no tendency to spontaneous cure in arteriovenous aneurysm. Edema is the rule, muscular atrophy is common, ulceration or even gangrene of a limb may occur. In arteriovenous aneurysm the artery on the proximal side of the fistula dilates. In many reported cases the condition of the artery has not been noted. Halsted has found proximal dilatation noted in 52 cases. The distal segment shrinks and the arterial blood-supply to the periphery is greatly lessened. Matas has collected 17 cases of arteriovenous aneurysm of the subclavian vessels ("Transactions of Amer. Surg. Assoc.," vol. xix). In this list is the celebrated case of his own, a traumatic (gunshot) arteriovenous aneurysm, in which cure followed operation; in the operation it was necessary to obliterate the artery by ligatures, but the venous orifice was closed by sutures

without obliterating the lumen of the vein. In the analysis of Matas's paper 15 cases are used, 2 having been noted too late for incorporation; 9 of the cases resulted from "stab or penetrating cut wounds," 6 from bullets—in 5 of the cases the brachial plexus was injured. In 8 out of the 11 unoperated cases the time after the injury, when symptoms of arteriovenous aneurysm were noted, is stated; in 1 signs were definite within four hours, in 3 they were noted on the second day, in 3 on the third day, in 1 on the sixth day, in 1 on the eighth day, in 1 on the ninth day, and in 1 a few days later. In 3 of the 15 cases secondary hemorrhage followed the injury. Eleven of the 15 cases were treated expectantly; 1 died from secondary hemorrhage and sepsis three weeks

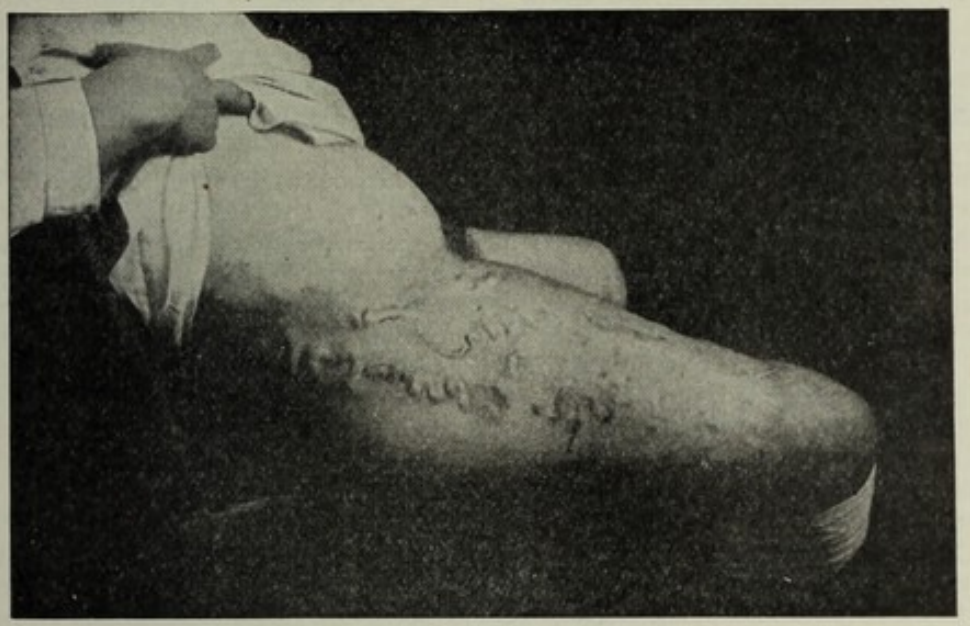


FIG. 208.—Dilatation of veins in arteriovenous aneurysm of the femoral vessels.

after the injury and 10 "survived the immediate effects of the injury, their wounds healing after the cessation of the primary hemorrhage."

In 4 of the 15 cases operation was performed. In 3 the operation was done soon after the injury because of violent secondary hemorrhage. In 1 (Matas's own case) operation was done deliberately to prevent complications. Three of these cases recovered (including Matas's); 1 died of renewed secondary hemorrhage on the twenty-fourth day after operation. Matas points out the fact that in stab wounds of the subclavian vessels the largest proportion of cases die of primary hemorrhage before assistance is obtained, but in a considerable number of cases temporary hemostasis occurs, which is followed by secondary hemorrhages or arteriovenous aneurysm.

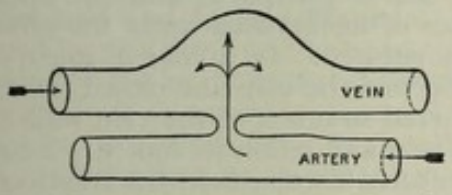


FIG. 209.—Plan of aneurysmal varix (arteriovenous fistula).

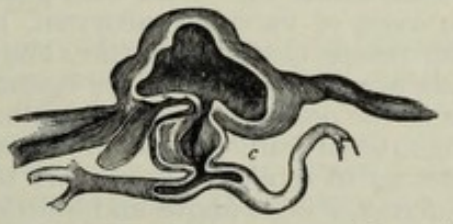


FIG. 210.—Varicose aneurysm (Spence).

Symptoms.—The arterial blood is cast forcibly into the vein, and as a consequence the vein becomes enlarged, tortuous, and thickened. The scar of a wound is almost invariably apparent. At the seat of vascular trouble the most marked dilatation exists and it is of bluish color. The swelling pulsates markedly, and imparts a sensation to the finger like that felt when the hand is laid upon the back of a purring cat. This thrill or vibration is very characteristic. A sound of a hissing or buzzing nature can be easily heard. The swelling at once disappears on pressure being made upon it or on the artery between it and the heart. It is diminished in size by raising the limb, is increased in size by a dependent position of the limb, and by compressing the vein between the heart and the tumor. The adjacent veins are dilated and often the dila-

tation is manifested over a wide area above and below (Fig. 208), and the thrill and bruit are transmitted a considerable distance. If an extremity is involved, it is usually edematous. The parts, as a rule, are painful. The condition progresses, but very slowly, and sometimes years may elapse without any notable aggravation. If pressure is made upon the fistula or on the artery proximal to it, so as to keep blood from entering the vein, the pulse-rate at once lessens 20 to 40 beats a minute and the patient becomes faint. This was pointed out by Brauham and is called the *Brauham bradycardiac phenomenon*. The sudden relief of back pressure upon a heart hypertrophied from prolonged pressure explains the phenomenon.

In varicose aneurysm we find many of the symptoms of aneurysmal varix, but in varicose aneurysm pressure over the artery of supply between the heart and the lesion does not cause the entire disappearance of the swelling; the veins collapse, it is true, but a distinct sac remains, which may be emptied by direct pressure.

Treatment.—The prognosis after operation is better than in ordinary aneurysm, but, nevertheless, some surgeons refrain from operating so long as the condition is not progressing obviously, is borne without inconvenience, and is not leading to complications. Matas voices the radical view: "The effects of short-circuiting the arterial current into the venous system when a fistula is created in one of the great vascular tracts is to overtax and finally cripple the heart after a variable period of hypertrophic compensation. In addition to the disabling effects of the varicosities and ulcers which develop on the extremities and other well-known trophic lesions caused by arterial anemia, the graver but less known dilatation and progressive organic changes in the leaking artery on the cardiac side of the fistula, so well demonstrated by W. S. Halsted and his pupils, have changed the traditional benign character with which arteriovenous aneurysms have been credited in the past. The secondary and disabling cardiopathies which recent clinical and experimental evidence have brought to light suffice to justify the more aggressive attitude of modern surgery toward these aneurysms at the present time" (Matas in "Touro Record File," No. 83633). If we refrain from operating upon aneurysmal varix the patient should wear a support; but if the part becomes painful or if there seems to be danger of rupture of the vein, operation should be performed. Ligation of the artery alone is not to be practised. In half of the cases in which this was done in the South African War gangrene followed. In such a case blood from the collaterals does not reach the periphery, but soon returns to the vein, as such a course is the line of least resistance. If the vein is also ligated, the danger of gangrene is lessened materially. Until recently, when operation was indicated, surgeons advised that each vessel should be tied above and below the opening and a portion of each vessel should be excised, the excised area including the opening (the quadruple suture with excision). In varicose aneurysm it was the custom to tie each vessel above and below the sac, and excise the sac with a portion of vessel. In 36 cases of arteriovenous aneurysm Bier resected the damaged portion of the artery and united the ends of the divided trunk by circular sutures. At the present American surgeons prefer the Matas operation for both varicose aneurysm and aneurysmal varix. The operation of choice is to open the vein, suture the fistula with paraffined silk, and close the wound in the vein. In some cases of varicose aneurysm, however, the sac is extirpated and the openings in the vessels closed by suture, and in some cases of aneurysmal varix the adherent vessels are separated and the opening in each is sutured. In a case of aneurysmal varix of the popliteal due to a gunshot wound, I opened the vein and closed the fistula in the arterial wall. In accomplishing this I gathered so much of the vein wall in the sutures as to render it impossible to suture the vein and retain its lumen. I cut the vein across, a little above and a little below the sutured fistula, used the trapdoor-like piece of vein to reinforce the arterial suture line, and did end-to-end anastomosis of the vein ends. The result was a complete success ("Annals of Surgery," April, 1912).

I attempted a similar operation on a varicose aneurysm of the brachial in the middle of the arm. I found that the superior profunda also ran into the sac, and that a saccular aneurysm had formed on the brachial a little below the varicose aneurysm. I was obliged to ligate the profunda and tie the artery and vein above and below before extirpating the aneurysm. I feared gangrene, but, fortunately, the patient escaped it. Before doing any operation test the collaterals and, if necessary, endeavor to develop them (p. 373).

Cirsoid Aneurysm, or Aneurysm by Anastomosis.—Cirsoid means varix like. It is a condition in which there are several or many communications between arteries and veins. As Elkin says ("Annals of Surgery," Sept., 1924) it "resembles an arteriovenous fistula with the difference that in the latter condition the communication is

usually (though not invariably) single, whereas in the true cirsoid the communications are multiple." The anastomoses between the vessels may be the result of developmental defect or may arise in a cavernous angioma. The veins are enormously dilated, pouched, and tortuous. The arteries, too, are dilated and tortuous, but not to such a great degree as the veins. The vessels tend to rupture. Cirsoid aneurysm is most commonly met with upon the forehead and scalp of young people, where it sometimes takes origin from a nevus. It is sometimes seen upon the back or upper extremity. The cause is unknown. Usually there is no assignable cause, but occasionally the condition follows an injury. Pregnancy causes a cirsoid aneurysm to grow rapidly, and so usually does the onset of puberty. Occasionally some of the enlarged vessels fuse and form a great cavity. If rupture occurs, desperate hemorrhage ensues.

Symptoms.—There is a pulsating mass, irregular in outline, composed of dilated, elongated, and tortuous vessels that empty into one another. The mass is soft, can be much reduced by direct pressure, and is diminished by compression of the main artery of supply. A thrill and a bruit exist.

Treatment.—In treating a cirsoid aneurysm the ligation of the larger arteries of supply is a wretched failure. Subcutaneous ligation at many points of the diseased area has affected cure in some cases, but it has failed in more. Direct pressure is also entirely useless. Ligation in mass has been successful. Destruction by caustic has had its advocates. Electropuncture with circular compression of the arteries of supply has once or twice effected a cure. Injection of astringents has been recommended. Verneuil ligated the afferent arteries, incised the tissues around the tumor, and sank a constricting ligature into the cut. The proper method of treatment is excision after exposure and ligation of every accessible tributary supply. In a very

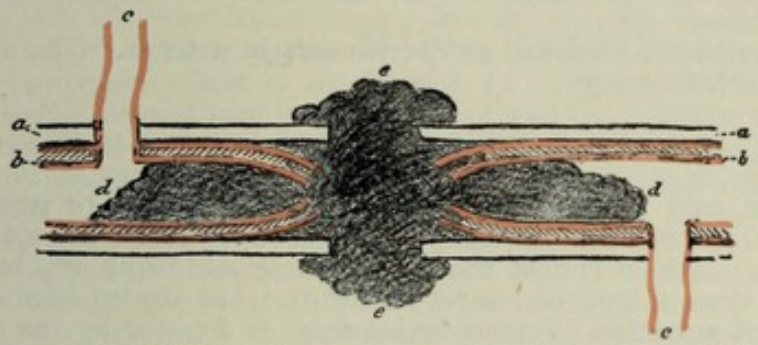


FIG. 211.—Clots formed after division of an artery: *a*, Sheath; *b*, outer, middle, and inner coats; *c*, *c*, branches; *d*, *d*, internal clot; *e*, *e*, external clot.

extensive mass extirpation is impossible; hence one of the other methods suggested must be employed. A very considerable mass may be excised, and the resulting wound should be covered with Thiersch skin-grafts.

Wounds of arteries are divided into contused, incised, lacerated, punctured, and gunshot wounds, and vascular ruptures.

Contused and Incised Wounds.—A contusion may destroy tissue vitality and be followed by sloughing and hemorrhage. A contusion may rupture a blood-vessel, and is especially apt to do so if the vessel is diseased. Blood is at once effused at the seat of rupture. If an artery is ruptured, there may or may not be pulsation over the seat of rupture, a distinct bruit is usually heard over the seat of injury, pulse is absent below, and the limb below the injury swells and becomes cold. The rupture of a large vein is followed by a blood tumor, which does not pulsate and has no bruit, and the limb below becomes intensely edematous. Gangrene is apt to follow the rupture of the main blood-vessel of an extremity. A contusion may rupture the internal and middle coats of an artery, the external coat remaining intact. When this happens the internal coat curls up and the middle coat contracts and retracts, the blood-stream is arrested, and a large clot forms within the artery. If the clot blocks up many collaterals, gangrene may follow, and, as has been pointed out, the gangrene will not be preceded by great swelling at the seat of injury, which always occurs if a vessel is ruptured. A contused wound may do little damage, may produce gangrene from thrombosis, or may cause secondary hemorrhage. In an incised wound of an artery there is profuse hemorrhage. The artery after a time is apt to contract and retract, bleeding being thus arrested. A transverse wound causes profuse bleeding, but there is a better chance for natural arrest than in an oblique or in a longitudinal wound. The clot which

forms within a cut artery is known as the "internal clot." It used to be taught that the internal clot always reaches as high as the first collateral branch, and subsequently is replaced by fibrous tissue, which permanently obliterates the vessel, and converts it into a shrunken fibrous cord. As a matter of fact, when the parts are aseptic after a ligation the clot is rarely bulky and is often very scanty, repair being quickly effected by proliferation of endothelial cells. Between the vessel and its sheath, over the end of the vessel, and in the surrounding perivascular tissues the "external clot" forms (Fig. 211).

A **lacerated wound** of an artery may cause little primary hemorrhage. The internal coat curls up, the circular muscular fibers of the media contract upon it, the longitudinal fibers retract and draw the vessel within the sheath, and the external coat becomes a cap over the orifice of the vessel. All of these conditions favor clotting. The vessel wall is so damaged that secondary hemorrhage is usual.

Punctured Wounds.—In punctured wounds primary hemorrhage is slight unless a large vessel is punctured. Secondary hemorrhage is not common. Traumatic aneurysm and arteriovenous aneurysm are not unusual results.

Gunshot wounds of arteries by pistol balls and the balls of large-caliber rifles are apt to be contusions which may eventuate in sloughing and secondary hemorrhage or thrombosis and gangrene. A shell fragment makes a lacerated wound. A military rifle bullet may make a cut or puncture of an artery, but if the projectile is nearly spent may contuse the vessel. Secondary hemorrhage after gunshot wounds is most likely to occur during the third week after the injury. A cut or perforation of an artery may cause sloughing and secondary hemorrhage, thrombosis and gangrene, or diffused traumatic aneurysm. A complete rupture constitutes a lacerated wound, and is a condition accompanied by diffuse hemorrhage into the tissues. Such a hemorrhage may be rapid or slow.

Wounds of veins are classified as are wounds of arteries. The symptom of any vascular wound is hemorrhage.

Hemorrhage, or Loss of Blood

Hemorrhage may arise from wounds of arteries, veins, or capillaries, or from wounds of the three combined. In arterial hemorrhage the blood is scarlet and appears in jets from the proximal end of the vessel, these jets being synchronous with the pulse-beats; the stream, however, never intermits. The stream from the distal end is darker and is not pulsatile. Venous hemorrhage is denoted by the dark hue of the blood and by the continuous stream. In capillary hemorrhage red blood wells up like water from a squeezed sponge, and the color is between the bright red of arterial blood and the dark color of venous blood.

In *subcutaneous hemorrhage* from rupture of a large blood-vessel there are great swelling, cutaneous discoloration, and systemic signs of hemorrhage. If a main artery ruptures in an extremity, there is no pulse below the rupture, and the limb becomes cold and swollen. At the seat of rupture a large fluctuating swelling forms, usually there is bruit, and often pulsation. If a vein ruptures in an extremity, a large, soft, non-pulsatile swelling arises, there is no bruit, and intense edema occurs below the seat of rupture. Profuse hemorrhage induces constitutional symptoms, and death may occur in a few seconds. Loss of half of the blood (from 4 to 6 pounds) will usually cause death, though women can stand the loss of a greater relative proportion of blood than men. Young children, old people, individuals exhausted by disease, drunkards, sufferers from Bright's disease, diabetes, and sepsis stand loss of blood very badly. An individual with *obstructive jaundice* is apt to suffer from persistent oozing of blood after operation, an oozing which is particularly persistent and dangerous in obstruction of the bile-ducts due to malignant disease. It not unusually causes death. After profuse bleeding has gone on for a time, syncope usually occurs. Syncope is nature's effort to arrest hemorrhage, for during this state the feeble circulation and the increased coagulability of blood give time for the formation of an external clot. When reaction occurs the clot may hold and be reinforced by an internal clot, or it may be washed away with a renewal of bleeding and syncope. These episodes may be repeated until the patient dies in syncope. Nausea exists and there may be regurgitation from the stomach. Vertigo is present. The room may seem to be turning around. There is dimness of vision or everything looks black; black specks float before the eyes (muscæ volitantes), or the patient sees flashes of light or colors. There is a roaring sound in the ears (tinnitus aurium). The patient yawns, is restless, tosses to and fro, casts

off the bedclothes, and complains of great thirst. The mind may be clear, but delirium is not unusual, and convulsions often occur. After a very severe hemorrhage an individual is intensely pale and his skin has a greenish tinge; his lips are blanched, the tongue is cold and white; the brow is covered with cold moisture, the breath is cold; the eyes are fixed in a glassy stare and the pupils are widely dilated, and react slowly to light; the respirations are shallow and sighing; the skin is covered with a cold sweat; the hands are clammy and look like wax; the legs and arms are extremely cold, and the body temperature is below normal. The pulse is very frequent, soft, small, compressible, fluttering, or often cannot be detected; the heart is very weak and fluttering, and the arterial tension is almost abolished. There is muscular tremor; the patient tosses about, and asks often and in a feeble voice for water. The suffering from thirst is terrible and no amount of water gives relief. There is often dreadful dyspnea; at each inspiration the nostrils open widely and the accessory muscles of respiration are all in action. A man who is bleeding to death grasps at his chest, makes efforts to rise, and then falls back in a dead faint. Usually reaction occurs after a faint, though the patient is obviously weaker than before; again a faint may happen, and so there is fainting spell after fainting spell until death ensues. Convulsions frequently precede death. In hemorrhage the hemoglobin is greatly diminished in amount. In an *intra-abdominal hemorrhage* the above symptoms are noted, and, except in splenic hemorrhage, blood gathers in both loins, and dulness on percussion exists which gradually rises and shifts as the patient's position is shifted. The blood also gathers in the rectovesical pouch in the male, and in the recto-uterine pouch in the female, and may be detected by digital examination. If the spleen is wounded the blood usually clots quickly, and if it does, an area of dulness, which does not shift and which progressively increases, is noted in the splenic region.

Treatment.—When serious hemorrhage exists the surgeon should, when possible, arrest bleeding temporarily, and should then bring about reaction and arrest bleeding permanently. Temporary arrest is not possible in an intra-abdominal hemorrhage. In any case of severe hemorrhage lower the head, and have compression made upon the femorals and subclavians, so as to divert more blood to the brain, and bandage the extremities (autotransfusion). Apply artificial heat. The value of adrenalin in restoring or maintaining arterial tension has been demonstrated by Crile. We should give the patient by hypodermoclysis 1 pint of hot normal salt solution containing 1 dr. of the 1 : 1000 solution of adrenalin chlorid. The fluid is allowed to run in the subcutaneous tissue beneath the breast. The infusion of 1 pint or more of hot salt solution into a vein is a very valuable remedy; it gives the heart something to contract upon and thus maintains cardiac action. If the depression is very severe, inject ether hypodermically, then brandy, and then atropin. Strychnin may be given hypodermically in doses of 1/20 gr., but atropin is of more service. Digitalin is advised by some, but it is not sufficiently rapid in action. Give enemata of hot coffee and brandy. Apply mustard over the heart and spine. Lay a hot-water bag over the heart.

In hemorrhage from a vessel of an extremity temporarily arrest bleeding while bringing about reaction. Do so by digital pressure in the wound, or, if the bleeding be arterial, by the application of an Esmarch band. In some cases forced flexion is used. As soon as reaction is established, permanently arrest bleeding by the ligature. In intra-abdominal or concealed hemorrhage it is not possible to arrest it temporarily and wait for reaction, but the abdomen must be opened and the work proceeded with in spite of the patient's condition. Every moment we wait he is growing worse.

A severe hemorrhage is apt to be followed by fever, due to the absorption of pyrogenous materials from extravasated blood and its action upon a profoundly debilitated system. After a severe hemorrhage leukocytes are increased not only relatively, but absolutely. Red corpuscles are diminished both relatively and absolutely. Hemoglobin diminishes; many of the corpuscles become irregular and microcytes are noticed.

In treating a patient who has thoroughly reacted after a severe hemorrhage, apply cold to the head. Fluids and ice are grateful. Frequently sponge the skin with alcohol and water. Milk-punch, koumiss, and beef juice are given at frequent intervals.

Hemostatic agents comprise: (1) the ligature and suture; (2) torsion; (3) acupressure; (4) elevation; (5) compression; (6) styptics; (7) the actual cautery; (8) forced flexion of a limb.

The *ligature* was known to the ancients, but was rediscovered by Ambroise Paré. "Ligature of blood-vessels was known in the days of Hippocrates, Celsus, Galen, and Paulus Ægineta, but they were not confident of its utility, and it remained for

Ambroise Paré to show that the ligature was the proper means to apply in the practice of amputation. Before the days of Paré the surgeon removed a limb with reluctance,

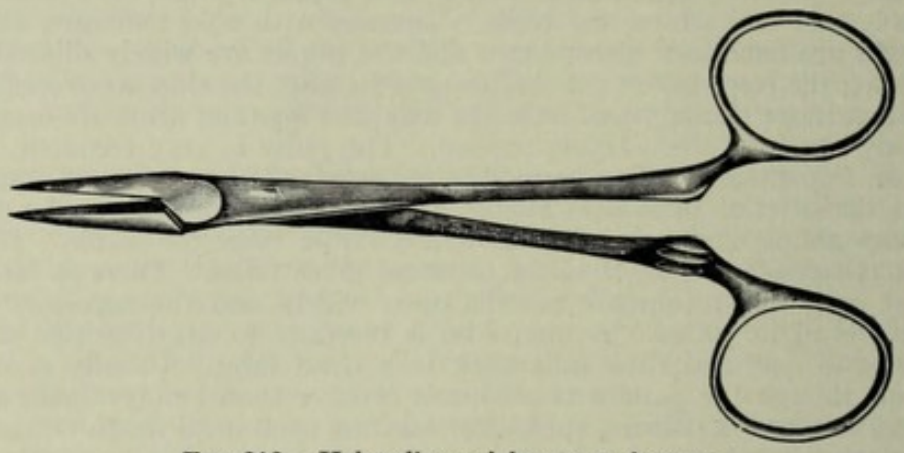


Fig. 212.—Halsted's straight artery forceps.

for he doubted his ability to arrest hemorrhage, because they looked to the red-hot iron, or to the styptic, as their chief help, but Paré, having many times employed the ligature in recent wounds, determined to apply this means in case of amputation

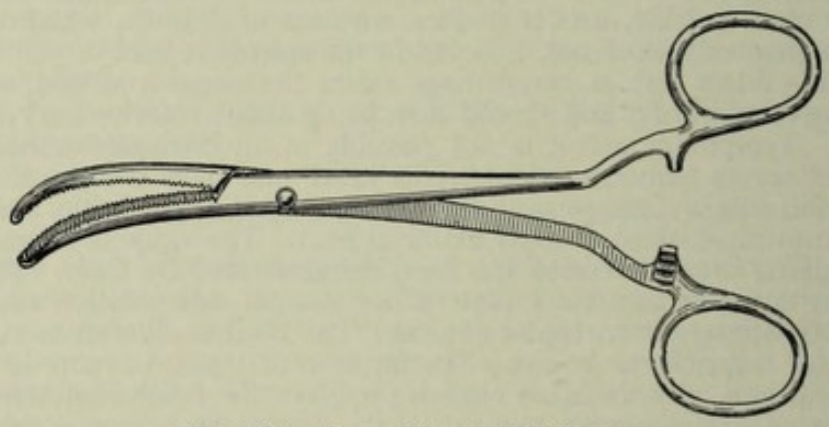


Fig. 213.—Curved hemostatic forceps.

of a limb, and has earned a niche among the immortals for his work" ("Lawson Tait, his Life and Work," by Stewart McKay). Paré used spring forceps, catching on closing, to grasp and hold the vessel during ligation. Early users of the ligature soon

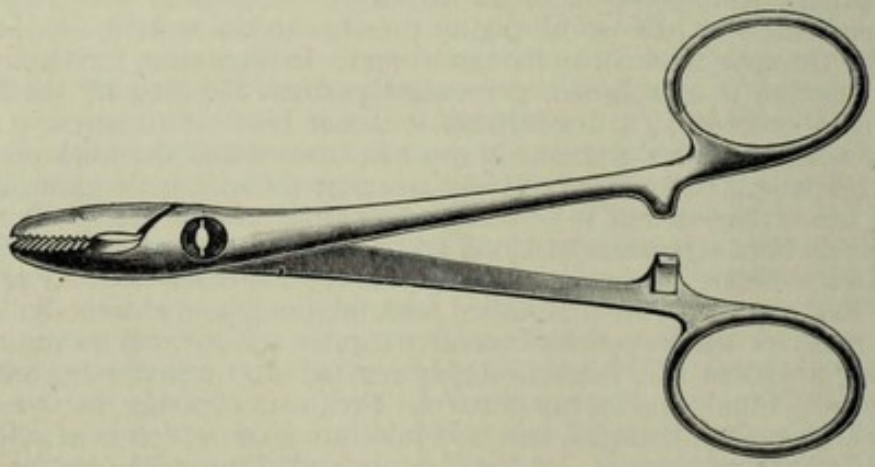


Fig. 214.—Straight hemostatic forceps.

discovered that it was better to use the immediate ligature (tying the vessel alone) than the mediate ligature (enclosure of the vessel and some surrounding tissue in the string). The ligature may be made of silk, floss-silk, or catgut. Whatever material

is used must, of course, be rendered aseptic. A ligature should be about 10 inches long. The vessel to be tied must be drawn out with forceps and separated for a short distance from its sheath, but must not be separated to any considerable extent; to do so may lead to necrosis of the vessel and secondary hemorrhage. The hemostatic forceps (Figs. 212–214) is in most cases a better instrument than the tenaculum (Fig. 215). Paré used forceps and Heister introduced ringed handles like those of scissors (McKay, Ibid.). The tenaculum makes a hole in the vessel, and sometimes a slit-like tear. A portion of this opening may remain back of the tied ligature, the vessel may retract a little, or the ligature may slip slightly, and bleeding may occur. When the artery lies in dense tissues or is retracted deeply in muscle or fascia, the tenaculum, when carefully used, is the better instrument. The ligature is tied in a reef knot (Fig. 216), not in a granny knot (Fig. 217) and not in a surgeon's knot (Fig. 218). It is often the purpose of the surgeon to divide the internal and middle coats of the vessel, and if such is his desire the first knot is firmly tied. The second



FIG. 215.—Tenaculum.

knot must not be tied too tightly or it will cut the ligature. The ligature must not be jerked as it is being tied. If a third knot overlies the first two, the ligature can be cut off close to the knot, otherwise it is cut off so that short ends are left. Both ends of a divided vessel should be ligated. If a vessel is atheromatous, it is not desirable to divide the internal and middle coats. In such a case a ligature should be applied firmly rather than tightly, and another ligature should be put on above it, or ligation should be effected by the stay knot. If an artery is incompletely divided, a ligature should be applied on each side of the wound and the vessel divided between the ligatures.

When the parts about an artery are so thickened that the vessel cannot be drawn out, arm a curved Hagedorn needle (Fig. 219) with catgut and pass the latter around the vessel in such a manner that the catgut will include the vessel with some of the surrounding tissue. Then tie the ligature (Fig. 221). This method is known as the application of a *suture-ligature*, and is pursued in necrosis, atheroma, scar tissue,

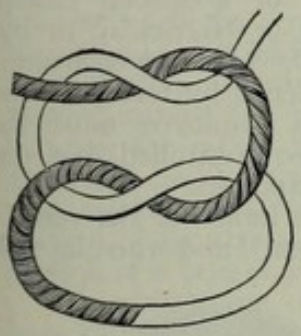


FIG. 216.—Method of tying square or reef knot.

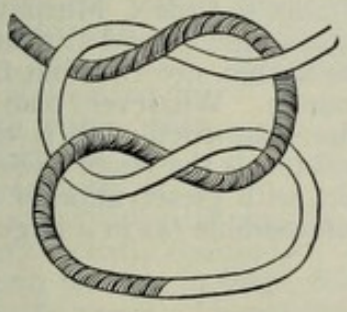


FIG. 217.—Method of tying granny knot.

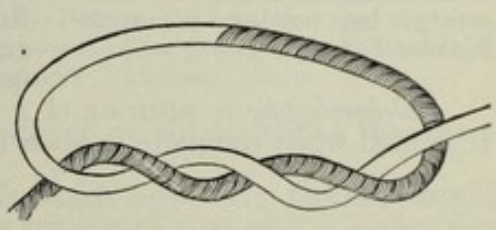


FIG. 218.—Method of tying surgeon's knot.

sloughing, etc. Never include a nerve of any size in the ligature. If this mode of ligation fails, we may try acupressure.

Doyen, when about to tie a thick pedicle, crushes it by means of a very powerful instrument and then ties a ligature about the crushed and attenuated area. The vessels are closed by laceration wide of the ligature and the ligature does not tend to slip. Some trust such a stump without a ligature, but most surgeons prefer to ligate. This instrument is known as the vasotribe or angiotribe and is used particularly in hysterectomy. Figure 222 shows a vasotribe.

Veins are ligated as are arteries. If a large vein is torn, we wish, if possible, to control hemorrhage without obliterating the lumen of the vein by ligation. If the wound is not greater in length than the measure of the diameter of the lumen, a lateral ligature may be used. It is practically always used in small transverse wounds. In order to apply a lateral ligature the two lips of the vein wound are seized by forceps

and drawn out into a tit (Figs. 220 and 242). A ligature is placed around the base of the cone and tied. The pull on the cone is relaxed while the first knot is being tied

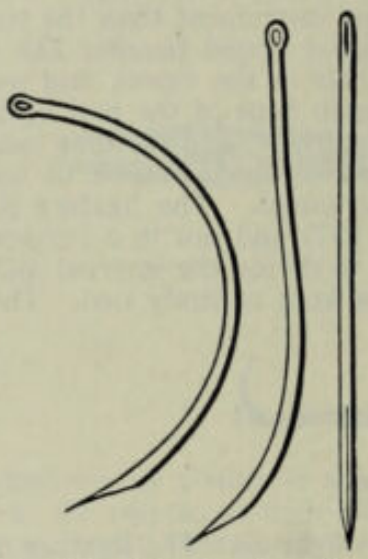


FIG. 219.—Hagedorn's needles.

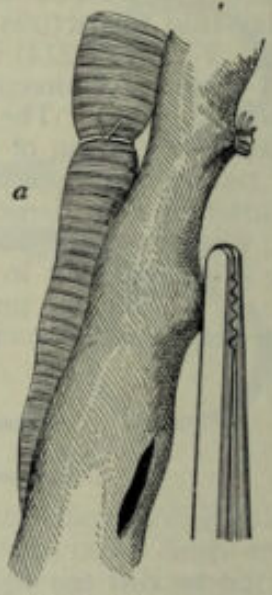


FIG. 220.—Method of controlling hemorrhage by ligature (after Esmarch): *a*, Artery ligated; *b*, lateral ligature of vein.

in order that the ligature may constrict tightly. In a large vessel the thread should be passed by a needle through the outer coats of the vein before it is used to encircle the cone. This plan prevents slipping. In some cases when a lateral ligature or suture cannot be applied, forcipressure will succeed. One or more clamp forceps are applied and are left in place for several days.

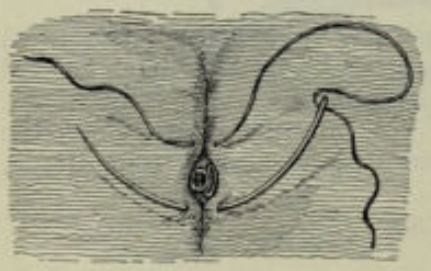


FIG. 221.—Arrest of hemorrhage by passing a suture-ligature.

Angiorrhaphy is suturing of a blood-vessel, either a vein or an artery. Temporary hemostasis is secured before suturing by the use of the elastic band (seldom), by the employment of a special clamp (Dorrance's, Crile's, Murphy's, or Herrick's), or by fine linen tape, passed around the vessel on each side of the wound, not tied, but fastened by forceps after tightening. Whatever plan is employed must be gentle. The circulation is to be controlled, but on no account is the vessel to be damaged.

Phleborrhaphy is suturing of a vein, with preservation of the lumen of the vessel. It is used when complete ligation is undesirable (as in a large vein), and when lateral

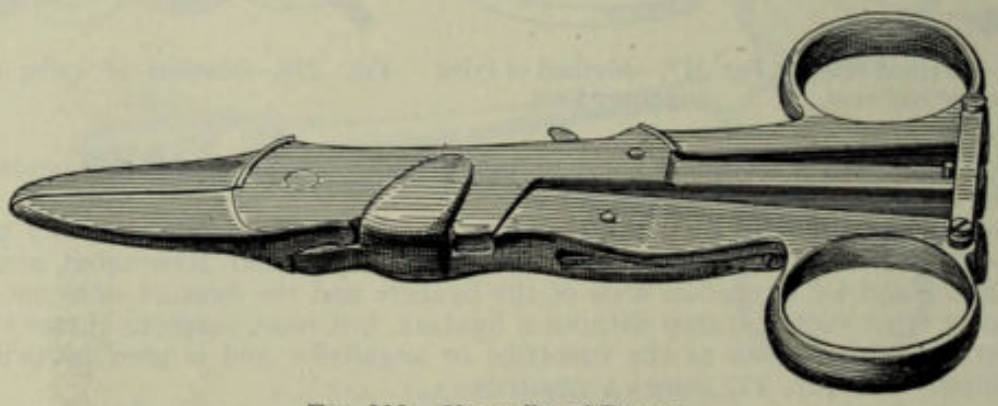


FIG. 222.—Vasotribe of Doyen.

ligation without obliteration of lumen is impossible. It is commonly employed for longitudinal wounds and for wounds in any direction when the length of the wound is not greater than half the circumference of the vessel. Fine catgut or silk may be

used. An intestinal needle threaded with paraffined or vaselined silk is entirely satisfactory. The thread is passed through the external coat and part of the middle coat on each side of the wound. Interrupted sutures are employed and thus the two lips of the wound are approximated. A vein completely divided across can be united by end-to-end suturing. Figure 223 shows the operation of phleborrhaphy for a longitudinal wound.

By suturing I successfully closed a tear in the innominate vein inflicted during the removal of a retrosternal goiter, and also a considerable longitudinal tear in the internal jugular vein inflicted during the removal of lymph-nodes.

Murphy and Damar Harrison each succeeded in suturing a wound of the inferior vena cava. Bier successfully applied sutures in 2 cases of wound of the inferior vena cava.

Israel points out how difficult it is to suture in the depths of a cavity full of blood. This complication always exists in wounds of the inferior cava, and in them it may be necessary to use forcipressure. He did this in 2 cases.

In a case of Körte's the cava was wounded during nephrectomy. Forcipressure and lateral sutures were found impracticable. The cava was tied. Thrombophlebitis arose in both legs, but the patient eventually recovered ("Zentralbl. für Chir.," Aug. 8, 1911).

Arteriorrhaphy.—As long ago as 1759 Hallowell and Lambert closed a small wound in the brachial artery by the use of a harelip pin and suture. The operation of arteriorrhaphy has only recently begun to claim surgical confidence and it has been brought into the realm of practical surgery largely by work in the experimental laboratory. The studies of Carrel, Murphy, Horsley, Matas, Abbé, and others have shown that wounded arteries can be repaired by suturing; that a portion of an artery can be removed and repair be obtained by end-to-end suturing, implantation, or lateral anastomosis; that an artery can be obliterated by suturing the intima from within; that an artery can be anastomosed into a vein, and that after resection of a portion of an artery vascular integrity may be restored by suturing into the gap a portion of a vein or artery recently resected.

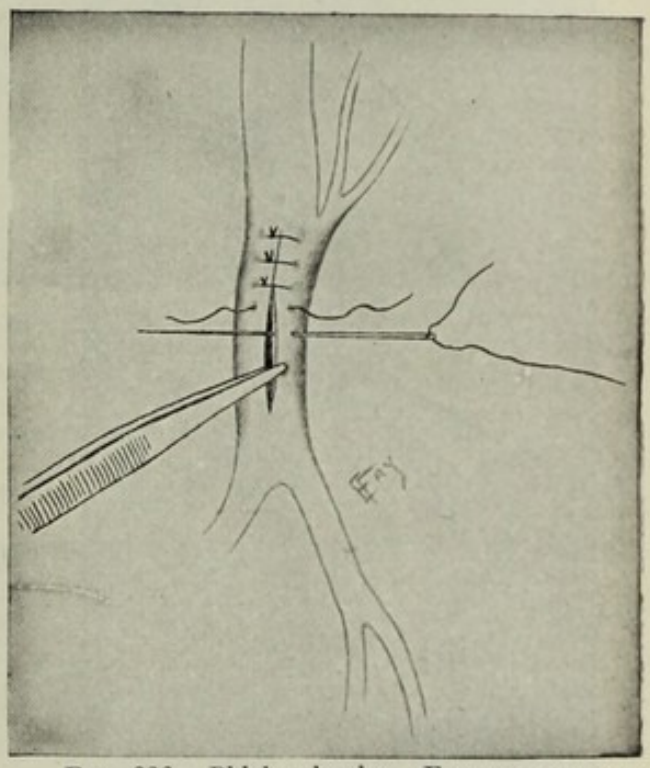


FIG. 223.—Phleborrhaphy. Forceps are seen everting lip of wound for passage of needle and interrupted sutures (Bickham).

We now suture certain wounds in large vessels which until very recently would have caused us to ligate the vessel. In extirpating malignant tumors it is sometimes necessary to remove large arteries or veins. This may cause grave danger of gangrene, and we may attempt to prevent gangrene by the restoration of vascular continuity.

The wonderful experiments of Carrel on the transplantation of organs and the brilliant studies and operations of Matas and Murphy have been the great influences that have brought vessel suture into the field of practical surgery.

There is yet much to learn. What we do know is really little, but we are probably at the threshold of great events.

We know that we can close by suture a lateral wound, or a transverse wound of less than half the circumference of the vessel; that we can perform end-to-end suturing; that we can insert a piece of resected vein to re-establish vascular continuity; that an artery can be anastomosed to a vein either by lateral anastomosis or end-to-end suturing; and that after such an operation the blood-current will in some cases be re-established. We do not know how long the circulation will continue after re-establishment. A sutured artery will certainly carry blood for a time, but in some cases, at least, only for a time, the ultimate fate of the vessel being obliteration by endothelial proliferation. If the vessel operated upon be diseased, obliteration by clot is practically certain

to ensue. But even temporary re-establishment of circulation is of the greatest value. Even though the lumen be finally closed, the closure is gradual. While the vessel is closing the collaterals are dilating. By the time one source of supply for the tissues is cut off, another has come into being. Thus gangrene is prevented. There appears to be a certain amount of danger of the development of aneurysm at the seat of suturing. In a longitudinal wound of an artery or in a transverse wound of not over half the circumference of the vessel, the wound may be closed by interrupted sutures, passing the threads through the three coats and bringing the wound edges together without inversion. Floss silk, Japanese silk, very fine Lyons silk, the celluloid hemp of Braun or No. 1 Pagenstecher thread should be used as a suture material. A very fine needle, straight or curved (No. 16) and devoid of a cutting edge, is to be employed (intestinal needle). The silk should be as large as the eye of the needle will carry, so that leaking through the stitch hole will not occur. Carrel has shown that it is highly important to im-

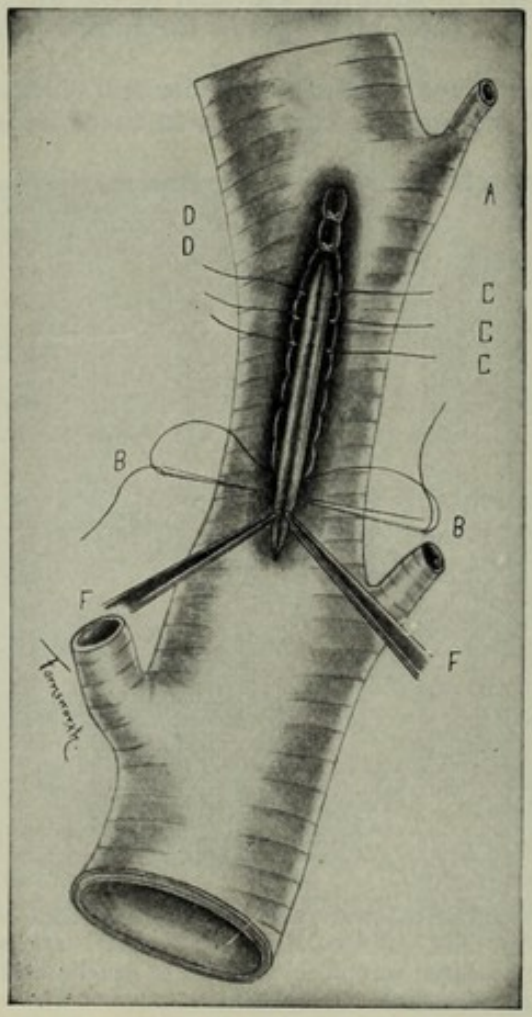


FIG. 224.—Repair of longitudinal wound of artery by combination cobbler's stitch through all coats, and interrupted sutures through outer coats, as suggested by the author: A, Beginning of cobbler's stitch through all coats; B, B, needles in act of passing through same opening in opposite directions, in characteristic cobbler fashion; C, C, C, three interrupted sutures through outer coats, ready to be tied; D, D, two interrupted sutures tied, passing through outer coats (Bickham).

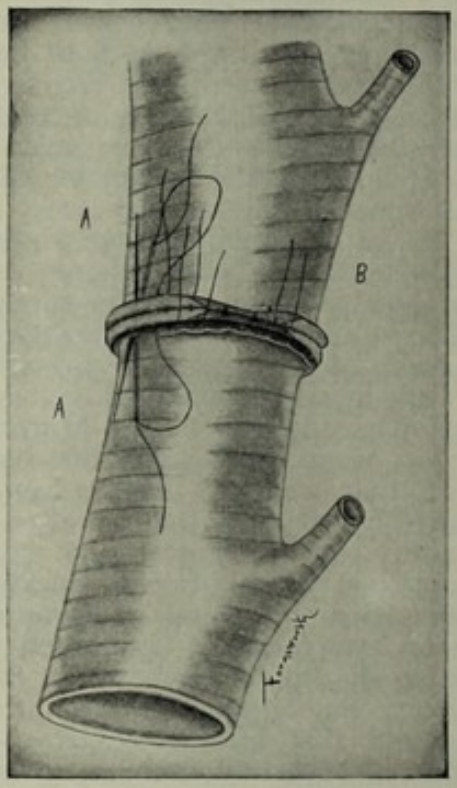


FIG. 225.—Repair of complete transverse division of artery by combination cobbler's stitch through all coats, followed by interrupted sutures through outer coats, as suggested by the author: A, A, Needles passing in opposite directions through all coats, in act of placing cobbler's stitch; B, superficial tier of interrupted stitches through outer coats, showing three untied and two tied (Bickham).

pregnate the suture material with sterile vaselin. This prevents clotting upon the thread. The sheath must be sutured over the stitch line ("Bickham's Operative Surgery").

Lateral arteriorrhaphy for a longitudinal, an oblique, or a transverse wound may be employed if it does not too nearly obliterate the arterial lumen. Some surgeons pass sutures through the external and middle coats, but not through the intima. This is an objectionable method. The blood is very liable to clot and blood may enter between the coats and cause an aneurysm. A better plan is to include all the coats in the sutures and so approximate the endothelial surfaces. Some operators use interrupted sutures, but most prefer a continuous suture. A suture which everts the lips

of the wound has been used by Dorrance, Brien, Jaboulay, and Archibald Smith. Each suture when introduced is U shaped. Bickham passes cobbler's stitches through all the coats and interrupted stitches through the outer coat (Fig. 224).

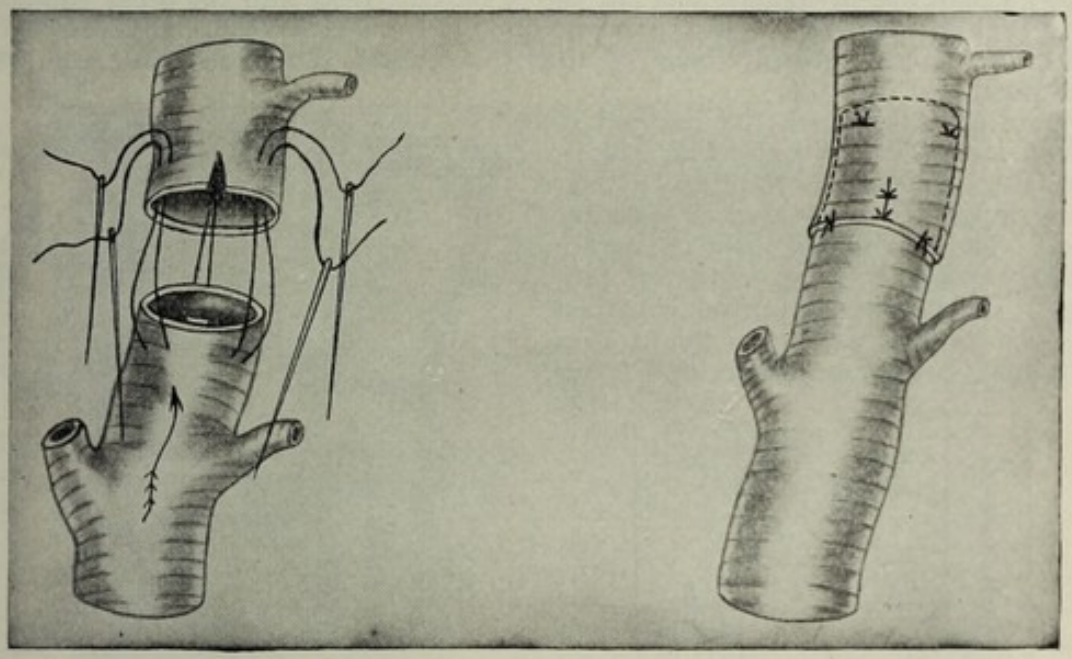


FIG. 226.—Arteriorrhaphy in complete circular division of an artery (Murphy's method). A, Intussusception, with sutures passing through outer and middle coats; B, intussuscipiens (split to aid invagination), with sutures passing through all coats; C, showing all sutures tied (Bickham).

End-to-end anastomosis (*circular arteriorrhaphy*) may be used when a large vessel has been cut across completely or when a portion of an artery has been excised. The sheath is pulled over the end of the vessel and clipped off. During the operation the

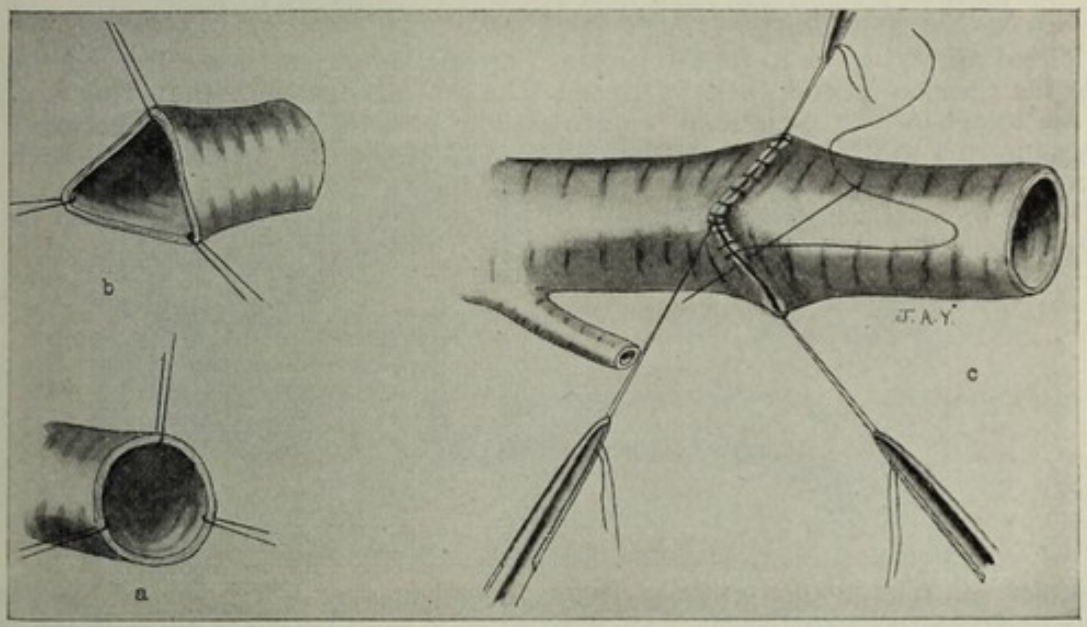


FIG. 227.—The Carrel method of uniting transversely divided vessels by direct suturing: *a*, Three stay sutures carried through the margins of the divided vessel ends, equidistantly from each other, a single vessel end being here shown; *b*, traction upon the stay sutures, triangulating the end of the vessel; *c*, placing the overhand, continuous suture, approximating the margins of each third of the vessel circumferences, in turn, the suture passing through all the coats. ("Bickham's Operative Surgery," vol. ii.)

structures are kept moist by the application of sterile vaselin or by the employment of salt solution. The operation may be done by Bickham's plan, viz., a cobbler's stitch through all the coats to bring the intima of each lip together and interrupted sutures through the outer coats. This is a modification of Dorrance's cobbler stitch.

Horsley used a similar method. In a work of this sort it is impossible to go into operative details and the reader is referred to a work upon operative surgery. In "Bickham's Operative Surgery" there is an illuminating chapter on blood-vessel suturing. Murphy's plan was invagination of one end of the cut vessel into the other end split to receive it (Figs. 225, 226). If a vessel be divided transversely through more than half of its circumference Murphy believed that the division should be made complete as a preliminary to suturing.

Figure 229, A, shows the method of Salomoni and Tomaselli and Fig. 229, B, shows Gluck's method. Payr uses a magnesium ring which is grooved on its outer surface. The central end of the cut artery is pulled through the ring so that it protrudes. The protruding portion is turned back over the ring as a lady might turn back a long cuff over a bracelet. A suture is tied around so as to fix the parts. The ring is now extravascular and the free end of the vessel is an endothelial surface. The central segment with its ring is passed into the lumen of the peripheral segment. The parts are fixed by a ligature. The magnesium ring will be absorbed eventually. The method by the cobbler's stitch and interrupted sutures is shown in Figs. 224, 225.

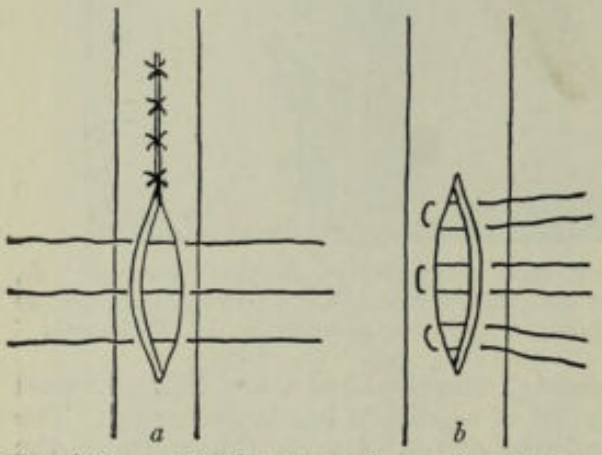


FIG. 228.—*a*, Simple suture; *b*, eversion suture.

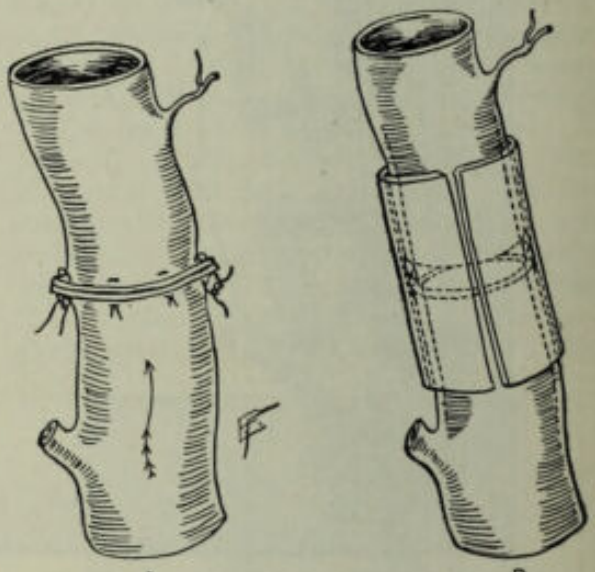


FIG. 229.—Circular arteriorrhaphy in complete division of an artery: A, Method of Salomoni and Tomaselli—interrupted sutures through all coats; B, method of Gluck—interrupted sutures through outer coats, protected by cylinder of decalcified bone, ivory, or rubber (Bickham).

Venous implantation is an operation in which a gap in an artery is filled by the implantation of a segment removed from a vein.

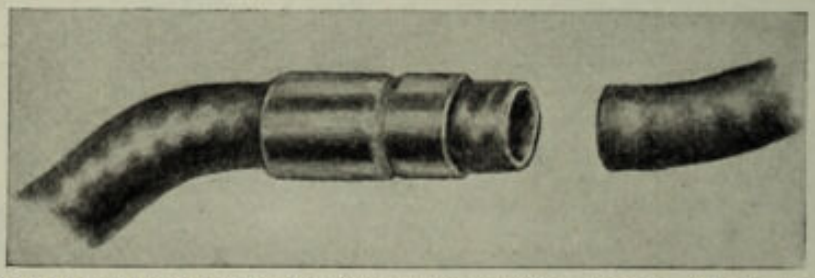


FIG. 230.—Circular arteriorrhaphy by Payr's magnesium ring: I, The form of the ring, or cannula, grooved upon its outer aspect. The proximal end of the artery is seen within the ring, ready to be cuffed back. The distal end of the artery is shown, ready to be dilated. ("Bickham's Operative Surgery," vol. ii.)

The author successfully sutured a wound in the axillary artery and closed by suture the arterial opening of an aneurysmal varix after resecting and ligating the vein. Stewart removed a clot from the femoral and sutured the vessel. He also resected a portion of the brachial and in another case a portion of the femoral, suturing by Murphy's method in the first case and by Carrel's in the second. Murphy removed a clot from the external iliac artery and sutured the vessel. Braun ("Zentralbl. für Chirurgie," Aug. 29, 1908) resected a portion of the aorta along with a tumor and

performed circular suture. The patient was well in four weeks. Depage successfully sutured the common carotid artery. Pringle sutured a wound of the external iliac artery. The wound was ¼ inch in length. Dejemil Pasha sutured a lacerated wound of the axillary artery. Torance sutured a wounded brachial artery. Martin sutured a lacerated wound of the femoral artery ("Annals of Surgery," Oct., 1905). Henderson sutured a transverse wound extending half across the femoral artery ("American

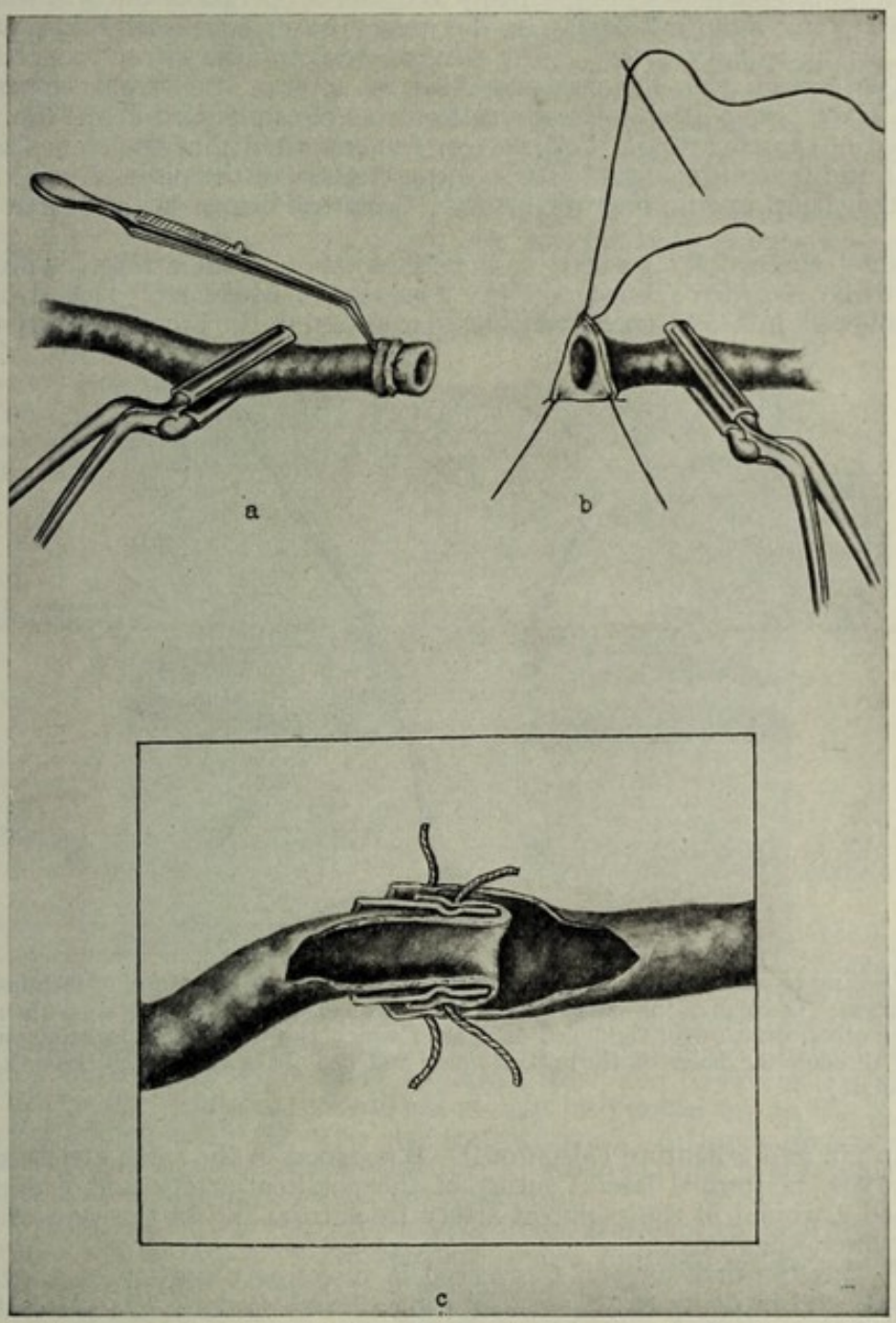


FIG. 231.—The same—II, Accomplishing the anastomosis: *a*, The proximal end of the artery is rolled back and tied over the ring, which is held by Payr's special forceps; *b*, the distal end has been stretched, and its margins held apart by three traction-sutures, ready to draw it over the intussusceptum; *c*, a sectional view of the primary and secondary circular ligatures, and the relations of the parts is shown in the insert picture. ("Bickham's Operative Surgery," vol. ii.)

Medicine," Jan. 14, 1905). A. E. Halstead cut two-thirds through the circumference of the axillary artery and sutured the wound directly instead of making the wound first of all a complete division, as advised by Murphy. Two months later the radial pulse was present.

Faykiss made an end-to-end suture of a divided carotid artery ("Zentralbl. für Chirurgie," 1908, xxxv). Braun, while removing an abdominal tumor, tore the aorta.

He resected and performed end-to-end anastomosis. The patient recovered (quoted by Behan in "Surgery, Gynecology, and Obstetrics," Sept., 1916).

Lexer ("Archiv. für klinische Chirurgie," 1907, No. 2) resected the sac of a traumatic arteriovenous aneurysm of the popliteal vessels, removing at the same time 5 cm. of artery and as much vein. He performed end-to-end anastomosis of each vessel by aid of thin magnesium tubes (*Payr's tubes*). The pulse was restored. Nine months after operation the pulse was present below the seat of operation, but was weaker than it had been some months before. In this paper Lexer speaks of a case of diffused aneurysm of the axillary artery. The surgeon resected the sac and a portion of the artery. The gap of over 3 inches was filled by a piece of internal saphenous vein sutured in place (*autoplasty*). The circulation was re-established in the limb, but the patient died of complications. Postmortem demonstrated that the transplanted vein was patent and the sutures firm. There was a clot above the piece of vein due to the action of the clamp upon a sclerotic artery. Gangrene began on the fourth day after operation.

Manteuffel successfully sutured a wound of the femoral artery. This was the first case to be recorded (Bloodgood in "Progressive Medicine," Dec. 1, 1908), although Hallowell, in 1759, successfully closed a wound in the brachial artery by means

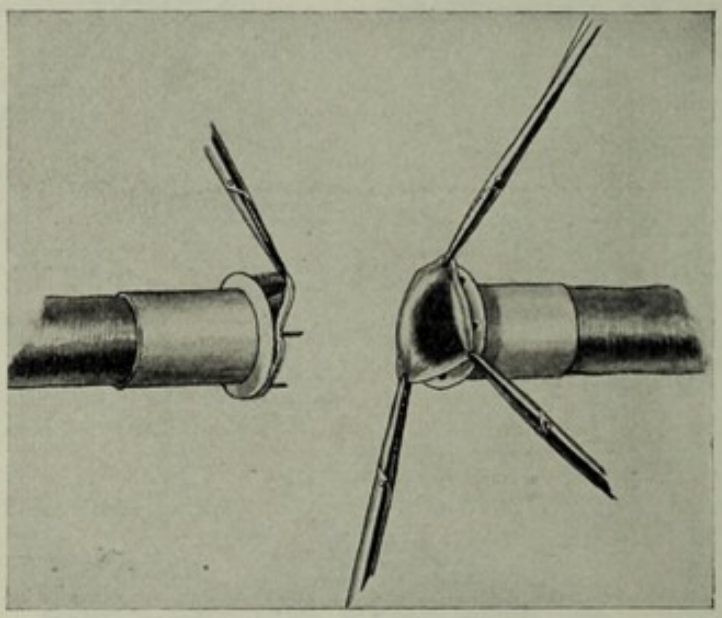


FIG. 232.—End-to-end vascular anastomosis by means of Payr's later form of magnesium tubes, with disk flanges. One end of the vessel being drawn through one tube and impaled upon its pinned disk, and the other, drawn over the holed disk, after which the disks are approximated, and the pins passed through the holes of the opposite disk and bent backward. ("Bickham's Operative Surgery," vol. ii.)

of a harelip pin and a ligature (Mumford). Bloodgood in the same article notes that Körte, in 1904, performed lateral suture of the popliteal artery and vein, and that Garré closed a wound in the popliteal artery by suture, and in the vein of the same patient by lateral ligature.

Murphy was the first surgeon to succeed in resecting a portion of a large artery (the femoral) and in doing end-to-end suturing ("Med. Record," Jan. 16, 1897).

Lund ("Annals of Surgery," March, 1909) sutured a double stab wound of the femoral artery and vein, and six months later there was a pulse in the dorsalis pedis. Routier tore the aorta in removing a hypernephroma of the kidney. He sutured the wound with catgut. The patient died on the fourteenth day, but not from hemorrhage ("Gaz. des Hôpitaux," 1911). Mantelli filled a gap in the femoral artery by a segment of a vein (autoplastic graft). Buchanan performed circular resection and suture of the axillary artery, the vessel having been lacerated by the bone fragments after fracture-dislocation of the anatomic neck of the humerus. Buchanan has collected 29 instances of end-to-end suture of divided arteries ("Surgery, Gynecology, and Obstetrics," Dec., 1912).

Among other surgeons reporting successful cases of arterial suture are Heidenhain, Orlow, Pean, Baum, Sherman, Krause, Payr, Kümmell, Seggel, Martin Lindner, and

Brougham. A great many successful cases of circular arteriorrhaphy were recorded during the World War.

Torsion was practised by the ancients, but was reintroduced in modern times, particularly by Amussat, Velpeau, Syme, and Bryant, of London. Amussat and Maunon pointed out that the essential element in the arrest of hemorrhage is the turning up of the internal and middle coats of the vessel and that this is accomplished most efficiently by twisting. By means of torsion the internal and middle coats are ruptured and the external coat is twisted. The middle coat retracts and contracts, and the inner coat curls into the lumen of the artery. It is a safe procedure, and has been practised upon vessels as large as the femoral by many surgeons of the greatest eminence. Before the days of asepsis torsion possessed the signal merit of not introducing possible infection in ligatures. At the present time it offers no particular advantage. It is no quicker than the ligature, and damages the vessel so much that necrosis may occur. It cannot be used if the vessel is diseased. In what is known as free torsion the vessel is grasped, drawn out, and twisted until the free end of the vessel is twisted off. Limited torsion is more often used. The vessel is drawn out of its sheath by a pair of forceps held horizontally, and is grasped a little distance above its extremity by another pair of forceps held vertically (Fig. 233). The first instrument is used to twist the artery six to eight times.

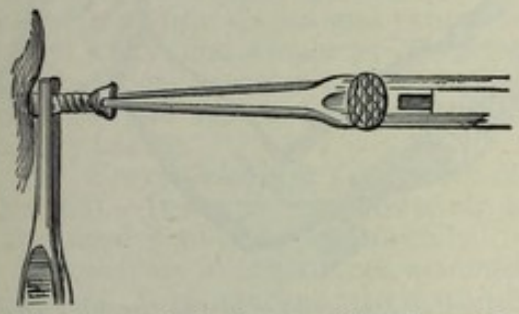


FIG. 233.—Method of controlling hemorrhage by torsion.



FIG. 234.—Tamponade of intercostal artery (after Von Langenbeck).

Acupressure is pressure applied by means of a long pin. The method of hemostasis by acupressure was devised by Sir James Y. Simpson. A pin is simply passed under a vessel (transfixion), leaving a little tissue on each side between the pin and vessel. A pin can be passed under a vessel, and a wire be thrown over the pin and twisted (circumclusion). The pin can be inserted upon one side, passed through ½ inch of tissues up to the vessel, be given a quarter twist, and be driven into the tissues across the artery (torsoclusion). Some tissue may be pricked up on the pin, folded over the vessel, and pinned to the other side (retroclusion). Acupressure is occasionally used to arrest hemorrhage if vessels are inflamed or atheromatous, in sloughing wounds, in scar tissue, and when a ligature will not hold firmly.

Elevation is used as a temporary expedient or in association with some other method. It is of use in a wound of a bursa, in bleeding from a ruptured varicose vein or from bone, and its use is frequently associated with compression.

Compression is either direct or indirect—that is, in the wound or upon its artery of supply. After the removal of the upper jaw arrest bleeding by plugging the cavity. In injury of a cerebral sinus plug with gauze. Compression and hot water (115°–120° F.) will stop capillary bleeding. A graduated compress was formerly recommended in hemorrhage from the palmar arch (Fig. 235). A compress will arrest bleeding from superficial veins. The knotted bandage of the scalp will arrest bleeding from the temporal artery. Long-continued pressure causes pain and inflammation.

Indirect compression is used to prevent hemorrhage or to arrest it temporarily. It may be effected by encircling a limb above a bleeding point with an Esmarch band or by applying a tourniquet or an improvised tourniquet (Fig. 236). It may also be effected by a clamp. Crile has devised a clamp to effect temporary closure of the common carotid artery. In operations about the head one or both carotids may be closed for a considerable time and bleeding may thus be largely prevented. In 10 cases Crile

temporarily closed both carotids. A hypodermic injection of atropin is given to prevent inhibition, the vessels are exposed, and the clamps are applied with just sufficient firm-



FIG. 235.—Conical aseptic tampon (graduated compress) compressing an artery (Senn).

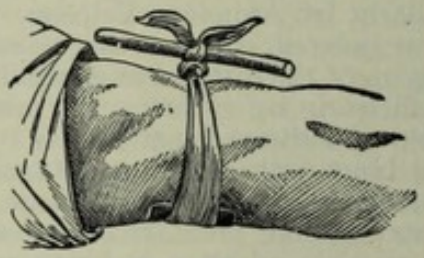


FIG. 236.—Impromptu tourniquet for compressing an artery with a handkerchief and a stick.

ness to approximate the vessel walls. No clot will form if the walls are not squeezed. The patient is in the Trendelenburg position. If it be found that respiratory difficulty

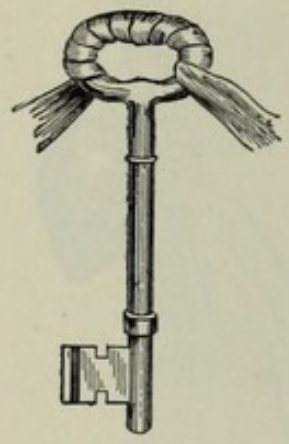


FIG. 237.—Handle of door-key, padded.

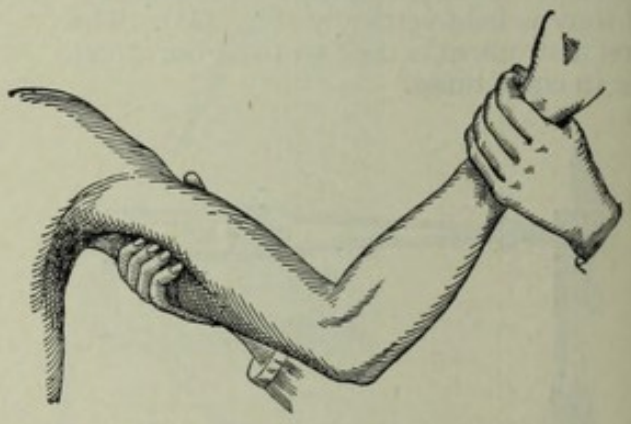


FIG. 238.—Digital compression of the brachial artery.

occurs, one clamp must be loosened. After the completion of the operation the patient must be brought to the horizontal before the clamps are removed (Crile in "Annals of Surgery," April, 1902).

Digital compression is a form of indirect compression. It can be maintained for only a few minutes by one person,

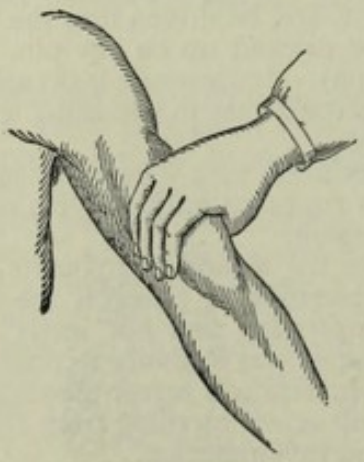


FIG. 239.—Digital compression of the brachial artery.

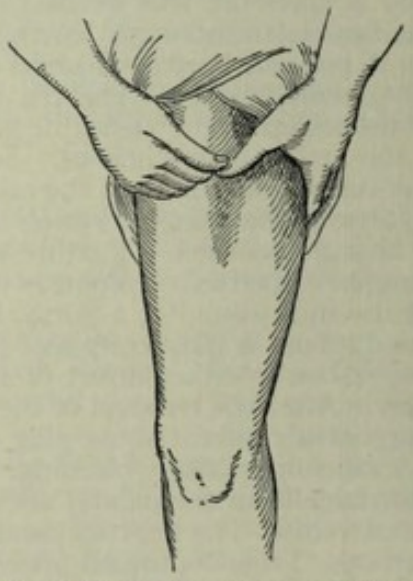


FIG. 240.—Digital compression of the femoral artery.

but a relay of assistants can carry it out for a considerable time. In compressing the subclavian artery wrap a key as shown in Fig. 237, and compress the artery against the outer surface of the first rib. The shoulder must be depressed and pressure

applied in the angle between the posterior border of the sternocleidomastoid and the upper border of the clavicle. The direction of the pressure should be downward, backward, and inward.

The brachial artery can be compressed against the humerus. In the upper part of the course of the artery the pressure should be from within outward (Fig. 238); in the lower part, from before backward (Fig. 239). The abdominal aorta can be compressed by Macewen's method (page 1406). The common iliac can be compressed through the rectum by means of a round piece of wood known as Davy's lever. The femoral artery can be compressed just below Poupart's ligament against the psoas muscle and head of the femur (Fig. 240). The pressure should be directly backward. In the middle third of the thigh digital compression is unsatisfactory, and a tourniquet should always be used or an Esmarch band be employed.

Forced flexion is a variety of indirect compression introduced by Adelmann. It will arrest bleeding below the point compressed, but soon becomes intensely painful. Forced flexion can be maintained by bandages. Brachial hyperflexion is maintained by tying the forearm to the arm. It is often associated with the use of a pad in front of the elbow. Genuflexion is maintained by tying the foot to the thigh. It is increased in efficiency by placing a pad in the popliteal space.

Styptics.—Chemicals are now rarely used to arrest hemorrhage. In epistaxis we may pack with plugs of gauze saturated with a 10 per cent. solution of antipyrin. In bleeding from a tooth-socket freeze with chlorid of ethyl spray, and then pack with gauze soaked with 10 per cent. solution of antipyrin or pack with dry sponge or styptic cotton (absorbent cotton soaked in Monsel's solution and dried). A bit of cork may be forced into the socket. In bleeding from an incised urinary meatus pack with styptic cotton and compress the lips of the meatus. Cold water, chlorid of ethyl spray, and ice act as styptics by producing reflex vascular contraction. Hot water produces vascular contraction and coagulates the albumin. The temperature should be from 115° to 120° F. A mixture of equal parts of alcohol and water stops capillary oozing.

The Use of Gelatin in Controlling Hemorrhage (for Use of Gelatin in Aneurysm see page 366).—It seems very positively proved that gelatin increases the coagulability of the blood if given hypodermically.

Intravenous injections are extremely dangerous, and are apt to be followed by embolism. Subcutaneous injections are decidedly painful and are not altogether safe, producing albuminuria and occasionally embolism. Another danger that may follow the subcutaneous administration of gelatin is the development of tetanus, and several cases have been reported. The existence of disease of the kidneys contraindicates the hypodermic use of gelatin.

It has been successfully used as an enema in intestinal hemorrhage, and as an injection in hemorrhage from the bladder. I have used it locally with success in arresting bleeding from the cut surface of the human liver; to check bleeding from an incised wound in a victim of leukemia; to arrest postoperative oozing in sufferers from cholemia; and in several cases of severe epistaxis.

When employed locally in solution, it should be of a strength of from 2 to 10 per cent. in normal salt solution. For hypodermic use some employ a 5 per cent., some a 2 per cent., and some a 1 per cent. solution. In using a 1 or 2 per cent. solution a very large amount of fluid must be injected. This causes pain; and Sailer maintains that the pain is slight or absent if the solution is not turbid and if but 10 c.c. of a 10 per cent. solution are injected. The injection may be repeated until from 1 to 3 gm. of gelatin have been administered. It should be injected into the outer side of the thigh, under the breast, or between the shoulder-blades. If the drug be given by mouth, 100 c.c. of a 10 per cent. solution is the dose, and this may be repeated every two or three hours.

On account of the possible danger of the development of lockjaw after injection great care in sterilizing must always be exercised. Fractional sterilization is demanded imperatively.

In view of the fact that gelatin is such an excellent culture material, whenever it is used in the rectum, nose, pharynx, vagina, or bladder it should be mixed with some antiseptic agent. Because of the definite danger of tetanus I have practically abandoned the subcutaneous use of gelatin.

Suprarenal extract is a valuable agent to control capillary oozing. It constricts small vessels, and if applied to a mucous membrane will rapidly blanch it. It is extensively used to check bleeding during operations on the nose, throat, larynx, and ear,

and to arrest epistaxis and bleeding from the uterus. The solution to employ is adrenalin chlorid of a strength of from 1 : 10,000 to 1 : 1000. A piece of cotton soaked in this solution is pressed lightly upon the part or the solution is sprayed upon the part by an atomizer.

Chlorid of calcium, given internally, is said to favor coagulation of the blood and is used to check oozing or to prevent hemorrhage. It is used particularly in jaundice cases when operation must be performed. If given several times a day for two or three days it increases the coagulability of the blood; but if given for more than four days, actually diminishes it. The initial dose is from 15 to 30 gr., then 5 gr. every hour are given until five or six doses have been taken. It is apt to provoke gastric irritability, and it is often given by the rectum. I have never been convinced of the value of the drug.

Blood-serum.—In hemophiliacs and in the postoperative oozing of jaundiced patients blood-serum is of great value. The wound may be tamponed with fresh animal blood or blood-serum. A suitable material for local use can be made by grinding up the fresh liver of an animal, soaking it in sterile water, filtering the mixture through gauze, soaking gauze in the filtrate, and tamponing the wound with the wet gauze. This fluid contains the thrombokinase necessary in coagulation (Kottmann and Lidsky in "Deutsch. medizin. Wochen," 1910, vol. i). The thymus gland of an animal may be used instead of liver. Human serum is efficient locally. In ordinary cases of hemorrhage horse serum may be given subcutaneously; in very severe hemorrhage, intravenously. In jaundice cases a serum injection should precede operation. As a prophylactic or for therapeutic effect human serum, horse serum, rabbit serum, antistreptococcus serum, or diphtheria antitoxic serum may be used. The dose is 10 to 40 c.c. subcutaneously.

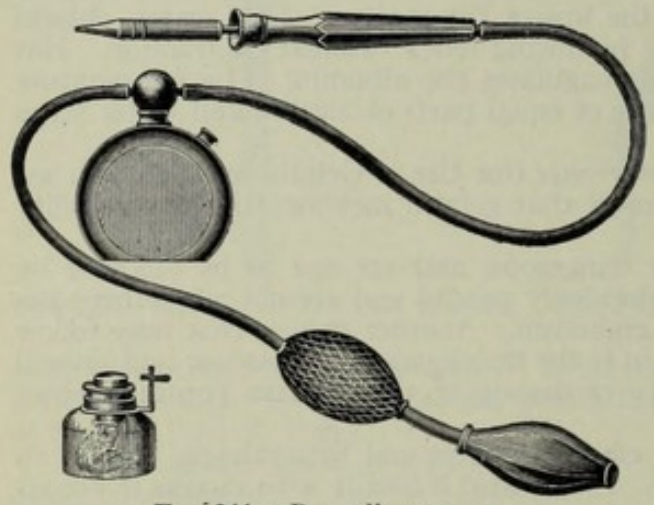


Fig. 241.—Paquelin cautery.

Coagulose is an anhydrous material obtained by precipitating horse serum. It is obtained on the market in a glass bulb. The amount in the bulb is the equivalent of 10 c.c. of horse serum. Into this bulb are poured 6–8 c.c. of sterile water at the temperature of the body. Solution is accomplished by shaking. The fluid is given hypodermically, and the dose can be repeated in two or three hours. The powdered coagulose may be sprinkled on a wound or applied to a wound upon gauze. A substance which strongly activates thrombin is obtained by making an ethereal extract of ox brain (Hirschfelder, "Science," Aug. 18, 1916). The residue when the ether evaporates or an emulsion of the residue in salt solution will quickly arrest bleeding from gland, muscle, or bone. The surgeon may use it while operating in order to get a clear field.

The *actual cautery* is a very ancient hemostatic. It is still used occasionally after excising the upper jaw, in bleeding after the removal of some malignant growths, in continued hemorrhage from the prostatic plexus of veins after lateral lithotomy, and to stop oozing after the excision of venereal warts. We are often driven to its use in "bleeders," that is, those persons who have a hemorrhagic diathesis, and who may die from having a tooth pulled or from receiving a scratch. It will arrest hemorrhage, but the necrosed tissue separates, and when it separates secondary hemorrhage is apt to set in. The iron for hemostatic purposes must be at a cherry heat. The old-fashioned iron, which was heated in a charcoal furnace, is rarely used. It is large, clumsy, and cools quickly if the bleeding be profuse. In an emergency we may heat a poker or a coil of telegraph wire. The best instruments are the electric cautery and the Paquelin cautery. The Paquelin cautery consists of an alcohol lamp, a metal chamber containing benzene, a tube of entrance for air connected with two bulbs, an exit tube, and a wooden-handled cautery instrument, the tip of which is hollow and composed of platinum (Fig. 241). The tip can be kept hot even when bleeding is profuse. If the iron is very hot, it will not stop bleeding completely. In order to use the Paquelin cautery, light the lamp, heat the cautery-tip in the flame until it becomes red, remove it from the flame, and squeeze the bulb re-

peatedly until the tip becomes bright red. Each time the bulb which is not covered with netting is squeezed air is driven through the metal chamber into the tube and cautery, and this air carries with it the vapor of benzene, which passes to the hot tip and takes fire. The degree of heat maintained depends upon the rapidity with which the bulb is squeezed.

Skene has devised a method known as electrohemostasis. He grasps the vessel or tissue with specially constructed forceps, an electric current generates heat, the tissue is cooked, and the walls of the vessel united. For the small instrument Skene uses a current of 2 ma. and for the larger instrument a current of 8 ma.[1]

Downes has devised an instrument to apply electrothermic hemostasis in abdominal and pelvic operations. He asserts that by this method an intra-abdominal operation can be rendered bloodless; that the lymph-ducts are sealed and the stump rendered sterile; that adhesions are less apt to form; and that there is less postoperative pain than if ligatures were used ("Boston Med. and Surg. Jour.," July 10, 1902).

Rules for Arresting Primary Hemorrhage.—1. In arterial hemorrhage tie both ends of the divided artery in the wound, enlarging the wound if necessary (*Guthrie's rule*). In tying the main artery of the limb in continuity for bleeding from a point below we fail to cut off the bleeding from the distal extremity of the divided artery, and hemorrhage is bound to recur. If the surgeon does not look into the wound, he cannot know what is cut; it may be only a branch and not a main trunk. The same rule obtains in secondary hemorrhage.[2]

2. We can safely ligate veins as we would arteries.

3. In a wound of the superficial palmar arch tie both ends of the divided vessel.

4. In a wound of the deep palmar arch enlarge the wound, if necessary, in the direction of the flexor tendons, at the same time maintaining pressure upon the brachial artery. Catch the ends of the cut arch by hemostatic forceps and tie both ends. If the artery can be caught by but cannot be tied over the points of the forceps, leave the instruments in place for four days. If the artery cannot be caught by forceps, use a tenaculum. The ends of the divided vessel can be caught and must be caught even if large incisions are needed to effect it. An incision which will probably always expose the vessel is as follows: Make a cut on a line with the injury from the web of the fingers to above the carpus, separating the metacarpal and carpal bones, until the artery is reached. (This is really Mynter's incision for excision of the wrist.) In former days, if the surgeon found trouble in grasping the ends of the vessel, he applied a graduated compress (see Fig. 235). This is applied as follows: Insert a small piece of gauze in the depths of the wound, put over this a larger piece, and keep on adding bit after bit, each successive piece larger than its predecessor, until there exists a conical pad, the apex of which is at the point of hemorrhage and the base of which is external to the surface of the palm. Bandage each finger and the thumb, put a piece of metal over the pad, wrap the hand in gauze, bandage the palm and wrist, place the arm upon a straight splint, apply firmly an ascending spiral reverse bandage of the arm, starting as a figure-of-8 of the wrist, and hang the hand and forearm in a sling. Instead of applying a splint, we may place a pad in front of the elbow and flex the forearm on the arm. The palmar pad is left in place for six or seven days unless bleeding continues or recurs. The graduated compress is unreliable, hence it is a dangerous method of treatment. It is an evasion. It should be employed at the present time only as a temporary expedient until ligatures can be applied. The old rule of surgery was as follows: If bleeding is maintained or begins again after application of a graduated compress, ligate the radial and ulnar arteries. If this maneuver fails, we know that the interosseous artery is furnishing the blood and that the brachial must be tied at the bend of the elbow. If this fails, amputate the hand. At the present day it is hard to conceive of such radical procedures being necessary for hemorrhage from a palmar vessel.

5. In primary hemorrhage from a small vessel, if the bleeding ceases, do not disturb the parts to look for the vessel. If the vessel is clearly seen in the wound, tie it; otherwise do not, as the bleeding may not recur. This rule does not hold good when a large artery is probably cut, when the subject will require transportation (as on the battlefield), when a man has delirium tremens or mania, or when he is a heavy drinker. In these cases always look for the artery and tie it.

6. When a person is bleeding to death from a wound of an extremity, arrest hemorrhage temporarily by digital pressure in the wound and apply above the wound a

[1] "New York Medical Journal," Feb. 18, 1898.

[2] For observations on suture of vessels see page 392.

tourniquet or Esmarch bandage. Bring about reaction and then ligate, but do not operate during collapse if the bleeding can be controlled by pressure.

7. If a transverse cut incompletely divides an artery, it may be found possible and may be considered desirable to suture the cut. Longitudinal cuts can certainly be sutured (see page 388). If suturing is impossible, or if the surgeon prefers not to attempt it, apply a ligature on each side of the vessel wound and then sever the artery so as to permit of complete retraction.

8. If a branch comes off just below the ligature, tie the branch as well as the main trunk.

9. If a branch of an artery is divided very close to a main trunk, the rule used to be, tie the branch and also the main trunk. It was thought that if the branch alone were tied the internal clot, being very short, would be washed away by the blood-current of the larger vessel. We now know that a large clot is not required in repair, and under aseptic conditions it is trivial in size and rarely reaches the first collateral branch. Repair is effected by endothelial proliferation.

10. If a large vein is slightly torn, put a lateral ligature upon its wall (Fig. 242). Gather the rent and the tissue around it in a forceps and tie the pursed-up mass of vein wall. It is a wise plan to pass the ligature through the two outer coats by means of a needle and tie the knot subsequently. This expedient prevents slipping. If a longitudinal wound exists in a large vein, take an intestinal needle and fine silk and sew it up (see page 387). Many transverse wounds can also be sutured.

11. When a branch of a large vein is torn close to the main trunk, tie the branch and not the main trunk. Apply practically a lateral ligature.

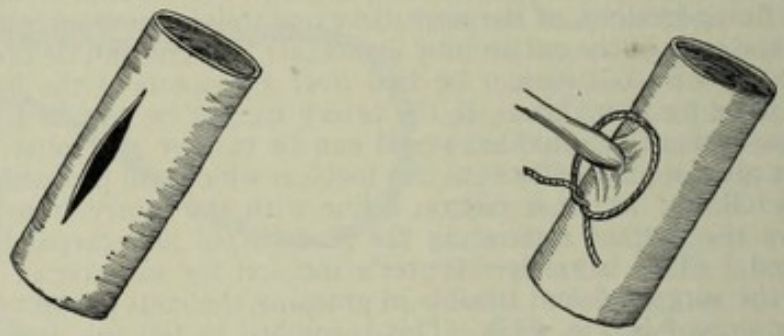


FIG. 242.—Application of lateral ligature to a vein.

12. If, after tying the cardial extremity of a cut artery, the distal extremity cannot be found, even after enlarging the wound and making a careful search, pack the wound firmly.

13. In bleeding from diploë or cancellous bone use Horsley's antiseptic wax (bees-wax 7 parts, almond oil 1 part, and salicylic acid 1 part), or break in bony septa with a chisel, or plug with threads of gauze or scrapings of catgut. If the bleeding is very free, wax will not stick and mashing the bone edges usually fails. The expedient suggested by Vaughan should then be employed, viz., a piece of muscle or other tissue is cut off, and, by means of the fingers or a knife handle, forcibly rubbed against the bleeding bone surface. Minute fragments of the soft tissue plug the open vessels and arrest the bleeding (George Tully Vaughan in "Jour. Amer. Med. Assoc.," Nov. 9, 1907).

14. In bleeding from a vessel in a bony canal, plug the canal with an antiseptic stick and break the wood, or fill up the orifice of the canal with antiseptic wax or a separated bit of tissue. If this fails, ligate the artery of supply.

15. In bleeding from the internal mammary artery the old rule was to pass a large curved needle holding a piece of silk into the chest, under the vessel and out again, and tie the thread tightly; but it is better to make an incision and ligate the artery.

16. In bleeding from an intercostal artery make pressure upward and outward by a tampon (see Fig. 234), or throw a ligature by means of a curved needle entirely over a rib, tying it externally; or, what is better, bring the vessel into view and tie it.

17. In collapse due to puncture of a deep vessel, the bleeding having ceased, do not hurry reaction by stimulants. Give the clot a chance to hold. Wrap the sufferer in hot blankets. If the condition is dangerous, however, stimulate to save life.

18. In punctured wounds, as a rule, try pressure before using ligation.

19. After a severe hemorrhage *always* put the patient to bed and elevate the damaged part (if it be an extremity or the head).

20. A clot which holds for twelve hours after a primary hemorrhage will probably hold permanently; but even after twelve hours be watchful and insist on rest.

21. If recurrence of a hemorrhage from a limb is feared, mark with anilin or iodin the spot over the main artery where compression is to be applied, apply a tourniquet loosely, and order the nurse to screw it up and to send for the surgeon at the first sign of renewed bleeding. This must be done in many gunshot-wounds.

22. When the femoral vein is divided high up, the advice commonly given is to ligate the vein and also the femoral artery. Braune taught that because of the venous valves there is no collateral circulation, and to tie the vein alone renders gangrene inevitable. Niebergall thinks that the valves may be overcome by moderate arterial pressure, and thus collateral circulation be established. Hence, when the femoral vein is divided tie the vein, but leave the artery untied, so as to furnish the necessary pressure.[1]

23. In extradural hemorrhage trephine. The side to be trephined is determined by the symptoms, and not by the situation of the injury, if symptoms arise. If there are no localizing symptoms, an opening is made on a level with the upper orbital border and 1¼ inches behind the external angular process. This opening exposes the middle meningeal and its anterior branch. If this does not expose a clot, trephine over the posterior branch, on the same level and just below the parietal eminence. When the clot is found, enlarge the opening with the rongeur forceps, scoop out the clot, and arrest the bleeding by passing ligatures on each side of the injury in the vessel through the dura, under the artery and out again, and then tying them. If the artery lies in a bony canal, plug the canal with Horsley's wax. In some cases packing must be used to arrest bleeding. In subdural hemorrhage open the dura and endeavor to ligate. If this procedure is impossible, place a bit of severed muscle over the bleeding point. In rare cases pack with iodoform gauze.

24. In hemorrhage from a cerebral sinus catch the edges of the opening with forceps, if possible, and apply a lateral ligature, or leave the forceps in place for forty-eight hours, or compress firmly with iodoform gauze.

25. In extramedullary spinal hemorrhage rapidly advancing and threatening life perform laminectomy and arrest the hemorrhage.

26. In bleeding from a tooth-socket use chlorid of ethyl spray or ice. If this treatment fails, plug with gauze infiltrated with tannin or soaked in antipyrin solution of a strength of 10 per cent., or in Carnot's solution of gelatin (page 395). Close the jaws upon the plug, and hold them with Barton's bandage. If this expedient fails, soak the plug in Monsel's solution (liquor ferri subsulphatis), or plug with a bit of cork, dry sponge, or fragments of muscles. If these plans fail, use the cautery. Pressure on the carotid and ice over the jaw and neck are indicated. It may be necessary to tie the external carotid artery.

27. In intra-abdominal hemorrhage open the belly. In intra-abdominal hemorrhage it is necessary to operate during shock. If the blood accumulates so rapidly as to prevent the location of the bleeding point, compress the aorta or pack the abdominal cavity with large gauze pads. In seeking for the bleeding point remove the pads one by one, or have the pressure momentarily relaxed from time to time. In parenchymatous hemorrhage from the liver, suture the torn edges or use the cautery. In some cases the liver is sutured to the abdominal wall and the wound is packed. The portal vein may be sutured. It has been ligated successfully (Burdenko in "Deutsch. Ztschr. f. Chir.," cxxiv). The hepatic artery may be sutured. There are on record 20 cases of ligature of the hepatic artery (Narath in "Deutsch. Ztschr. f. Chir.," 1916, cxxxv). Ligature of the main trunk is not followed by liver necrosis. Ligature between the origins of the pyloric and gastroduodenal branches is very apt to cause hepatic necrosis, and ligature beyond the emergence of those branches is certain to do so (Narath, Ibid.). Severe wounds of the spleen demand splenectomy. In hemorrhagic pancreatitis packing is used (page 1040). Wounds of the kidney may be sutured, but may require partial or complete nephrectomy. Wounded mesenteric vessels are ligated *en masse* with silk (Senn). If a portion of intestine is found to be deprived of blood it must be resected. Wounds of the stomach and intestines causing hemorrhage require stitching of their edges. The aorta and cava may be sutured. The cava has been successfully ligated. An aorta should not be ligated, but has been resected and sutured successfully. When there are a great many points of

[1] Niebergall, "Deutsch. Ztschr. f. Chir.," vol. xxxvii, Nos. 3 and 4.

bleeding, take a number of gauze pads, tie a piece of tape firmly to each one, pack many places in the belly with the sponges, bring the tapes out of the wound, and remove the sponges from below upward one at a time, securing the bleeding points as they come into view.

28. In abdominal section for disease of the female pelvic organs bleeding is limited by the clamp or by pressure-forceps. Most vessels are tied. Ligation *en masse* is often practised. A large mass can be transfixed and tied in sections. Bleeding edges are stitched. Areas of oozing are treated by temporary pressure and hot water or, if this fails, by the cautery. Packing can be used as a tamponade, which is a gauze pouch, pieces of gauze being packed into this pouch after its insertion into the belly.

29. A ruptured varicose vein requires a compress, a bandage from the periphery up, and elevation.

30. Most cases of capillary bleeding can be controlled by compression with gauze pads soaked in water at a temperature of 115° to 120° F. This contracts the vessels and seals them with coagulated albumin. Keetly in 1878 impressed the profession with the value of hot water as a styptic. Centuries ago surgeons used hot oil for the same purpose. Capillary bleeding can often be controlled by the application of gauze soaked in Carnot's solution of gelatin. A solution of suprarenal extract may control capillary oozing. If other means fail to control capillary hemorrhage, the cautery must be used. Understand that the term "capillary bleeding" does not so much mean bleeding from genuine capillaries as it does bleeding from arterioles and venules.

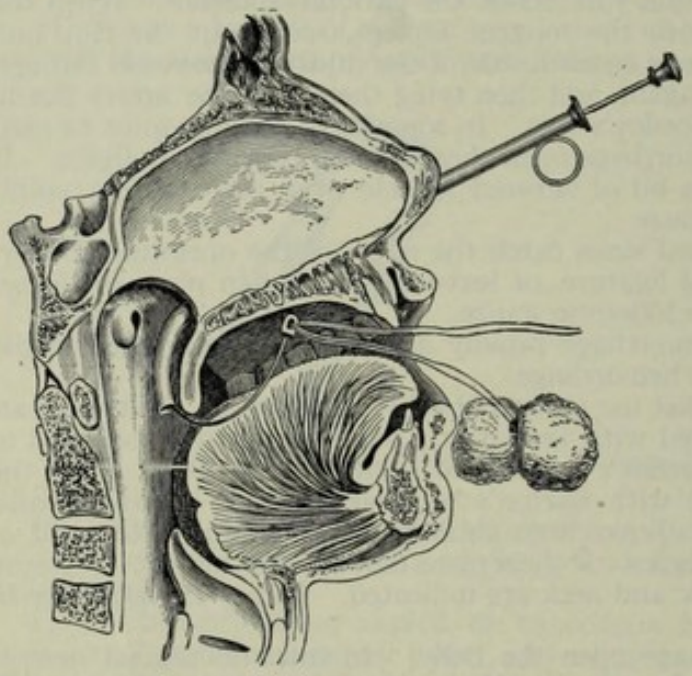


FIG. 243.—Plugging the nares for epistaxis by the aid of Bellocq's cannula (Guerin).

31. Pressure above a wound may arrest arterial hemorrhage, but will aggravate venous bleeding. Pressure below a wound may arrest venous hemorrhage, but will increase arterial bleeding.

32. A moderate epistaxis, or bleeding from the nose, may be arrested by an injection of peroxid of hydrogen, an injection of a solution of antipyrin, or an injection of Carnot's solution of gelatin (see page 395). Favorite domestic expedients are keeping the arms raised above the head and applying ice to the back of the neck. In severe epistaxis examine the nose by means of a head-mirror and a speculum. If a distinct point of ulceration is found, touch it with a cautery. If the bleeding is a general ooze, if it is high up, or if the cautery does not arrest it, pack the nares. It may be necessary to pack one nostril or both. The usual method is as follows: Pass a Bellocq cannula (Fig. 243) along the floor of one nostril into the pharynx, project the stem into the mouth, tie a plug of lint or gauze wet with Carnot's solution of gelatin to the stem, and withdraw it. Hold the double string which emerges from the nostril in the hand and pack gauze wet with gelatin solution from before backward. Tie the strings together over the plug; if both nostrils are plugged, the strings from one nostril are fastened to the strings from the other. Do not use subsulphate or iron, as it forms a disgusting, clotty, adherent mass. If Bellocq's cannula is not obtainable, push a soft catheter into the pharynx, catch it up with a finger, pull it forward, and tie the plug to it. Remove the plug in twenty-four to thirty-six hours. Do not leave it longer. It blocks up decomposing fluids and may lead to blood-poisoning. Pick out the front plug first, hold the string of the second plug in the hand, push the plug back into the pharynx, catch it with forceps, and withdraw plug and string through the mouth. If the gauze soon becomes saturated with blood it will not be efficient. J. G. Levin ("Jour. Amer. Med. Assoc.," Jan. 19, 1924) suggested the following plan: Take a rubber finger-cot, grease it, grasp with forceps, insert the blind end as far as it will go in the nasal cavity with the open end just emerging from the nostril. While the

cot is held a piece of gauze, ½ inch wide is packed within it. This makes firm and even pressure. The packing does not become foul and can be removed easily. It can be left in place safely for over twenty-four hours.

33. In gunshot wounds the primary hemorrhage is slight unless a large vessel is cut. The bleeding may be visible or may be internal (concealed), the blood running into a natural cavity or among the muscles. Capillary oozing is arrested by very hot water and compression. Venous bleeding is usually arrested by compression. If a large vessel is the source of bleeding, enlarge the wound and tie the vessel. If the artery cannot be found in the wound, tie the main trunk.

34. In prolonged bleeding from a leech-bite try compression over a plug saturated with alum or with tannin. If this fails, pass under the wound a harelip pin and encircle it with a piece of silk. If this fails, use the actual cautery or excise the bite and suture the incision.

35. In severe bleeding from the ear elevate the head, put an ice-bag over the mastoid, give opium and acetate of lead, and, if blood runs into the mouth, plug the eustachian tube with a piece of catheter.

36. Umbilical hemorrhage in infants requires pressure over a plug containing tannin, alum, or gelatin solution. If compression fails, pass harelip pins under the navel and apply a twisted suture. If this fails, use the actual cautery.

37. Rectal bleeding requires elevation of the buttocks, insertion of pieces of ice, ice to the anus and perineum, astringent injections (alum), injections of gelatin, injections of adrenalin, and the internal use of opium and acetate of lead. If these means fail, insert and inflate a Peterson bag, a colpeurynter, or tampon, and use a T-bandage. If the bleeding persists or if a considerable vessel is bleeding, stretch the sphincter, catch the bowel and draw it down, seize the vessel, and tie it if possible; if not, leave the forceps in place. Failing in this, the actual cautery must be used.

38. Subcutaneous hemorrhage, if severe and persistent, demands that an incision be made and ligatures be applied.

39. Bleeding from a cut urethral meatus requires the insertion of styptic cotton and the application of pressure. Moderate bleeding from the deeper urethra can usually be arrested by a very warm bougie, by very warm injections, or by tying a condom over a catheter, and, after inserting it, inflating the condom by blowing through the catheter and plugging the orifice of the instrument, thus using pressure. Sitting with the perineum on a thickly folded towel is useful. Ice to the perineum does good. The patient can lie down, have a folded towel applied to the perineum, and a crutch-handle pushed upon the towel, the lower end of the crutch being jammed against the foot of the bed. If a solid bougie has been first introduced, firm pressure can be made by this method. If these means are futile, perform external urethrotomy and reach the bleeding point.

40. Hemorrhage from the prostate requires hot injections, the introduction of a large bougie first dipped in very warm water, and the retention of a catheter for two days. Perineal section may be required, or suprapubic cystotomy with packing which does not occlude the ureteral orifices.

41. Vesical hemorrhage usually ceases spontaneously, in which case the urine must be drawn off and the viscus be washed out frequently with a solution of boric acid, to prevent septic cystitis. If blood-clots prevent the flow of urine, break them up with a catheter or a lithotrite and inject vinegar and water, a 2 per cent. solution of carbolic acid, or a solution of bicarbonate of sodium. Perfect quiet is to be maintained, cold acid drinks are given, ice-bags are put to the perineum and hypogastric region, and opium, with acetate of lead or gallic acid, is to be given by the mouth. If the hemorrhage is severe or persistent, perform suprapubic cystotomy, wash out the bladder, and, if necessary, plug the bladder with gauze, leaving the ureters uncovered.

42. In hemorrhage after lateral lithotomy, ligate if possible. If the vessel can be caught, but cannot be ligated, leave the forceps in place. If it is not possible to catch the vessel with forceps, use a tenaculum. If the tenaculum fails, pass a threaded curved needle through the tissues around the vessel and tie the ligature (suture ligature). Plugs of ice and injections of hot water may be tried. These means failing, pressure is indicated. Take a cannula, fasten to it a chemise (Fig. 244), empty clots from the bladder, insert the instrument through the wound into the viscus, and pack gauze between the sides of the cannula and the chemise. The chemise is bulged out and pressure is made. Tie the cannula by means of tapes to a T-bandage. Pressure is thus combined with vesical drainage. Buckstone Brown makes pressure by inflating a rubber bag with air. The hot iron may occasionally be demanded.

43. Renal bleeding requires ice to the loin, tannic acid and opium, gallic acid or sulphuric acid internally, and perfect quiet. The use of a cystoscope will show from which ureter blood is emerging. If the bleeding threatens life and the diseased organ is identified, make a lumbar incision and suture or perform nephrectomy.

44. Vaginal hemorrhage requires the ligature or the tampon.

45. Severe uterine hemorrhage (unconnected with pregnancy) requires the tampon. Persistent hemorrhage due to morbid growths may require radium, removal of the tubes and appendages, ligation of the uterine and ovarian arteries, or hysterectomy.

46. Hematemesis, or bleeding from the stomach, is treated by the swallowing of ice, giving tannic acid (dose, 20 or 30 gr.), or Monsel's solution (3 drops). Gelatin by the mouth is recommended. Never give tannic acid and Monsel's solution together, as they mix and form ink. Opium is usually ordered. Acetate of lead and opium and gallic acid are favorite remedies, ergot is used by many, and adrenalin may be of service. Horse serum may be needed. Give no food by the stomach. If life is threatened by bleeding from an ulcer, open the belly and excise the ulcer and suture the wound. Transfusion may be necessary. If severe hemorrhage follows injury, perform an exploratory laparotomy. Always remember that furious and even fatal gastro-intestinal hemorrhage may be due to mere erosions or to cirrhosis of the liver, and a slight injury may have been the exciting cause of a hemorrhage. In such a condition, of course, operation is useless.

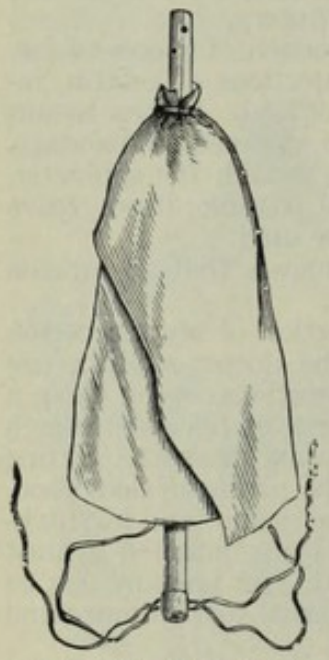


FIG. 244.—Cannula à chemise.

47. In bleeding from the small bowel give acetate of lead and opium, sulphuric acid, or Monsel's salt in pill form (3 gr.), perhaps horse serum, hypodermically, allow no food for a time, and insist on liquid diet for a considerable period. If hemorrhage threatens life, open the abdomen and find the cause. If ulcer exists, excise it and suture, or suture a perforation without previously excising. If violent hemorrhage follows injury, explore to discover the vessel. Transfusion may be necessary.

48. In bleeding from the large bowel, use styptic injections (10 gr. of alum or 5 gr. of bluestone to 1 oz. of water). If bleeding is low down, use small amounts of the solution; if high up, large amounts. Do not use absorbable poisons. In dangerous cases perform an exploratory operation to find the vessel. (For rectal bleeding, see page 401.)

49. Hemoptysis, or bleeding from the lung, is treated by morphin hypodermically, by perfect rest, by dry cups or ice over the affected spot if it can be located, and by the administration of gallic acid, which aids coagulation.[1] It is said that nitrite of amyl by inhalation has given good results.

50. In hemorrhage from wound of the lung do not open the chest unless life is threatened. If life is endangered, resect a rib, allow the lung to collapse, and see if this arrests bleeding. If bleeding still continues, remove several ribs, find the bleeding point, ligate, suture, or employ forcipressure. A small cavity may be packed with gauze. If a large surface is bleeding, fill the pleural sac with gauze and pack more gauze against the oozing surface.[2]

51. Hemorrhage from the scalp, if from a large vessel like the deep temporal, is arrested by ligatures, by suture ligatures, or by suturing the wound. In the fibrous subcutaneous tissue it is very difficult to pick up, draw out the end of, and ligate a vessel.

Reactionary or Recurrent Hemorrhage (called also *Consecutive*, *Intermediate*, or *Intercurrent*).—This form of hemorrhage comes on during reaction from an accident or an operation, that is, during the first forty-eight hours, but in most cases within twelve hours. It is usually bleeding from a vessel or vessels which did not bleed during the shock which accompanied operation, and which were overlooked and not tied. It may be due to faultily applied ligatures. It is favored by vascular excitement or

[1] The use of ergot is a general but questionable practice. Bartholow and others hold that this drug does harm; it contracts all the arterioles, and hence more blood flows from an area where there is damage. Purgatives do good in bleeding from the lung by taking blood to the abdomen and lowering blood-pressure.

[2] See author's case, "Annals of Surgery," Jan., 1898.

hypertrophied heart. The bleeding is rarely sudden and severe, but is usually a gradual drop or trickle. The Esmarch apparatus is not unusually the cause. The constricting band paralyzes the smaller arteries, which do not bleed during shock and do not contract as shock departs; hence bleeding comes on with reaction. To lessen the danger of the Esmarch apparatus use a broad constricting band rather than a rubber tube. After an amputation, when the larger vessels have been tied and the band has been removed, gauze pads wet with hot water (115° to 120° F.) should be placed between the flaps. This not only arrests capillary oozing, but stimulates vessels and shows points of bleeding which were not previously visible, and these points are ligated. During reaction after an amputation, if slight hemorrhage occurs, elevate the stump and compress the flaps. If the hemorrhage persists or at any time becomes severe, make pressure on the main artery of the limb, open the flaps, turn out the clots, find the bleeding point, ligate, asepticize, drain, close, and dress. In any severe reactionary hemorrhage open the wound at once and ligate.

Secondary hemorrhage may occur at any time in the period between forty-eight hours after the accident or operation and the complete cicatrization of the wound. Secondary hemorrhage may be due to atheroma, to slipping of a ligature, to inclusion of nerve, fascia, or muscle in the ligature, to sloughing, to erysipelas, to suppuration, to septicemia, to pyemia, to gangrene, and to overaction of the heart. The great majority of cases of secondary hemorrhage are due to infection, and the application of modern surgical principles has rendered secondary bleeding a rare calamity. If during an operation the vessels are found atheromatous, a thread should be passed, by means of a curved needle, around the vessel, including a cushion of tissue in the loop of the ligature (this prevents cutting through, see Fig. 221). Acupressure may be used in such a case. If the surgeon decides to employ the ligature, he must not tie tightly, but must endeavor to approximate the coats rather than to cut them. Two ligatures can be applied or the stay knot may be used. One great trouble with atheromatous arteries is that their coats cannot contract; another trouble is that the ligature is apt to cut entirely through them. If after an operation the pulse is found to be forcible, rapid, and jerking, give aconite, opium, and low diet. The bleeding may come on suddenly and furiously, but is usually preceded by a bloody stain in wound fluids which had become free from blood.

Treatment of Secondary Hemorrhage.—Suppose a case of leg amputation in which, several days after the operation, a little oozing is detected: the treatment is to elevate the stump, apply two compresses over the flaps, and carry a firm bandage up the leg. If the bleeding is profuse or becomes so, make pressure on the main artery, open and tear the flaps apart with the fingers, find the bleeding vessel and tie it, turn out the clots, asepticize, drain, close, and dress. If the bleeding begins at a period when the stump is nearly healed, cut down on the main artery just above the stump and ligate. In secondary hemorrhage from a blood-vessel in nodular tissue apply a suture-ligature or tie higher up, or, if this fails, amputate. When secondary hemorrhage arises in a sloughing wound apply a tourniquet or an Esmarch bandage, tear the wound open to the bottom with a grooved director, look for the orifice of the vessel, dissect the artery up until a healthy point is reached, cut it across, and tie both ends. If this fails, apply a suture-ligature or use acupressure. In secondary hemorrhage from atheromatous vessels use the suture-ligature, double ligature with a stay knot, or employ acupressure.

Secondary hemorrhage may occur after ligation in continuity, the blood usually coming from the distal side. If the dressings are slightly stained with blood, put on a graduated compress. If the bleeding continues or is severe, make pressure on the main artery of the limb, open the wound and ligate, wrap the part in cotton, elevate, and surround with hot bottles. If this religation is done on the femoral and fails, do not ligate higher up, as gangrene will certainly occur, but amputate at once above the point of hemorrhage. If dealing with the brachial artery, do not amputate, but ligate higher up and make compression in the wound. In a secondary hemorrhage from the innominate, tie the innominate again and also tie the vertebral.

Hemorrhage After an Abdominal Operation.—Hemorrhage may occur after an abdominal operation. It may come on gradually with reaction. If it does so, it causes weakness, thirst, restlessness, blurring of vision, an increasing pulse-rate, pallor, increasing rate of respiration, dyspnea, and coldness of extremities. The temperature is normal or subnormal. If the hemorrhage is small in amount the condition may be recovered from. If it continues it produces the grave symptoms set forth on page 382. A rapid secondary or reactionary hemorrhage produces those grave symp-

toms almost suddenly. If a severe hemorrhage is occurring in the abdomen, nothing but an operation can save life (see page 399).

Hemophilia, Hemorrhagic Disease, or Hemorrhagic Diathesis.—The term "hemophilia" expresses the existence in an individual of a tendency to joint effusions, to serous hematomata, and to profuse or even uncontrollable hemorrhage which occurs spontaneously or as a result of some injury, perhaps trivial. In this disease blood coagulation is slow and imperfect because of congenital defect. We know that certain abnormal materials retard coagulation. Among these are an extract made from the heads of leeches, snake venom, pepsin, and trypsin. An excess of antithrombin does the same thing. But none of these things is responsible for the inherited tendency known as hemophilia. Sahli asserts that hemophilia is due to defects in certain cells, which defects are responsible for a deficiency of thrombkinase, the coagulating agent ("Deutsch. Arch. f. klin. Med.," 1910, vol. xcix).

It may exist in the robust as well as the pale and weakly, the rich as well as the poor. It is almost limited to males, and in those rarely recorded instances of the defect in females it was seldom provocative of dangerous bleeding. In 70 per cent. of all cases the condition is noted before the fifth year of life (R. C. Cabot in "International Text-book of Surgery"). There is a late or deferred form which some call acquired which does not arise until the first dentition or perhaps till puberty. The family history of a bleeder shows that he comes of a bleeding stock, in other words, the defect is hereditary. The women of a family of bleeders almost never show symptoms of hemophilia, seldom bleed seriously at menstrual periods, but are sometimes predisposed to epistaxis, postpartum hemorrhage, and severe bleeding at the menopause. It has been noticed that the women of bleeding families are apt to be excessively fertile. In four families of a single stock there were 19 children each (Sir Almroth E. Wright in Allbutt and Rolleston's "System of Medicine"). As we have said, the bleeders are males. The females are seldom bleeders. But a non-bleeding mother imparts the hemophiliac tendency to her male child and he does bleed. All the mothers of a bleeding family may not transmit the defect, but more than two-thirds of them do. All of the sons may not bleed. Probably two-thirds of them do. All of the daughters may not transmit the inheritance, but most of them do. A male bleeder seldom transmits the defect to a son or the tendency to a daughter, although he does so in rare instances (Goodall in "Scottish Med. and Surg. Jour.," Feb., 1905). Wright (Ibid.) is inclined to believe that "in the absence of a definitely hemophilic ancestry the disease" may "originate *de novo* from the conjunction of a male and a female both predisposed to bleeding, whose blood has in each case the characters associated with the hemophilic predisposition." The pathology of hemophilia is still in dispute. Some urge that the blood that oozes from a wound in a hemophiliac does clot, hence we cannot say that inability to clot lies at the base of the trouble. It is true that the blood clots, but it clots slowly. Those who disbelieve in the view that the fault is in clotting of the blood explain the condition by assuming the existence of hypoplasia of the aorta and arteries. Certainly in Agnew's case in which profuse bleeding from trivial causes occurred above the clavicles and not below them, there must have been structural defect in the vessels. But such a case was not an instance of genuine hemophilia. The same statement may be made of non-traumatic hemorrhage from one kidney. In a case of hemophilia in the Jefferson College Hospital it became necessary to amputate a finger. A careful study of the vessels of the amputated digit failed to show any vascular defect. Wright (Ibid.) shows that if the blood of a bleeder is tested when he is not in a hemorrhagic crisis coagulation will be found to be very slow. Instead of five minutes, which is normal, it will be ten minutes, twenty minutes, even fifty or sixty minutes. Great confusion has arisen in reports because we know that during and for some time after hemorrhage the blood becomes temporarily more rapidly coagulable than in health. The real test for coagulation is when no hemorrhage exists and no hemorrhage has taken place for some time. Wright (Ibid.) sets forth the blood condition of bleeding families as follows: "a diminished content in leukocytes, a relatively diminished number of polymorphonuclear leukocytes, and diminished blood coagulability." The deficiency in polymorphonuclear leukocytes explains the slowness of coagulation, for these corpuscles furnish the blood with an element necessary to coagulation. This element is thrombokinase. The serum of circulating blood according to Wright and Morawitz contains fibrinogen and a ferment called thrombogen. Thrombokinase in the presence of calcium converts thrombogen into thrombin and thrombin converts fibrinogen into fibrin (Wood in "Australian Med. Jour.," vol. xcix). The coagulation time of blood obtained by puncture of the skin and that obtained by

tapping a vessel are different. The latter has a longer coagulating time than the former because in the puncture the kinase obtained from the wound shortens the time (Dorrance in paper read before the Section on Surg. of the Med. Soc. of the State of Penna. Session of Sept. 21, 1916). It becomes evident that the method and instrument used in obtaining coagulation time must be stated.

Hemorrhage may take place from mucous or serous membranes or from wounds of the cutaneous surface, into tissue, into organs, into a joint, under the skin, under the scalp, or into the external genitals. In a hemophiliac, if a cut is made, the hemorrhage from the larger vessels is easily arrested, but capillary oozing continues.

The discovery of the existence of such a condition may not be made until a tooth is pulled, and extraction is followed by persistent bleeding. It is alleged that the tendency may disappear in middle life. The earlier in life the condition appears, the worse the prognosis. Coagulability improves as age advances. In an adult spontaneous hemorrhages will usually cease eventually, and in most cases traumatic hemorrhage can be controlled. Recurrent joint involvement is a very serious matter, as it may lead to ankylosis.

A joint lesion in hemophilia is called *hemophilic arthritis*.

Symptoms.—In a child who is a bleeder a subcutaneous or a deeper effusion may occur from very trivial causes. The condition is *serous hematoma*. If superficial, it presents the appearance of a bruise, if deeper seated, an extensive swelling forms. The condition is due to transudation of blood liquor and red corpuscles into the tissues. This fluid may clot. The condition is seldom seen in older bleeders. A serous hematoma is always the seat of tenderness, and when the muscular sheaths are involved, of severe pain.

Joint effusions occur in all bleeders, but are far and away most common in children. They follow traumatism or active exercise. The effusion is similar to that of a serous hematoma. Repeated attacks tend to cause stiffness from adhesions and perhaps to cause a condition resembling osteo-arthritis. As a rule, more than one joint is involved, but only a few joints suffer. In Rugh's case only one knee-joint suffered ("Annals of Surg.," May, 1907). If more than one joint is attacked, the involvement may or may not be symmetric.

The acute form resembles acute rheumatism and lasts about ten days. In the subacute form the temperature is lower, the symptoms less intense, and the duration shorter. In both forms joint function is restored after a first attack (Frolich, "Centralbl. für Chir.," 1905, vol, xxxii). The chronic form resembles tuberculous arthritis or osteoarthritis. In this form there is a tendency to loss of function, but there is no reaction to tuberculin.

Bleeding from mucous membranes occurs in nearly every case and is often spontaneous. The most usual form is epistaxis. There may be bleeding from the bowel, the stomach, the bladder, or the gums. Epistaxis lasts for many hours or perhaps for days when the blood begins to clot. A fatality may result. Bleeding usually ceases when the victim is almost exsanguine. The clots gather in the nose, pharynx, and mouth and undergo putrefaction.

Of course bleeding may be caused by a wound. Even very trivial wounds which would scarcely be thought of in a normal person cause prolonged hemorrhage. A wound resulting from accident or made by the surgeon may result in death. Pulling a tooth seems to be particularly dangerous. Removal of the tonsils is very dangerous. There is little peril in vaccination and apparently none at all in making a needle prick to get blood for examination, in drawing blood from a vein, and in giving hypodermic injections. Blood from a wound flows for hours or days. Sooner or later clots begin to form, but blood runs under the clots. The bleeding is not violent. It is not from the large vessels. It is a capillary ooze and may prove unarrestable. Wright (Ibid.) points out the curious tendency of hemorrhage, spontaneous and traumatic, to begin at night during sleep, a time in which the tissue output of CO_2 is at its lowest, and we know that CO_2 in the blood increases coagulability. The oozing so common in leukemia is not due to hemophilia. Neither is the oozing met with in jaundice. A child who is a bleeder must be watched and guarded unceasingly. A surgeon must be ever on the lookout for hemophilia and should inquire for it before operating. If a person is a bleeder he should be operated upon only when operation is demanded by imperative necessity.

Treatment.—The oozing is difficult and often impossible to control, although most of these cases, in the long run, recover. In the so-called acquired form the prognosis is better than in the congenital (Weil, "Centralbl. für Chir.," 1907, vol. xxxiv). Internal

administration of such drugs as ergot, gallic acid, and acetate of lead is useless. It is claimed that chlorid of calcium internally is of service. Lactate of calcium, 15 to 20 gr., is sometimes given three times a day by the mouth. It may also be given by the rectum. The value of gelatin probably depends on its calcium content. Milk may be given by rectum in order to obtain the combination of salts of milk unchanged by gastric juice (Solt, Ibid.). The local use of astringents is of no avail. Prolonged elevation may in rare cases succeed. In the case in the Jefferson Medical College Hospital the bleeding was arrested, after numerous expedients failed, by compression and hot water. Nurses sat by the bed for several days, constantly compressed the wound with gauze pads soaked in hot water, and changed the pads as soon as they cooled. The local use of Carnot's solution of gelatin has apparently saved several cases from death. Blood from another person may be injected into the depths of the wound (Bienwald). Intramuscular injection of from 10 to 20 c.c. of human blood is valuable (Kolmer). A valuable plan is to tampon the wound with gauze containing fresh animal or human blood or blood-serum, coagulose, coagulin ceba, or extract of animal organs. Kepalin is derived from the brain or thymus. It is a phosphate and is valuable. A rapid method of obtaining thrombokinase is to take the liver from a rabbit or other animal, chop it, grind it, soak in sterile water, and filter through cloth. Gauze soaked in this fluid is used to tampon a wound (Koltmann, Ibid., June 2, 1910). Wright (Ibid.) uses thymus gland. The residue from an ethereal extract of ox brain applied locally is a valuable material to combat bleeding from bone, muscle, glands, etc.

Serum in doses from 10 c.c. up may be given hypodermically or, if bleeding is very severe, intravenously. We may use human serum, horse serum, rabbit serum, diphtheria serum, or antistreptococcus serum (see page 396). After each injection of serum there is leukocytosis, and leukocytosis means increase of cells containing thrombokinase. (See Tremburg in "Medizinische Klinik," Berlin, Nov. 7, 1910.)

Witte applies locally an extract of lymphoid organs (spleen, lymph-glands, or thymus) and injects hypodermically a 5 per cent. solution of sterile peptone in 0.5 salt solution. The dose is 3 c.c. every other day until three or four doses have been taken. Then the injections are intermitted for three or four weeks (Nolf and Herry, "Reme de Medécine," Feb., 1910, and "Gaz. des Hôpitaux," 1911). Thyroid extract should be tried, as in some cases it seems to have been of value. The dose is 5 gr. after each meal. Eugene Fuller's case of hemophilia ("Med. News," Feb. 28, 1903) was apparently cured by the administration of 5 gr. of thyroid extract three times a day. In a case of hemophilia in the Jefferson Hospital thyroid extract apparently arrested the bleeding. In Rugh's case, after excision of a knee-joint, bleeding was profuse and continued, but ceased in eight days. The patient was given 5 gr. of thyroid extract three times a day. The cases are particularly interesting in connection with W. J. Taylor's observation that thyroid extract increases the rapidity of blood coagulation in jaundice cases and lessens the tendency to postoperative oozing in such cases. Wright gives tablets of thymus extract to supply the blood with nucleoprotein, administers a mixture of calcium and magnesium salts, giving CO_2 by passing into the mouth a small tube from a generator, and applies to the wound a physiologic styptic made from the thymus gland of the calf or lamb.

Operations on the Vascular System

Paracentesis auriculi, or tapping the heart cavity, has been suggested for the relief of an overdistended heart from pulmonary congestion. The right auricle or ventricle can be tapped. Push the aspirator needle directly backward at the right edge of the sternum, in the third interspace. This operation is not recommended, as it is highly dangerous and is of questionable value. It has caused fatal hemorrhage in several reported cases.

Paracentesis pericardii, or tapping the pericardial sac, is done only when life is endangered by effusion. The surgeon must avoid the pleura, lung, heart, and internal mammary artery. Introduce the needle in the costoxiphoid space close to the sternum or else 2 inches to the left of the left edge of the sternum, in the fifth interspace, and push it directly backward. By puncturing close to the sternum or more than an inch external to it we avoid the artery. The operation of tapping is extremely dangerous. The heart is lifted up and pushed forward by an effusion and the needle may enter it. The puncture of a ventricle may do no harm, although it is very liable to, but the puncture of an auricle is very apt to be followed by fatal hemorrhage. It is wiser and safer to expose the pericardium and incise it, as is done for pericardial suppuration.

Operation for Pericardial Effusion or Suppuration.—The operation of tapping should be abandoned in favor of a safer but more radical procedure. There is no spot where we can introduce the needle with perfect safety, and the heart or pleura may be wounded; further, as Brentano shows,[1] tapping will not completely empty the sac. In a purulent case tapping gives practically no chance of cure. No general anesthetic should be used. An inch of the fourth left costal cartilage should be removed or the sixth and seventh cartilages should be removed. The exposed pericardium is to be punctured in order to determine the nature of the fluid present. If the fluid is serous, it can be drained away through a small incision and the pericardium may be sutured. If the fluid be purulent, a vertical incision is made and the pericardium is stitched to the chest wall and opened. Clots should be removed by hot salt solution irrigation and a drainage-tube should be introduced. For several days the sac is irrigated daily with normal salt solution and then Dakin's oil is used daily. The mortality is about 30 per cent.

Operation for Wound of the Heart.—At once give atropin hypodermically in order to antagonize vagus inhibition. Stimulants would increase bleeding and stimulants are not to be given until bleeding has been arrested. In many cases it is obviously impossible to administer an anesthetic, but when possible it should be given because the movements of the patient while under the knife make operation difficult and increase bleeding. Ether may be used or we may take Hill's advice and give chloroform. Hill would give an anesthetic unless the patient is unconscious and the corneal reflex is abolished. The pericardium can be exposed freely and Rotter's incision gives excellent access, although it always opens the pleura. This exposure is described by Hill in the "Medical Record," Nov. 29, 1902, and was employed in his successful case. Begin an incision over the third rib ⅝ inch from the left edge of the sternum and carry it outward along the rib for 4 inches. Begin an incision over a corresponding point of the sixth rib and carry it out for a like distance. Join the outer extremities of these cuts. Cut through the ribs and pleura by bone forceps and scissors. Raise the flap upon its hinges of cartilages, and have an assistant grasp the lung to prevent collapse. The pericardium thus exposed is opened widely if necessary. The pleura is packed off with gauze. If the right auricle, left auricle, or right ventricle is wounded the flow of blood is continuous. If the left ventricle is wounded the flow of blood is pulsatile. An auricular wound or a wound in the right ventricle gaps. A wound in the left ventricle closes from contraction. Hill advises us to steady the heart by pressing the hand under it and lifting it. Parrozzani did this by inserting a finger in the wound. Other surgeons have used traction sutures of silk. Rehn takes the organ in the palm and arrests hemorrhage by pressure on the great veins (page 350). For wound closure interrupted sutures are preferred to the continuous suture. China silk should be used. They should be inserted by a round needle. "As few as possible should be passed commensurate with safety against leakage, as they cause a degeneration of the muscular fiber." It does no harm apparently if they enter a heart chamber, but it is wiser not to have them do so. The moment bleeding has been arrested by the sutures institute active treatment for shock. Ligature of one coronary artery may be survived. Stewart's patient lived several years ("Amer. Jour. of Surg.," lviii). Babcock ("N. Y. Med. Jour.," June 10, 1916) emphasizes the danger of air being sucked into a cardiac cavity or into a coronary artery. He says it is more dangerous if air is sucked into the left ventricle than if it is drawn into the right. Before closing the left ventricle he would aspirate it of air and if air bubbles are seen in the coronary vessels he would aspirate them through a hypodermic needle. If the heart fails, use heart massage (L. L. Hill, Ibid.), and inject into the organ a small amount of adrenalin. The pericardial and pleural sacs are cleansed by salt solution. The question of drainage is still *sub judice*. The pleural sac is treated according to indications in each case.

George Tully Vaughan, in reporting his second case of heart suture and a table of 150 operations ("Jour. Amer. Med. Assoc.," Feb. 6, 1909), mentions five methods for exposing the heart, and states that no single method has yet been agreed on as the best. The kind of operation is often determined by the external wound, and, begun as an exploration, the subsequent steps depend on the necessities which arise during its progress. The five methods mentioned by Vaughan are: (*a*) Through an intercostal space, with or without the division of one or two cartilages; (*b*) resection of one or more cartilages, with or without a portion of rib; (*c*) flap method across the sternum, dividing the sternum and cartilages (this avoids opening the pleura); (*d*) flap of car-

[1] "Deut. Med. Woch.," Feb. 11, 1890.

tilages and ribs with an external hinge; (*e*) flap of cartilages and ribs with an internal hinge.

Vaughan's table shows that in 46 patients the pericardium was drained, with 25 recoveries and 21 deaths; in 44 the pericardium was not drained, with 25 recoveries and 19 deaths; in 42 both the pericardium and pleura were drained, with 21 recoveries and 21 deaths; in 19 both pericardium and pleura were closed without drainage, with 12 recoveries and 7 deaths; in 72 the pleura was drained, with 30 recoveries and 42 deaths; in 21 the pleura was not drained, with 13 recoveries and 8 deaths. These figures would indicate that drainage should not be the rule. It should be used though if bleeding continues or if we greatly fear infection. Of course, drainage causes irritation, prevents the lung expanding, and makes secondary infection more probable (Vaughan in "Jour. Amer. Med. Assoc.," Feb. 6, 1909).

In Vaughan's table of 150 cases we find that 98 died and 52 recovered, a mortality of 65 per cent.; 32 patients died in less than twenty hours after the operation for the injury, and 15 died on the table or just after the operation. In all but 1 of these cases death was due to hemorrhage. In 1 it was due to pneumothorax on opening the pleura. The remaining 66 deaths occurred in from twenty-four hours to five months after the operation: 6 died of pleurisy, 5 of pericarditis, 21 of combined pleurisy and pericarditis, 3 of pneumonia, 3 of peritonitis, 2 of pericarditis and nephritis, 1 of pleurisy and cerebral abscess, 1 of pleurisy and wound of the tricuspid valve, 1 of pleurisy and double pneumonia, 1 of gangrene of the lung, 1 of two wounds, one of which was not sutured, 3 of bleeding into the pleura, 2 of bleeding into the pericardium, 1 of clot in the tricuspid opening, and 15 of unassigned causes. Laotta's table ("Policlinic," xx, 1913) contains 236 cases of cardiac suture. It shows that 44.91 per cent. recovered. The reader may consult Pool in "Annals of Surgery," 55, 1912, and Ballance's collection of 152 cases collected since Pool's cases and published since (Bradshaw, "Lecture on the Surgery of the Heart," McMillan Co., 1920).

Cardiolysis.—As a result of pericarditis the heart may adhere to the pericardium and the pericardium to the chest wall. Adhesions may form in the mediastinum. The muscular wall of the heart may be involved. The descent of the diaphragm is interfered with. The heart hypertrophies. Ascites and edema develop. This condition is dangerous, and, if unrelieved, will eventually prove fatal.

Delorme (Gaz. d. hôp., 1908, 125) has suggested that the pericardial sac be opened and the adhesions be broken down with the finger, a very dangerous procedure, which is almost certain to inflict serious injury upon the heart.

Brauer's method, which he suggested in 1902 (Arch. f. klin. Chir., lxxi, 1902), consists in removing portions of the several ribs and their cartilages and the portion of the sternum to which the pericardium adheres. The fourth, fifth, sixth, and seventh ribs are the ones selected. The periosteum is to be removed with the bone to prevent the formation of new bone. This is the preferable operation. The safest plan is to remove the anterior, but not the posterior, periosteum. The danger of fresh ossification is then slight and we avoid injuring the left pleura (Poynton and Trotter, quoted by Simon, in "Brit. Med. Jour.," Dec. 14, 1912). The operation can be done with the aid of local anesthesia. Brauer's operation may benefit a patient greatly if the interference is with systole. It is of no value if the interference is with diastole. In the latter case only a direct attack on the adhesions as practised by Delorme could be of avail. Delagenière ("Archiv prov. de Chir.," 1913) collected 33 cases of operation. One died from operation, 6 were not successful, 26 were successful.

Decompression for Heart Hypertrophy.—In a case of cardiac hypertrophy from aortic valvular disease, in which the heart knocked violently against the ribs, and in which there were no adhesions, Morrison performed thoracotomy. He removed several inches of the fifth rib and an equal length of the sixth rib. The patient was much improved, the capacity of the chest was increased, and the painful attacks were practically cured ("Lancet," July 4, 1908).

Cardiotomy and Valvulotomy for Mitral Stenosis.—Elliott C. Cutler and S. A. Levine ("Boston Med. and Surg. Jour.," June 28, 1923) report the first case in the history of surgery of operation for mitral stenosis. The patient was much benefited. This brilliant operation and the years of patient laboratory toil which led up to it mean that a new field has been opened in the surgery of the heart and a field which we hope and believe will be rendered lustrous by achievement.

Operation to Permit of Resuscitation by Direct Cardiac Massage.—This procedure was suggested by Schiff in 1874.

1. **Abdominal Route.**—Open the abdomen, place the hand between the diaphragm

and the left lobe of the liver, grasp the heart through the diaphragm and squeeze it twenty or thirty times a minute, at the same time press on the chest wall with the other hand. An assistant gives an intravascular or intracardiac injection of adrenalin. Babcock claims that this treatment may restore cardiac action twenty minutes "after somatic death unless the patient is exsanguinated or has markedly degenerated organs" ("N. Y. Med. Jour.," June 10, 1916). If the cells of the cerebral cortex have been entirely deprived of blood for seven minutes they perish. In a case in which the heart is restored to action after having been stopped for seven minutes consciousness will not return and the patient will die.

2. **Transthoracic Route.**—Several ribs or rib cartilages are quickly resected and the hand is plunged in the chest and grasps the heart. Cardiac massage acts by emptying the distended chambers of the heart, maintaining a certain small amount of circulation, and stimulating the heart muscle to contraction.

Operation for Varix of Leg.—Many cases do not require operation. In some, operation is positively harmful. In some selected cases operation is very useful to remove certain complications (ulcer, eczema, etc.), and to relieve the patient from annoyance, but the operation rarely absolutely cures the condition. As Blake points out, a cure cannot be claimed until at least one year has passed after operation without reappearance of the varix ("Boston Med. and Surg. Jour.," Sept. 25, 1902). The indications and contraindications are discussed on page 357. Never operate if phlebitis exists except to treat thrombosis. After any operation for varicose veins of the leg follow Bennett's advice and keep the patient in bed for three weeks and do not let him resume active work for three weeks more ("Lancet," Nov. 22, 1902).

The superficial veins must not be tied or excised if the deep veins are involved (page 357). In such a case no operation is justifiable except incision of the fascia lata, placing the internal saphenous vein under the deep fascia (Cecca's operation). This procedure enables tissue to give support to the vein without blocking it.

Homans ("Surgery, Gynecology, and Obstetrics," Feb., 1916) describes certain clinical tests to demonstrate the true nature of varicose veins. "The tests devised by Trendelenburg are easily performed. The leg is raised and held above the level of the heart until the veins are empty. It is then rapidly lowered when the blood can be seen to flow back into the leg and suddenly distend the surface vessels. This test for varicosity may be positive even when the reflux cannot be seen to distend the vein walls, for if the veins are so sclerosed that no change in the tension of their walls can be noted by the eye, it can quite readily be felt by the fingers.

"By such means valvular incompetence of the surface veins as opposed to hypertrophy or distention of normal vessels can be diagnosed, but still more information may be derived from a variation of the same simple procedure. Suppose it has already been determined that the surface veins allow a free back flow. The leg is now raised and the veins emptied of blood. If, before it is lowered, a constriction only firm enough to compress the surface vessels, as by a piece of bandage, is made about the upper thigh, blood cannot flow from above into the varicose superficial veins, and until they are filled by the natural circulation they remain empty.

"This French writers have called the *contre-epreuve* of the Trendelenburg test, and it confirms the diagnosis, for on releasing the constriction, the empty or partially filled veins become distended with a palpable shock. But this procedure tells even more. Suppose the perforating veins share the varicosity of the surface vessels. The blood in the deep veins will then be able, as normally it cannot do, to leak into the surface vessels, and in applying the constriction test it will be found that in spite of the prevention of back flow down the superficial veins, these fill rapidly below the constriction. That is to say, blood is finding its way out from the unobstructed deep veins through incompetent perforating vessels to the surface. In varicosity of the surface veins alone filling below the constriction takes place in three-quarters of a minute or more, and even then these vessels may not be very tense, for the perforating veins are continually carrying off the excess of blood. If, on the other hand, the perforating veins are incompetent, the surface vessels will fill below the constriction, possibly in ten, twenty, or thirty seconds, according to the importance of the leak.

"These two tests, which I shall hereafter call respectively the Trendelenburg test and the constriction test for perforating veins, serve to separate the cases of pure surface varicosity from surface varicosity complicated by varicosity of the perforating veins. The tests ignore the possibility of varix of the deep venous system, a very rare condition if, indeed, it is ever fully developed."

Trendelenburg's Operation.—I have employed this with much satisfaction in

cases of varix of the leg following involvement of the saphenous in the thigh when the perforating veins are competent. Trendelenburg believes that in varix the valves in the saphenous become incompetent because of high central pressure. The veins of the leg distend, as they are unable to support such a long column of blood, and finally the blood begins to flow in the wrong direction in the saphenous, a "vicious circle" being established (page 357). The operation is performed as follows: Make an incision about 4 inches in length over the internal saphenous vein at the junction of the upper and middle thirds of the thigh. If the thigh is very fat make a transverse incision. Expose the vein, ligate each visible branch, ligate the saphenous at the lower end of the wound and also at the upper end, and remove the portion of vein included between the ligatures. Do an exactly similar operation just above the inner condyle, and another similar operation just below the inner condyle of the femur. If painful varicose tumors exist they should be excised. By this operation the central pressure is intercepted and the dilated veins in consequence shrink. Recurrence is frequent after Trendelenburg's operation, but only about half of the recurrences develop symptoms. The operation is valuable in the old and infirm or "to tide a young person over a difficult period, or, indeed, merely to heal an ulcer temporarily" (Homans, Ibid.).

Madelung's operation is used for surface varix with involvement of the perforating veins (Homans, Ibid.). It consists of complete excision of the great saphenous. *Charles H. Mayo* excises the vein. He ties and divides it just below the saphenous opening, passes the end of the vein through the loop of his dissector, and thus separates the vein as the dissector is passed down to near the knee. The end of the dissector is cut upon, the loosened vein is pulled out, ligated in the wound, and excised. The surgeon may remove in like manner as many more veins as he wishes. *Schede* makes a circular cut (a circumcision) completely around the leg at the junction of the upper and middle thirds, the incision reaching to the deep fascia. All bleeding points are ligated and the edges of the incision are stitched together. This operation is so often followed by persistent hard edema that it is now seldom performed. A recent operation is to place the internal saphenous beneath the deep fascia. *Delbet* implants the saphenous vein into the femoral 10 cm. below its normal point of junction. The valvular arrangement of the femoral restores normal tension in the saphenous. *Fergusson* ties the saphenous vein near the femoral and removes a section from it. This makes the varices clearly evident. A semilunar incision is made to surround the varices, which incision reaches to the deep fascia. The flap is raised and dissected up, the vessels are tied, and the flap is sutured in place. *Keller* removes a vein by inversion ("N. Y. Med. Jour.," Aug. 19, 1905). *Phelps* advises multiple ligation. *Katzenstein* places the vein under the sartorius muscle. Sir Wm. H. Bennett thinks that in ordinary cases the best operation consists in removing a portion of the long saphenous in the thigh and also in removing 3 inches of the vein from below the knee. If there are cystic dilatations above the knee he removes the saphenous from the thigh. Some local varices he dissects out ("Lancet," Nov. 22, 1902). As a matter of fact, excision of a short piece of vein seems to do as much good as excision of a long piece. Excision of a piece at several points is valuable. The object of excision is to reduce pressure on the vein walls by breaking up the column of blood (Barker in "Practitioner," Oct., 1910). Any of the suggested operations may be followed by relapse.

Phlebotomy, or Venesection.—Operation.—The patient sits on a chair "with the arm abducted, extended, and inclined outward" (Barker). The parts are asepticized and a tape is tied around the arm just above the elbow. The patient grasps a stick firmly and works his fingers in order to cause the veins to distend. The surgeon stands to the right of the arm, holds the elbow with his left hand, and puts his thumb upon the vein below the intended point of puncture. Either the median cephalic or the median basilic may be opened (Figs. 245, 246). The median basilic is the more distinct, and is the vein usually selected. In opening it do not cut too deep, as nothing but the bicipital fascia separates it from the brachial artery. The median cephalic may be selected (we thus avoid endangering the brachial artery); under this vein lies the external cutaneous nerve (Fig. 246). Steady the vein with the thumb and open it by transfixion, making an oblique cut which divides two-thirds of it. Remove the thumb and allow bleeding to go on, instructing the patient to work his fingers. When faintness begins, remove the fillet, put an antiseptic pad over the puncture, apply a spiral reversed bandage of the hand and arm and a figure-of-8 bandage of the elbow, and place the arm in a sling for several days.

Transfusion of Blood.—(In the revision of the technical part of this section I had the very valuable help of Dr. Harold W. Jones, Instructor in Medicine in Jefferson

Medical College.) Some would have us believe that it is spoken of in the "Book of the Wisdom of Solomon" and is referred to in the anatomy of Herophilus. Some ingenious students interpret certain obscure allusions of Roman poets to mean that the operation of transfusion was known and practised in the time of Augustus. The following line from Ovid has been cited: "Ut repleam vacuas juvenili sanguine venas."

It has been stated many times that the earliest application of transfusion was in the case of Pope Innocent the eighth in 1492. It seems absurd to believe that transfusion was practised before the discovery of the circulation of the blood. Villari, in his "Life of Savonarola," states that blood was transfused, but Villari wrote about the year 1860. The contemporary authority, Infessura, does not justify Villari's conclusion. Infessura's story is found in Sabatini's "Life of Cæsare Borgia," and is as follows: The Pope, who was sixty years of age, and who had been subsisting on the milk of women, passed into a state of such extreme weakness that the courtiers thought he was dead.

A Jewish physician claimed to be able to prepare a medicine from the blood of youths which would save the Pope's life. He performed phlebotomy on 3 ten-year-old boys, and all of them died. The Pope repudiated the act of the physician and ordered his arrest, but the enterprising practitioner escaped.

It is alleged that Libavius described transfusion in 1625, but according to Heister the name of the book is not stated by his sponsors (Heister's "Surgery"). Furthermore, Harvey did not publish his discovery of the circulation until 1628. Lower, of Oxford, and Sir Christopher Wren in 1665 experimented on transfusion from animal to animal and on the injection of drugs into veins.



FIG. 245.—Incisions for venesection (Bernard and Huette).



FIG. 246.—Superficial veins in front of elbow (Bernard and Huette).

In November of 1666 Dr. Croone (after whom the Croonian Lectures are named) told Pepys about "a pretty experiment" made very recently at Gresham College, the blood of a little dog having been "let out till he died, into the body of another." Pepys continues: "This did give occasion to many pretty wishes, as of the blood of a Quaker to be let into an Archbishop and such like" (Wheatley's Edition of "Pepys's Diary").

In Birch's "History of the Royal Society" this very experiment is recorded. From that book we learn that Mr. King (afterward Sir Edward King) and Mr. Coxe operated, and that the dog recovered. In June of 1667 Denys, of Montpelier, applied the treatment to a young man who was weakened by repeated hemorrhages. The blood of a calf was injected and the man recovered. November 23, 1667, a Bachelor of Divinity, aged thirty-two, was transfused from a sheep. Pepys says he was a "poor and debauched man" who was hired for 20 shillings by the Society. Birch's "History" states that he was the first man in England to be transfused. The operation succeeded. Pepys saw the man a week later and says he was "the first sound man that ever had it tried on him in England, and but one that we hear of in France, which was a porter hired by the virtuosos."

Great things were expected of the discovery. It was thought that it would permit of saving the weak, the aged, the diseased, by fresh blood, and offered an ideal method of administering drugs. Dr. Croone told Pepys it may "if it takes, be of mighty use to man's health, for the amending of bad blood by borrowing from a better body." The artery of a donor was opened and the blood was allowed to flow into the vein of a recipient. A fierce controversy quickly arose as to the merits and safety of the procedure. Proof was soon furnished that it was very dangerous. The Parliament of Paris issued an edict that no transfusion should be made without the consent of the Faculty of Medicine of Paris. The operation soon fell into desuetude. It was condemned in 1739 by Laurence Heister in his "System of Surgery." Now and then an attempt was made to revive transfusion, but it was not recognized as a legitimate procedure until Blundell's studies in 1824. For years some of its dangers were recognized and it was used only for hemorrhage which gravely threatened life. Postpartum hemorrhage was the particular indication. Some used immediate transfusion from the

vein of the donor to the vein of the recipient. Some used mediate transfusion, the blood of the donor being drawn into a vessel and injected into the vein of the recipient. It was claimed by Panum that the blood should be defibrinated before injection. Blundell believed that blood of animals of the same species was the only kind admissible, but Brown-Séquard denied this. Gaillard Thomas actually advocated the injection of milk. The chief value of transfusion was found in the fact that it supplied sufficient fluid to replace that which was lost and stimulated the heart to contraction. The great perils were thought to be clotting and entrance of air, and various plans were suggested to prevent them. It was for this reason that defibrination was employed. Richardson added a few drops of ammonia to each ounce of drawn blood, Braxton-Hicks used phosphate of sodium. Heuter advocated injecting the blood into an artery in order that it might reach the heart less rapidly and the danger of air embolism might be averted. Infection was a grave danger before the days of Listerism. In 1875 Landois discovered that animal serum was hemolytic to human blood. In 1892 Maragliano discovered that the serum of a healthy man was hemolytic to a serum alien to it. It thus became evident that human serum, alien to another serum, was dangerous and might cause death.

Von Bergmann maintained that after severe hemorrhage there is no need of injecting nutritive elements. The need is to restore the greatly diminished intracardiac and intravascular pressure and this can be done by the injection of salt solution. Senn insisted that the operation of transfusion had proved an absolute failure, that it did not prevent death from hemorrhage, and that the transferred blood elements did not retain vitality. In 1895 Sir A. Pearce Gould, writing in Treves's "System of Surgery," expressed the view of most surgeons when he said: "Since such excellent results have been obtained with saline injections, both forms of transfusion have been abandoned." It was seldom used except in victims of poisoning by illuminating gas, in which cases its effects were known to be more powerful and prolonged than those of saline fluid. In fact the operation was all but extinct until Crile and Carrel revived it, and showed that blood was superior to saline fluid. It proved of the greatest service in the World War.

Transfusion has gone through cycles of popularity and discredit. At present it enjoys wide confidence as a therapeutic measure in many conditions. The restoration of confidence is due to simplification of technic and a more accurate knowledge of methods of blood typing. Shattuck in 1899 instituted blood typing, and a few months later Landsteiner published a study upon the subject. These observers noted the presence of iso-agglutinins in the serum which differentiated individuals into four groups. According to the Moss classification 10 per cent. of all persons are in Group 1, 40 per cent. in Group 2, 7 per cent. in Group 3, and 43 per cent. in Group 4. Guthrie (Johns Hopkins Medical Bulletin, Feb., 1923) creates two additional groups, 5 and 6. Unger has showed that types of sera in the great majority of cases are not differentiated in the infant until six months of age. This explains the reason for the old belief that the mother's blood was always compatible with that of her baby.

What of the terms, *universal donor* and *universal recipient?* A person with Type 4 blood was called a universal donor because it was thought that his blood could be given to anyone without agglutinating the cells of any other group. An individual of Type 1 was called a universal recipient because it was thought that his cells could not be agglutinated by the serum of any other group. These beliefs are erroneous and if adhered to will lead to the occurrence of many violent reactions. We know that there are present minor agglutinins which in a certain percentage of cases agglutinate the cells of a patient of the same type as readily as those of another type. Cross-agglutination has notably reduced the number of serious reactions. It consists in matching the serum of the donor against the cells of the recipient and the serum of the recipient against the cells of the donor. The type of an individual sometimes, though very seldom, changes after transfusion, hence cross agglutination should be done before each transfusion even when the same donor is used. A change of type may follow ether or gas anesthesia. It doesn't last over four days. In Dr. Harold W. Jones's 100 cases of transfusion this change was noted in 3.

Reactions constitute the most disagreeable and dangerous element after blood transfusion. There are various reactions and various causes for them. We may specify these types: (1) Simple rise in temperature; (2) chill or chilly sensations; (3) chill and rise in temperature; (4) petechia; (5) petechia with ecchymosis and hemoglobinuria; (6) the allergic reaction. In type 1 the temperature seldom mounts to above 100° F. The chills and rise in temperature indicate nothing serious. The short mild

chills are of little consequence. In some cases there is very severe reaction, the temperature rising to 108° F., the fever being accompanied by deep cyanosis and a rapid and extremely feeble pulse. This latter type of reaction may result in death. The best treatment for the severe reactions is morphin hypodermically ($\frac{1}{6}$ to $\frac{1}{4}$ grain) and adrenalin chlorid (10 to 15 m. of a 1:1000 solution).

The petechial eruption developing during or shortly after the transfusion usually indicates that a certain degree of hemolysis has taken place. Severe hemolysis is indicated by petechiæ, ecchymosis, hemoglobinuria, epistaxis, abdominal pain, nausea, vomiting, diarrhea, and malenia. True allergic reactions are often called anaphylactic and are believed to be due to protein sensitization and are probably rare. They produce urticaria, pruritus, expiratory dyspnea, and edema of the lungs. They are more common if more than seven days are allowed to elapse between transfusions. In leukemia severe reaction may occur at any time. In pernicious anemia, after repeated transfusions, the patient may become so sensitized that any blood will be harmful.

Causes of Reactions.—(1) Improper typing; (2) failure to cross-agglutinate; (3) change of type; (4) the use of citrated blood; (5) the presence of the early products of coagulation; (6) poor technic in the performance of the operation; (7) the presence of large numbers of non-nucleated and nucleated red blood-cells which fail to agglutinate because of the presence of a resistant cell membrane (Raphael Isaacs, "Arch. Int. Med.," vol. 33, No. 2, p. 193, Feb., 1924); (8) the injection of too large an amount of blood; (9) the too rapid injection of blood. Reactions may be prevented by: (1) Careful typing; (2) cross-agglutination before each transfusion; (3) the use of whole blood; (4) transfuse within the seven-day period; (5) inject moderate amounts of blood except in cases of severe hemorrhage; (6) do not inject the blood too rapidly—50 c.c. per minute is rapid enough; (8) carry out the operation with dispatch, do not let the blood stand idle; (9) if petechia appear about the tourniquet, either do not perform the operation or proceed with the greatest caution; (10) when in doubt inject 20 to 40 c.c. of blood and wait to see if a reaction occurs before proceeding with the transfusion.

Danger Signs or When to Discontinue the Transfusion.—(1) Facial erythema; (2) feeling of oppression in chest; (3) difficulty in breathing; (4) precordial pain; (5) short dry cough; (6) epigastric pain; (7) nausea or vomiting; (8) presence of petechia about tourniquet except in cases of purpura hæmorrhagica.

Indication for Transfusion.—Acute hemorrhage. Transfusion is, incomparably, the best form of treatment for acute hemorrhage. Even cases apparently hopeless will often respond. It is difficult to state just what loss of blood must have taken place to warrant a transfusion. The blood-count is often misleading. Frequently when there has been considerable hemorrhage one is amazed to find that the hemoglobin and red cells are not reduced to a degree comparable to the severity of the clinical features, and the size of the hemorrhage. This is the result of the great fluid loss. The normal ratio between fluid and cells is lost, with a result that there are more cells per cubic millimeter due to the serum depletion. Later, when the serum is replenished, the hemoglobin and red cells are found to be lowered. Transfusion has a very definite place in duodenal and gastric ulcer complicated by hemorrhage, and should be used repeatedly until the blood elements approach normal figures before surgery is instituted. It lessens the coagulation time and will not raise the blood-pressure more than 10 points. In a study of 50 transfusions the blood-pressure was not raised more than 10 points and the coagulation time was reduced from one to five minutes.

In the severe hemorrhages of typhoid fever transfusion is of the greatest value. We recently gave a typhoid patient three transfusions at three-day intervals, without the slightest reaction.

In the great group of cases that come under the heading of secondary anemia transfusions are productive of the most brilliant results and attended with the least danger. This group includes acute and chronic hemorrhage, chronic suppurative conditions, such as pelvic peritonitis, tubo-ovarian disease, chronic osteomyelitis; and genito-urinary conditions, such as tuberculous kidney, pyelonephritis, cystitis, stricture, hypertrophic prostatitis, and chronic urinary fever. Transfusion promotes healing in suppurating and slowly healing wounds. It is useful in making a poor surgical risk a safe one; for instance, in making an operation possible in those who are debilitated by malignancy. It will often prepare a patient for an urgent operation, and, following the preliminary transfusion, further transfusions can be given, thereby shortening the convalescent period. It is used to advantage in the anemia of chronic nephritis and arthritis.

Transfusions in septicemia require special mention because so many are convinced that their use is contraindicated. They are not given to combat the infection directly or to dilute the toxemia, but to treat the existing secondary anemia. In the fulminating streptococcic septicemias that rapidly reach a fatal end transfusions are of little value and severe reactions are common. But in those blood-stream infections that tend to develop slowly and in which secondary anemia of increasing severity appears, transfusions are indicated and are of distinct value.

In purpura hæmorrhagica, now called thrombocytopenia because it is thought by some that the platelet reduction is the principal feature of the disease, blood transfusion is especially useful. Its first use is as a life-saving operation. In those cases in which the blood elements are so reduced that death is imminent, a transfusion of undiluted blood will save life; 600 to 800 c.c. should be given at intervals of three to five days or oftener until the blood-count is within the limit of safety. Then smaller amounts can be given at the same intervals until the blood elements are normal. The blood-platelets are the last to return to normal. Following this counts should be taken at frequent intervals, and if the red blood-cells or platelets fall, further transfusion should be instituted.

Transfusion will also prepare the patient for the operation of splenectomy, and following this may be used to more quickly carry the blood to a normal level.

In splenic anemia and in those patients that reach the stage called Banti's disease transfusion is useful before the operation of splenectomy, and after it to shorten the convalescent period.

In leukemia transfusions are often attended by very severe reaction and seem to do little good. However, we recently transfused a boy with acute lymphatic leukemia and were able to raise his blood from 24 per cent. Hb. and 1,600,000 red blood-cells to 62 per cent. Hb. and 3,460,000 red blood-cells. There was only one severe reaction, in which the temperature rose from 102⅘° to 105⅘° F. Five transfusions were given in amounts of from 150 to 340 c.c. over a period of fifteen days.

In pernicious anemia, contrary to the general belief, transfusions are of the greatest value. They are used first as a life-saving measure; second, with the hope of carrying the patient along at a fairly high level until a remission occurs. Third, with the hope of stimulating a remission. Fourth, bringing the blood to normal level and keeping it there by occasional transfusion or the subcutaneous injections of blood. Fifth, with the hope that a few of them will be cured. To accomplish this, however, it is essential to use undiluted blood in small amounts, 350 to 450 c.c. every three to five days. Unfortunately after repeated transfusions even though cross-agglutination has been carefully carried out, serious hemolytic reactions may occur. This results because the patient is immunized by repeated transfusions against bloods previously compatible (H. M. Bowcock, "Johns Hopkins Bull.," 1921, xxxii, 83).

The *subcutaneous injection of whole blood* is used more extensively in Europe than in this country. It is of value because the blood is easy to obtain, because there are no serious reactions, because its administration is very simple, and the expense is less to the patient than transfusions. Typing is unnecessary. The blood is drawn and immediately injected subcutaneously in amounts of 10 to 20 c.c. This can be done daily until a suitable rise in the blood elements occurs. The injection will reduce coagulation time and has been successfully used in stopping hemorrhages from mucous surfaces. We have observed a rise in hemoglobin of 5 per cent. and red cells 400,000 three days after the injections of 20 c.c.

It cannot, however, take the place of transfusions. It does not supply blood volume and the stimulation is not as great. It should be used as an adjunct to transfusion.

Autotransfusion has been successfully used in many patients where there is intraperitoneal hemorrhage. The blood is taken from the abdomen, filtered, and at once injected intravenously. In patients with gunshot wounds of the abdomen with perforated intestines and in those who have ruptured ectopic pregnancy complicated by tubal disease the use of this blood is dangerous. However, as an emergency measure it may be used in the latter trouble.

The *intraperitoneal injection of citrated blood* previously typed is advocated by Sipperstein and Sansby ("Amer. Jour. Dis. Child.," 25, 107, Feb., 1923). They have shown that following intraperitoneal injection of blood there is an increase in blood elements, and also, using red blood-cells of birds in transfusing dogs, that these cells appear in the circulating blood shortly after the intraperitoneal transfusion. This type of transfusion is particularly applicable in children and in those cases in which a suitable

vein is not available. One must use the greatest care in the insertion of the needle so that a loop of gut is not punctured.

Blood transfusion in children presents a varied problem. Bleeding in children rapidly produces severe anemia, but, fortunately, regeneration takes place almost as quickly. In the very young many difficulties are met within performing transfusion. Veins of sufficient size to admit a needle are few. It is almost always necessary to expose the vein at the elbow, and the wriggling, twisting infant will often cause the needle to fall out of the vein, and it may be impossible to reinsert it.

Injection of blood into the longitudinal sinus through the anterior fontanel can only be used in the very young and requires considerable skill. The dangers are clot formation and that the needle may perforate the sinus and the blood be injected into the brain substance.

The external jugular vein is frequently used.

The difficulties encountered here are, first, that the vein is not well supported and tends to move away from the needle as it is inserted. Second, the head and shoulder tend to come together through the movements of the child. Falls has devised a table which holds the child in position and permits of the best exposure of the vein ("Jour. Amer. Med. Assoc.," 80, 678, March 10, 1923). He considers this the best method.

One cannot definitely state the amount of blood that should be given in one transfusion. We know that it is possible to produce cardiac dilatation and pulmonary edema by the injection of too large amounts or by too rapid injection of blood. Except in cases of acute hemorrhage or in very severe anemias we seldom inject more than 350 to 500 c.c. It has been our experience that smaller amounts of blood given at intervals of three to five days are better tolerated by the patient, supply the necessary nutrition and stimulate the bone-marrow, or at least give it a chance to carry regeneration to its normal stage. In patients with secondary anemia of moderate severity it is seldom necessary to give more than three transfusions in order to bring the blood elements to their normal plane. However, in purpura hæmorrhagica, acute hemolytic jaundice, splenic anemia, and pernicious anemia repeated transfusions at intervals of three to five days are necessary to produce satisfactory results.

It should rarely be necessary to expose a vein in order to perform a transfusion. If frequent transfusions are to be given the exposure of the vein, which often results in its destruction, may prevent the carrying out of the plan of treatment.

The Use of Citrated Blood.—The advantages of the citrate method of transfusion are that the patient and the donor do not need to be in the same room, that there is no danger of infecting the donor, that the citrated blood may be kept in sterile containers for an indefinite period, and be used in cases of emergency.

The Disadvantages of the Citrate Method.—(1) Reactions are more frequent. Reports from various sources show reaction occurred in from 30 to 60 per cent. of cases in which citrate was used. Unger, using undiluted blood, reports 10 per cent. of reactions in a series of 100 cases. We find reactions occurring in about 19 per cent. of cases. This percentage includes the most simple type, that is, a slight rise in temperature without other signs or symptoms; (2) we personally know of one case of death from the injection of 50 c.c. of a 2 per cent. sodium citrate solution; (3) in some instances even though citrate is used the whole amount of blood clots, and of course cannot be used; (4) the chance for contamination is greater than with the Unger method; (5) the addition of the sodium citrate, the stirring that is necessary, and the exposure to air destroys the blood-platelets. Therefore the use of citrated blood is contraindicated in purpura hæmorrhagica.

Unger Method.—We regard this as the preferable method. This method was devised by Lester Unger of New York City in 1915. It did not, however, receive general recognition until after the World War. The apparatus is distinctive for its simplicity. Whole blood can be transferred rapidly without coagulation and without injection of air; 100 c.c. of blood can be transferred per minute or 1 pint in five minutes. In nearly a thousand transfusions we have never had a failure; never had clotting of blood, and in only 1 case was it necessary to expose the vein. It can be performed in the patient's room just as well as in the operating room.

Technic.—The recipient and donor should be as nearly as possible on the same level. The arm of the donor corresponds to the arm of the recipient; therefore the subjects oppose one another, feet to head. A table or a board is placed between them, so that the arms may rest upon it. The instrument is clamped on table or board as in Fig. 247.

The operator always faces the recipient.

The assistant always faces the donor.

The steel cylinder C, containing two grooves, one of which is shown, is held in place by screw D and rotates between J and K, so that when pointer M is to J, that is,

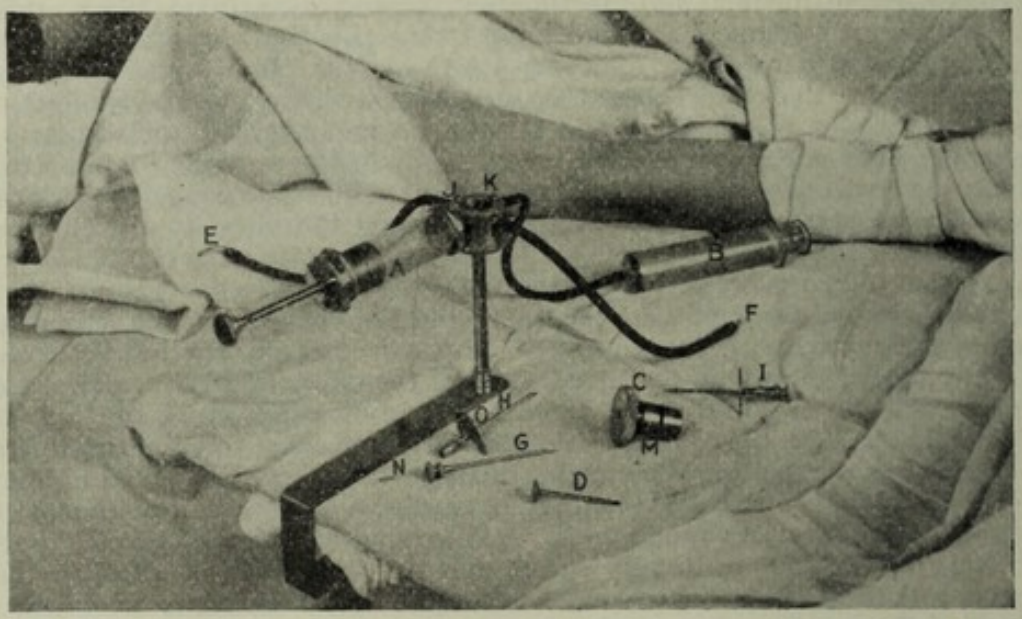


FIG. 247.—Unger apparatus: A, Record syringe, 20 c.c., for transfer of blood; B, Luer syringe, 20 c.c., for normal saline; C, steel grooved cylinder which rotates between J and K directing flow of blood and saline; D, screw to hold cylinder C in place; E, curved connecting piece fitting donor's needle; F, straight connecting piece for patient's needle; G, sharp inner portion of large needle for donor; H, dull outer portion of donor's needle—note collar that holds needle in position; I, smaller patient's needle, together, ready for use; J and K, posts between which cylinder rotates; L, long arm of clamp holding instrument to table; M, one of two grooves in cylinder C; N, table between patient and donor. (Harold W. Jones.)



FIG. 248.—Direct transfusion of whole blood (Unger method): Donor on right, patient on left. Operator always faces patient (Harold W. Jones).

toward the donor, the flow of blood is from the donor at E through the groove to the operator's syringe A. At the same time the other groove transmits normal saline by way of the assistant's syringe, B, through rubber tubing to recipient, thereby giving

a continuous flow of fluid. When the cylinder C is turned, and the pointer M is at K, the blood in the operator's syringe, A, goes through the groove to the recipient at F, and the assistant's salt solution keeps the donor's blood from entering his syringe or, if necessary, can be injected into the donor.

Ether is poured in a very fine stream on the syringe A during the operation. This prevents a degree of coagulation and prevents the steel cylinder of the syringe from dilating.

In giving 500 c.c. of blood 20 to 40 c.c. of salt solution is all that is necessary to be injected.

It is essential to have a large caliber needle for the donor. Note that the needles are of two parts—G the sharp part and H the dull portion. G is withdrawn after the needle is well in the vein, and H, the dull portion, remains. The collar holds the needle in place; N is the stilet for the needle; E is curved at the tip to permit attachment of

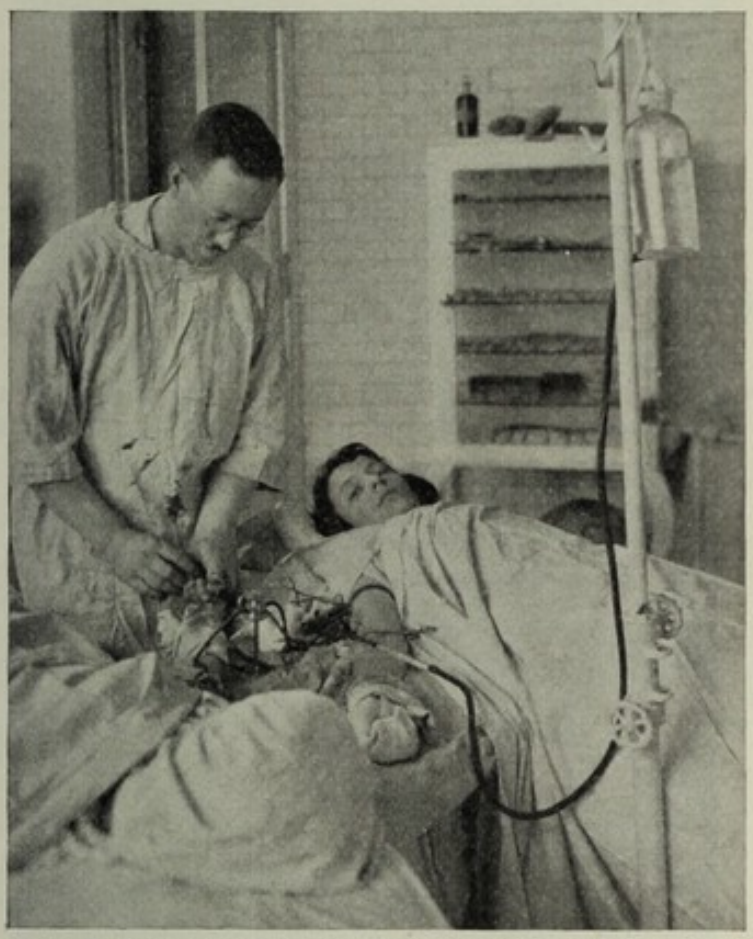


FIG. 249.—Jones's method for use of Unger apparatus without help of assistant: Salt solution feeds to the patient from a bottle placed high enough to produce pressure sufficient to prevent regurgitation of donor's blood (Harold W. Jones).

tubing to the donor's needle; F has a straight tip used to attach rubber tubing to the recipient's needle.

Operation.—Wash arms with alcohol or paint with iodin.

Apply tourniquets so that veins are fully distended but pulse is full and strong.

Insert donor's needle against flow of venous blood, that is, from shoulder to wrist.

Insert recipient's needle in direction of flow, that is, from wrist to shoulder.

After each needle is inserted, hook up tubing to it.

Remove the tourniquet from the recipient's arm after the hook-up is completed.

An assistant is not necessary and salt solution can be injected as shown in Fig. 249. The bottle should be raised just high enough to prevent the back flow of the donor's blood.

If the needles are well in the veins, little trouble is experienced. There are a few little refinements of technic which become apparent as the operator gains experience, but we are convinced after trying many methods of transfusion that this method is by far the easiest to manage and is productive of the best results.

Major George Dorrance, U. S. A., R. F., whose experience is very large, kindly wrote for me the following descriptions of the Kimpton-Brown method and the Lewisohn citrate method.

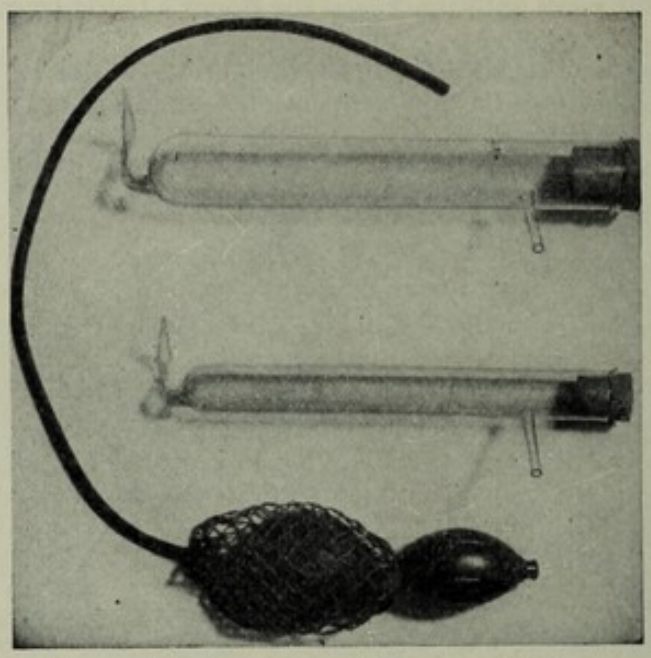


FIG. 250.—The Kimpton-Brown tubes; two sizes, 100 c.c. and 250 c.c. cautery bulb (Mason in "Surgery, Gynecology, and Obstetrics").

Kimpton-Brown Method.—The arms of the patient (recipient) and donor are carefully scrubbed and washed with alcohol, all surrounding parts being covered with



FIG. 251.—Donor's vein exposed, ligated centrally, and tube ready to be introduced into vein, the tip directed peripherally (Mason in "Surgery, Gynecology, and Obstetrics").

sterile towels or sheets. The donor and the recipient are placed on separate tables or the recipient may remain in bed. A blood-pressure cuff is used as a tourniquet on the donor's arm.

The median cephalic or basilic veins of both patient and donor are carefully exposed for a distance of 3 inches under proper aseptic technic, in the case of the donor the upper end of the vein—*i. e.*, the portion nearest the heart—may be ligated. A second ligature is placed around the lower end of the exposed vein, but not tied. Fine silk or double 00 plain catgut may be used.

In like manner, two ligatures are placed on the recipient's vein, but in this case the lower ligature is tied.

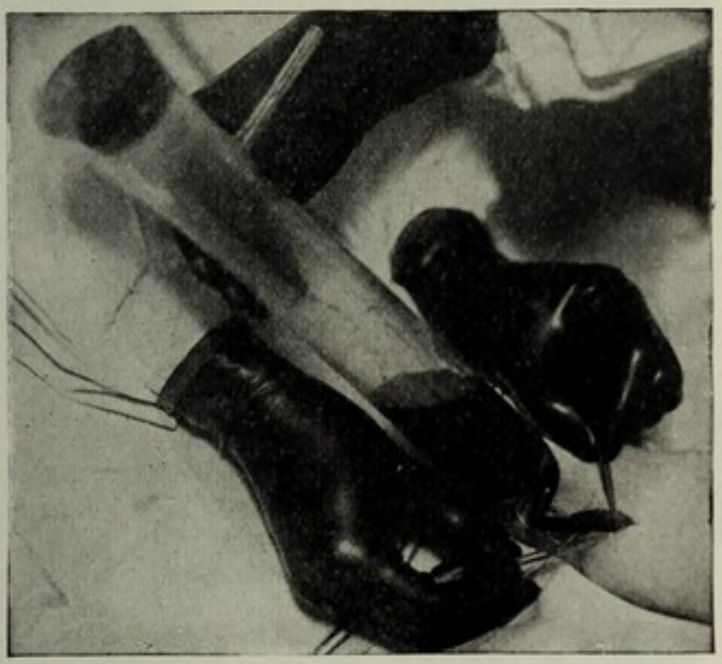


FIG. 252.—Tube in donor's vein, and blood flowing into the tube (Mason in "Surgery, Gynecology, and Obstetrics").

The blood-pressure cuff is now inflated and a dog ear cut made in the vein of the donor into which is inserted the curved end of the Kimpton-Brown tube which has previously been coated with Vincent's wax. The blood will quickly fill the tube which is then withdrawn and the blood-pressure cuff allowed to collapse. An assistant pulls up on the two free ends of the untied ligature and prevents further bleeding.

If any oozing occurs while the tube is being filled, the lower untied ligature may be tied over the cannula with one knot.

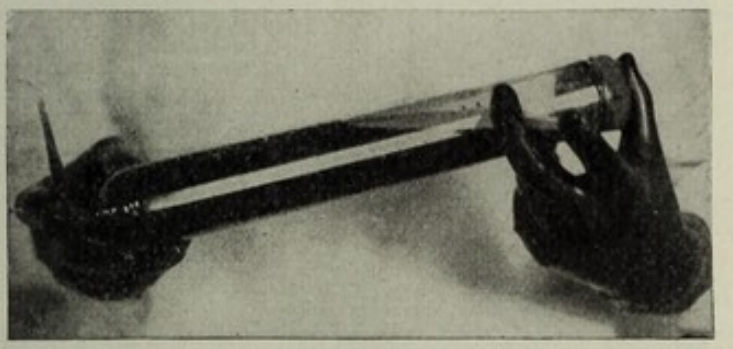


FIG. 253.—Proper method of holding the tube while transporting blood from donor to recipient (Mason in "Surgery, Gynecology, and Obstetrics").

The tube filled with blood is carried over to the recipient and inserted into an opening similar to the one made in the vein of the donor, only being placed in the opposite direction.

In order to permit the blood to flow more rapidly a bulb may be attached by means of a small tube to the horizontal glass cannula in the upper part of the tube.

The tube can only be used once, as it will require fresh coating with paraffin for each operation, hence several tubes should be prepared and held in readiness for each case.

Method of Preparing and Sterilizing Tubes.—The tubes are carefully cleansed and

a piece of Vincent's wax about the size of a small lemon is inserted into the tube. The tubes are then sterilized in an autoclave for twenty minutes, being so placed as



FIG. 254.—Recipient's vein exposed, ligated distally, and tube filled with blood ready for introduction into vein, the tip of the tube directed centrally (Mason in "Surgery, Gynecology, and Obstetrics").

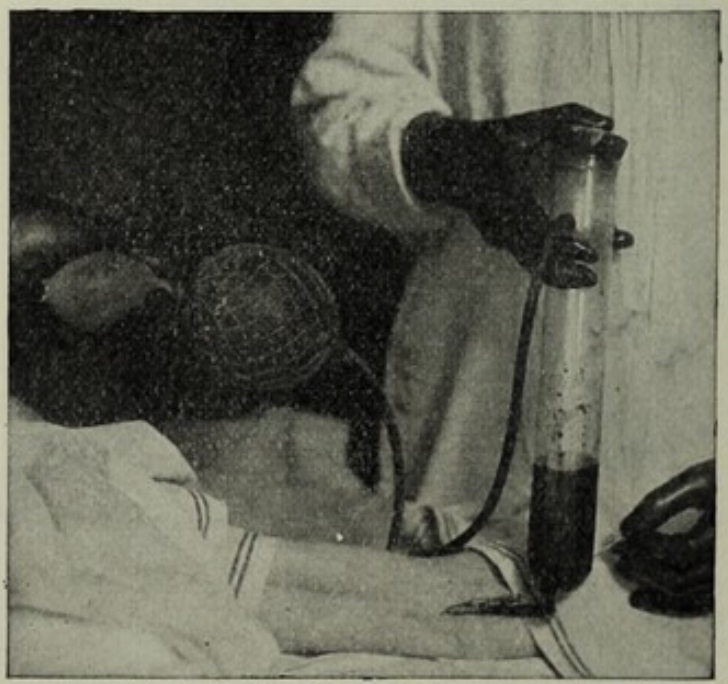


FIG. 255.—Tube in position, the bulb attached, and the blood being slowly forced into the vein of the recipient (Mason in "Surgery, Gynecology, and Obstetrics").

to prevent the melted wax from running out. The formula for Vincent's wax is: paraffin, 2 parts; vaselin, 2 parts; stearin, 1 part.

After sterilization the tubes are removed under aseptic conditions with gloved

hands and the rubber stoppers inserted. Now by means of rapid rotation of the tubes, with alternating up and down motion, the liquid wax can be distributed over the entire inner surface of the tube including the lower curved cannula, care being exercised in keeping the cannula patulous. As a rule, it will require about fifteen minutes to prepare a tube, as one must keep it constantly in motion until the wax solidifies. After a little practice it is comparatively easy to gage the amount of wax necessary to coat evenly the inner surface of the tube. By wrapping the tubes in sterile cotton and covering with a sterile towel it is possible to keep them indefinitely if stored in a cool place.

Technic of Lewisohn's Citrate Method.—Apply a tourniquet or blood-pressure cuff to the arm of the donor. By means of a needle of large caliber or a trocar and cannula a puncture is made in the median basilic or cephalic vein and the blood collected in a graduate glass which contains the 2 per cent. sodium citrate solution. If 450 c.c. of blood are to be withdrawn, 50 c.c. of the citrate are used, and the same proportion if smaller or larger amounts are to be used.

Infusion of Blood into Recipient.—The vein, median cephalic or basilic, is exposed by a small incision. The cannula is inserted and attached to a salvarsan apparatus or tubing attached to a glass funnel, the apparatus having been previously filled with physiologic sodium chlorid, as a rule 20 to 30 c.c. being used. The blood is then poured into this apparatus and allowed to flow into the recipient's vein by gravity.

Regardless of the method employed, we may look for a slight rise in temperature and occasionally a slight chill following the transfusion. This phenomenon if mild is of no consequence, but if severe indicates that we have not selected the proper donor and is likely to mean that hemolysis is occurring.

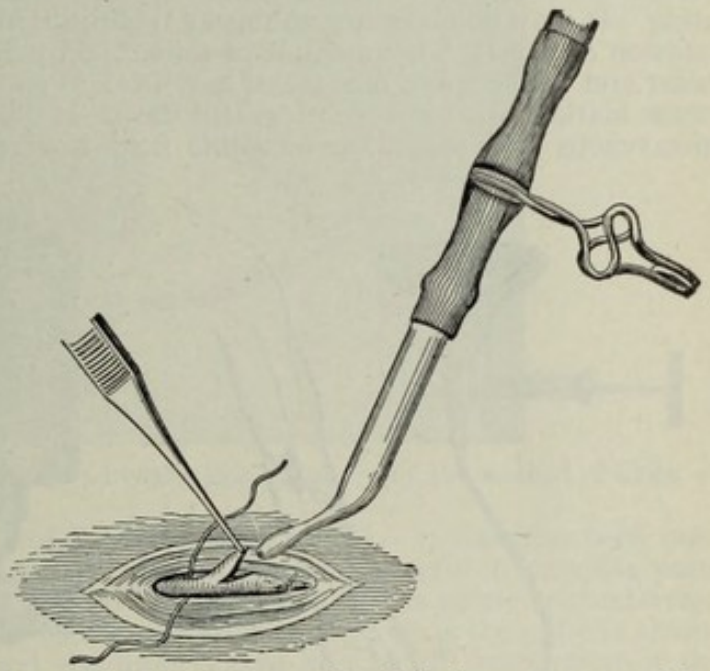


FIG. 256.—Intravenous saline infusion. Manner of incising vein and inserting glass tube (Senn).

The heart action of the recipient following a successful transfusion becomes stronger, the pulse more regular and of better volume, the mucous membranes regain their color, and the hemoglobin and red blood-cells show a proportionate increase.

Intravenous infusion of saline fluid is used after severe hemorrhage, in shock, in diabetic coma, in postoperative suppression of urine, and occasionally in sepsis. After a hemorrhage its beneficial effects are often prompt and obvious. The saline fluid increases the arterial tension, gives the heart enough matter to contract upon, and so restores the activity of the circulation, and does not destroy the red corpuscles as plain water would do. We may use a simple apparatus consisting of a rubber tube, a funnel, and an aspirating needle. Some employ an Aveling syringe, and others Collin's apparatus (Fig. 257). The last-named instrument can be used without any danger of air entering with the fluid. Spencer's instrument (Fig. 258) is convenient and useful. Normal salt solution is the fluid usually employed, of a strength of 0.9 per cent. (1 heaping teaspoonful of common salt to 1 quart of warm boiled water). Some surgeons employ artificial serum. Szumann's solution consists of 6 parts of common salt, 1 part of sodium carbonate, and 1000 parts of water. Ringer's solution consists of 0.7 per cent. sodium chlorid, 0.03 per cent. of potassium chlorid, 0.025 per cent. of calcium chlorid. The results from artificial serum containing many elements are no better than from normal salt solution. Adrenalin may be added to the normal salt solution (1 dram of the 1 : 1000 solution of adrenalin to 1 pint of salt solution). The results of a single dose of adrenalin are very transitory. Whatever fluid is used it should be at a temperature of 105° F. or over as it enters the vein. The stimulant effect of the heat is of great value. The fluid must not be allowed to cool; and a nurse gives constant attention to the temperature of the fluid in the reservoir. This degree

of heat will not damage the corpuscles; in fact, Dawbarn has used saline fluid at a temperature of 118° F. without doing damage to corpuscles and with great benefit to the patient. Globulin coagulates at 158° F. and serum albumin at 162° F. From ½ pint to 2 pints or even more are slowly injected, the condition of the patient determining the amount given. In one case of violent hemorrhage the author used over 2 quarts. In order to infuse this fluid tie a fillet well above the elbow, and expose by dissection the median basilic vein, or the basilic vein in the portion of its course where it is superficial to the deep fascia. Tie the vein. Incise it above the ligature, insert a fine cannula toward the heart, and hold the cannula firmly in the lumen by tightening a second ligature (Figs. 256, 257). Remove the fillet. Slowly and gradually introduce the fluid, carefully watching the pulse. Occupy at least ten minutes in introducing 1 pint, except in a very desperate case of hemorrhage, when the rapidity of the flow may be accelerated. When the tension of the pulse returns, withdraw the cannula, tie the second ligature tightly, sew up the wound, and dress it aseptically. In very severe operations an assistant should conduct the infusion while the surgeon is operating. It may be necessary to repeat the injection if the circulation fails again. The infusion of a very large amount of saline fluid may do harm. It may embarrass the heart and cause acute dilatation, may lead to edema of the lungs or brain, and may cause marked anemia which lasts for days. If dilatation of the right heart exists the intravenous administration of saline fluid is contraindicated. The giving of salt

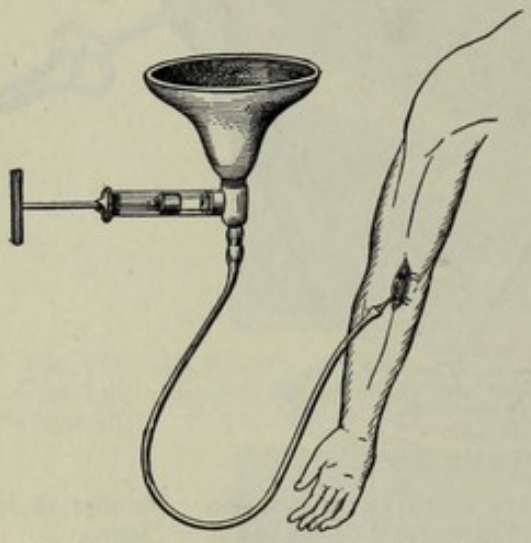


FIG. 257.—Intravenous injection of saline fluid.

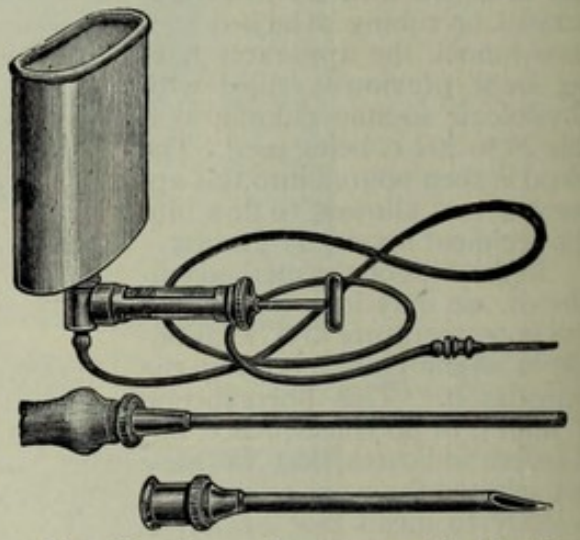


FIG. 258.—Spencer's apparatus for the infusion of saline fluid into a vein. The cannula can be plunged directly into the vessel without preliminary incision.

solution intravenously should never be regarded as routine treatment, judgment is required in determining that it should be used, when it should be used, and how much is required, and there is a distinct element of danger in the procedure.

Arterial Transfusion and Infusion of Saline Fluid Into Arteries.—Hueter preferred the arterial method of transfusion, in order to send the blood more gradually to the heart, and thus prevent sudden disturbance of the circulation. A little air in an artery will do no harm, and the danger of venous embolism is avoided. Saline fluid can be infused into an artery. The radial artery is exposed and surrounded by three ligatures, and the thread toward the heart is at once tied. The distal ligature is slightly tightened to cut off anastomotic blood-supply. The artery is cut transversely half through; the syringe is inserted, pointed toward the periphery, and fastened by the third ligature; the second ligature is loosened and the material is injected. On finishing, the peripheral thread is tied tightly and that portion of the artery which held the cannula is excised. Dawbarn puts a hypodermic needle into the radial artery and injects saline fluid.

Crile (Crile and Dolley in "Jour. of Exper. Med.," Dec., 1906) has shown that when a patient is nearly dead or apparently dead the introduction of saline fluid by a vein may overwhelm the heart. He gives it in these cases by an artery and has succeeded in resuscitating those apparently dead. The tube of the apparatus is quickly inserted into the carotid artery and toward the heart. The reservoir is raised, and

as the saline fluid begins to flow the tube is punctured with a hypodermic needle and adrenalin is added to the saline stream. If the heart starts to beat, blood will appear in the tube and then the administration is discontinued. By this method we may re-establish blood-pressure in the coronary arteries (Fig. 259).

Periarterial sympathectomy (*Leriche's operation*) is used particularly in the limbs for conditions resulting from damage to the nervous mechanism (violent pain, painful stump, contractures after injury, edema after injury, trophic lesions, after frost-bite, intermittent claudication, erythromelalgia, Raynaud's disease, causalgia, and perforat-



FIG. 259.—Injection of saline solution and adrenalin into an artery by the method of Crile.

ing ulcers. See Leriche in "Annals of Surgery," Oct., 1921). It has also been used for senile gangrene and thrombo-angiitis. It has been most useful in relieving pain. The sheath of the femoral artery is opened and a portion of the entire circumference of the external coat is removed. For some hours after the operation the pulse is absent below the level of the operation and the limb is cold because of contraction of the vessel in the area operated upon. In from three to fifteen hours the circulation is re-established, the vessels are dilated, arterial pressure is elevated, and there is a sensation of heat. These phenomena begin to disappear on the fifth or sixth day and are gone at the end of three or four weeks. The theory is that vasodilatation causes local circulatory activity and tissue growth. The operation is still on trial. So far I have seen no report of aneurysm having resulted

LIGATION OF ARTERIES IN CONTINUITY

The **instruments** used in this operation are two scalpels (one small, one medium), two dissecting forceps, several hemostatic forceps, blunt hooks or broad metal retractors, an Allis dissector, an aneurysm needle, for superficial arteries the instrument of Saviard (Fig. 260), for deep vessels the needle of Dupuytren (Fig. 261), ligatures of catgut, of chromicized gut, or of silk, curved needles and a needle-holder, sutures of silkworm-gut, and the reflector or electric forehead-lamp for deep vessels.

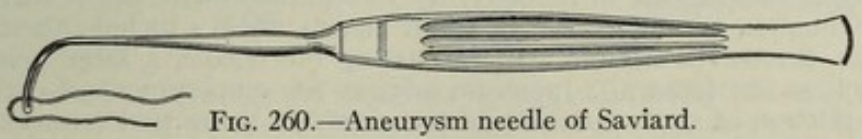


FIG. 260.—Aneurysm needle of Saviard.

The **position** in which the patient is placed varies according to the vessel to be ligated, though the body is supine except when ligation is to be performed on the gluteal, sciatic, or popliteal artery. The operator, as a rule, stands upon the affected side, cutting from above downward on the right side, and from below upward on the left side.

Operation.—Accurately determine the line of the artery, and make an incision at a slight angle to this line, avoiding subcutaneous veins, and holding the scalpel like a fiddle-bow or a dinner-knife while cutting the superficial parts, and like a pen while incising the deeper parts. On reaching the deep fascia make out the required muscular gap by the eye and finger, so moving the extremity as to bring individual muscles into action. Treves ("Operative Surgery") cautions us not to depend upon the yellow line of fat, which often cannot be seen in emaciated people or when an Esmarch bandage is employed; nor upon the white line due to attachment to the fascia of an intermuscular septum. In opening the deep portion of the wound relax the bounding muscles by altering the posture. Open a muscular interspace by a sharp knife, not by a dissector. Make the depths of the wound as long as the superficial incision. Do not tear structures apart with a grooved director; cut them. Arrest hemorrhage as it occurs. Try to find the situation of the artery with the finger. Pulsation is present, but it may be very feeble and hard to detect. The artery feels like a very thin rubber tube; it is compressible, though not so easily as a vein, and when compressed feels like a flat band which is thinner in the center than at the edges. A nerve feels like a hard, round cord. Veins are soft, larger than their related arteries, and so very compressible that they can scarcely be felt when pressed upon, and compression causes distal distention. If the wound can be seen into clearly, it will be noted, as Treves ("Operative Surgery") asserts, that "the nerves stand out as clear, rounded, white cords; that the veins are of a purple color and of somewhat uneven and wavy contour; that the artery is regular in outline and of a pale pink or pinkish-yellow tint, the large vessels being of lighter color than the small." Each artery of the upper extremity and each artery below the knee is accompanied by two veins, known as "venæ comites." The arteries of the head and neck, except the lingual,

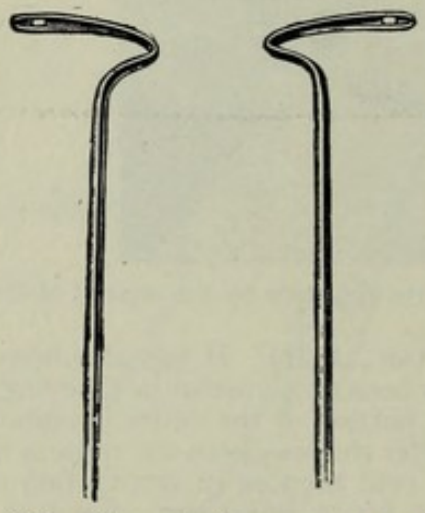


FIG. 261.—Dupuytren's aneurysm needles.

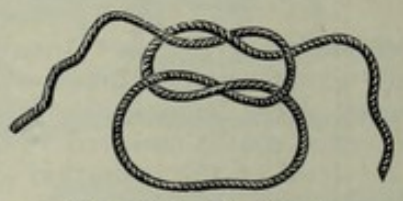


FIG. 262.—Reef knot.

have each a single attending vein; the lingual has venæ comites. Most of the smaller arteries of the trunk (pudic, internal mammary, etc.) have venæ comites. These companion veins may lie on each side of the artery or in front and back of it, and they communicate with one another by transverse branches crossing the artery. On reaching the sheath pick up this structure with toothed forceps so as to make a transverse fold, and thus avoid catching the artery or vein; lift the fold to see that it is free, and open the sheath by cutting toward the edge of the forceps with a scalpel held obliquely with its back toward the vessel, thus making a small longitudinal incision (Fig. 263). Hold the edge of the incised sheath with the forceps; pass a metal dissector under the vessel and from the forceps; this clears one-half of the vessel. Grasp the other edge of the sheath and pass the blunt dissector all the way around the vessel. Pass an aneurysm needle under the cleared vessel, away from the forceps holding the sheath and away from the vessel's most dangerous neighbor. Thread the needle and withdraw it. If venæ comites are in the way, try to separate them; but if this proves difficult, include them in the ligature. In small vessels always include them if they are in the way, as this saves trouble. If, in passing the needle, a large vein is severely wounded (such as the femoral), Jacobson advises the employment of digital pressure in the lower portion of the wound while the artery is being tied on a level above or below that of the vein injury, and after ligation the maintenance of pressure on the wound for a couple of days. A slight puncture in a vein merely requires a lateral ligature. A small wound can be closed with Lembert sutures of fine silk. After getting a ligature under an artery press for a moment upon the artery over the ligature, which is held taut; this pressure will arrest pulsation below if the ligature is around the main artery and there is not a double vessel. Tie the thread at right angles to the vessel

with a reef knot (Fig. 262), rupturing the internal and middle coats. As the ligature is tightened place the extended index-fingers along the ligature up to the artery (Fig. 263, 3), using the middle joints as the fulcrum of a lever by placing them against each other.

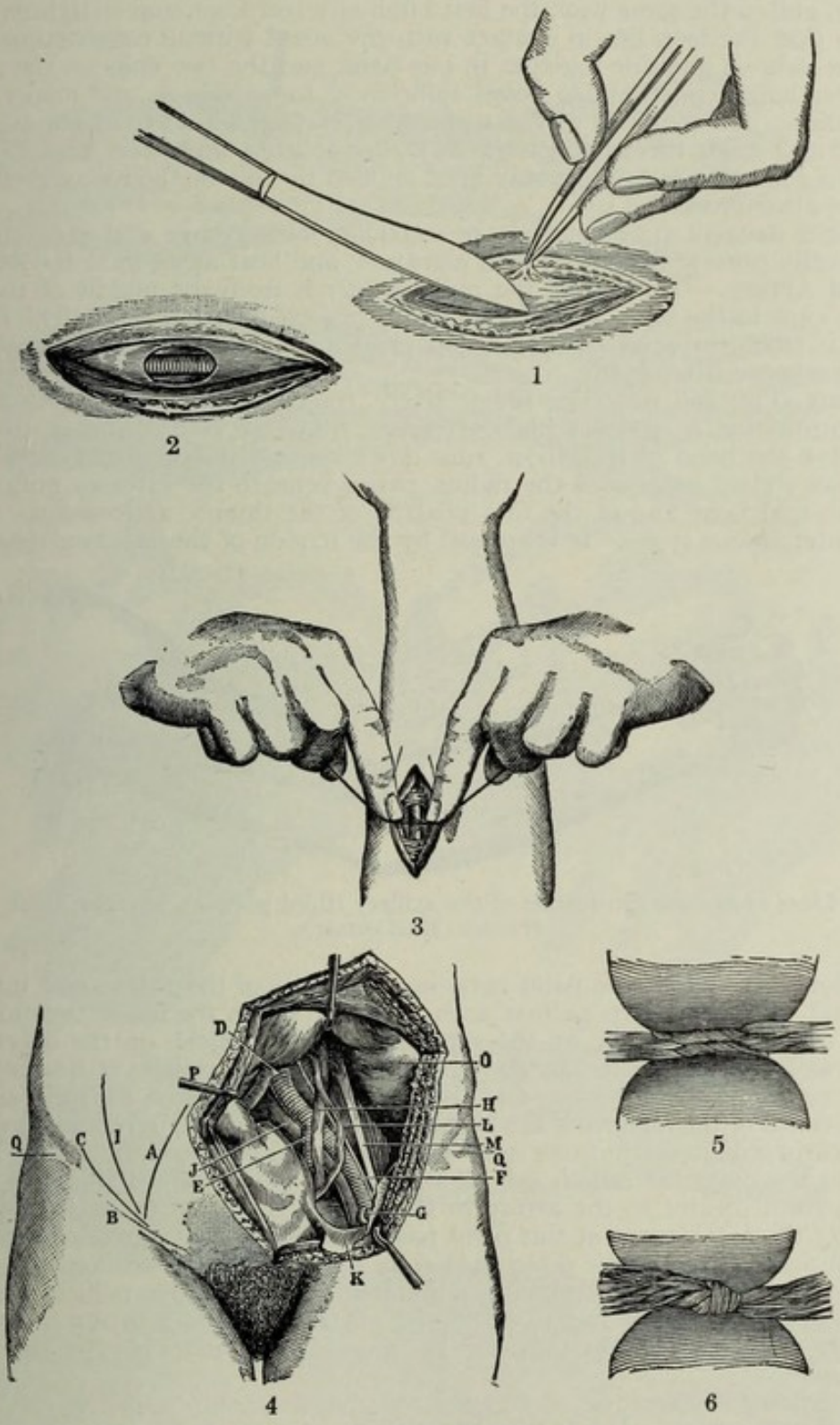


FIG. 263.—Ligations: 1. Opening the sheath for ligation of an artery (Guerin). 2. Sheath of artery open (Guerin). 3. Tightening the knot in ligation (Guerin). 4. Anatomy of the iliac arteries, and showing the lines of incision for their ligation: I, Abernethy's incision (Guerin). 5, 6, Ballance and Edmunds' stay knots.

Ballance and Edmunds claim, as Scarpa and Sir Philip Crampton claimed long since, that it is not necessary to divide the internal and middle coats to insure obliteration. If this claim be true, the danger of secondary hemorrhage can be greatly lessened.

Holmes, however, thinks the older method the more certain of the two. Ballance and Edmunds use floss silk as a ligature material, because it is soft, broad, and flat, and they surround the artery with a double ligature. These surgeons thus describe the application of the stay knot: "The best way of tying two ligatures is to make on each separately, and in the same way, the first hitch of a reef knot, and to tighten each separately so that the loop lies in contact with the vessel without constricting it. Then taking the ends on one side together in one hand and the two ends on the other side in the other hand, constrict the vessel sufficiently to occlude it, and finally complete the reef knot. The simplest way of completing the knot is to treat the two ends in each hand as a single thread and to tie as if completing a single reef knot." This knot is shown in Fig. 263, 5, 6. The stay knot applied by this method is of great value if a vessel be atheromatous.

The chief dangers after ligation are secondary hemorrhage and gangrene. Rigid asepsis usually prevents the first; rest, elevation, and heat antagonize the second.

Radial Artery.—The *line* of the radial artery is from the middle of the front of the elbow-joint to the ulnar side of the styloid process of the radius. The *line* in the tabatière is from the apex of the styloid process to the posterior angle of the first interosseous space (Fig. 264).

Anatomy (Fig. 265, 5).—The radial artery, though smaller than the ulnar, is the direct continuation of the brachial. It arises from the bifurcation of the brachial ½ inch below the bend of the elbow, runs down the radial side of the forearm to the front of the styloid process of the radius, passes beneath the extensor muscles of the first metacarpal bone and of the first phalanx of the thumb, and over the carpus to the first interosseous space. It is crossed by the tendon of the extensor secundi inter-

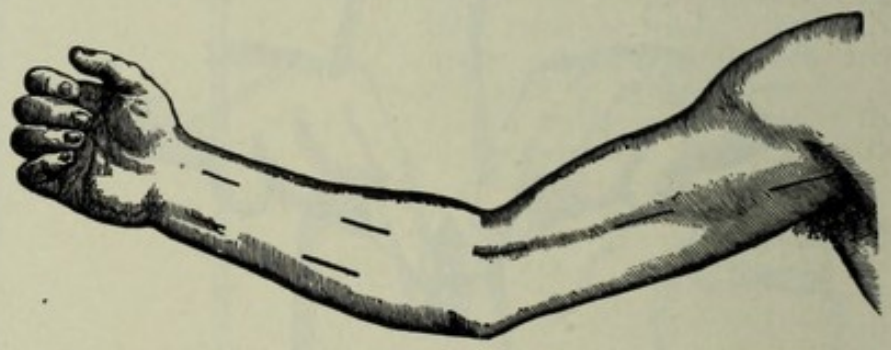


FIG. 264.—Lines of incision for ligation of the axillary (third portion), brachial, radial, and ulnar arteries (MacCormac).

nodii pollicis, enters into the palm between the heads of the first dorsal interosseous muscle, and forms the deep palmar arch. The artery in the upper two-thirds of its course is somewhat overlaid by the supinator longus muscle; in the lower third of the forearm it is superficial. In the upper third of the forearm it lies between the supinator longus on the outer side and the pronator radii teres on the inner side; in the lower two-thirds of the forearm it lies between the supinator longus on the outer side and the flexor carpi radialis on the inner side. Two venæ comites attend the vessel. The radial nerve is to the outer, or radial, side of the artery, well removed from the artery in the upper third, nearer to the artery in the middle third, far external to the artery in the lower third, the nerve at this point passing beneath the supinator longus muscle. The radial artery from above downward rests upon the biceps tendon, the supinator brevis, the flexor sublimis, the pronator radii teres, the flexor longus pollicis, the pronator quadratus muscles, and the radius. The best guide to the radial artery in the forearm is the outer edge of the flexor carpi radialis muscle or the inner edge of the supinator longus muscle.

The tabatière anatomique of Cloquet, or the anatomic snuff-box, is a triangle whose base is the lower edge of the posterior annular ligament, the ulnar side being formed by the extensor secundi internodii pollicis tendon, the radial side by the extensor ossis metacarpi pollicis and the extensor primi internodii pollicis tendons; the floor consists of the trapezium, scaphoid, their dorsal ligaments, and the base of the first metacarpal bone.

Operations.—*Ligation in the tabatière* is a dissecting-room operation of but little practical use. The patient is placed in a recumbent position, the arm is abducted, and the forearm is placed midway between pronation and supination (Barker). The

surgeon stands upon the side operated upon. An incision 2 inches in length is made along the radial border of the extensor secundi internodii pollicis muscle. The skin and superficial fascia are cut and some venous branches are divided. The deep fascia

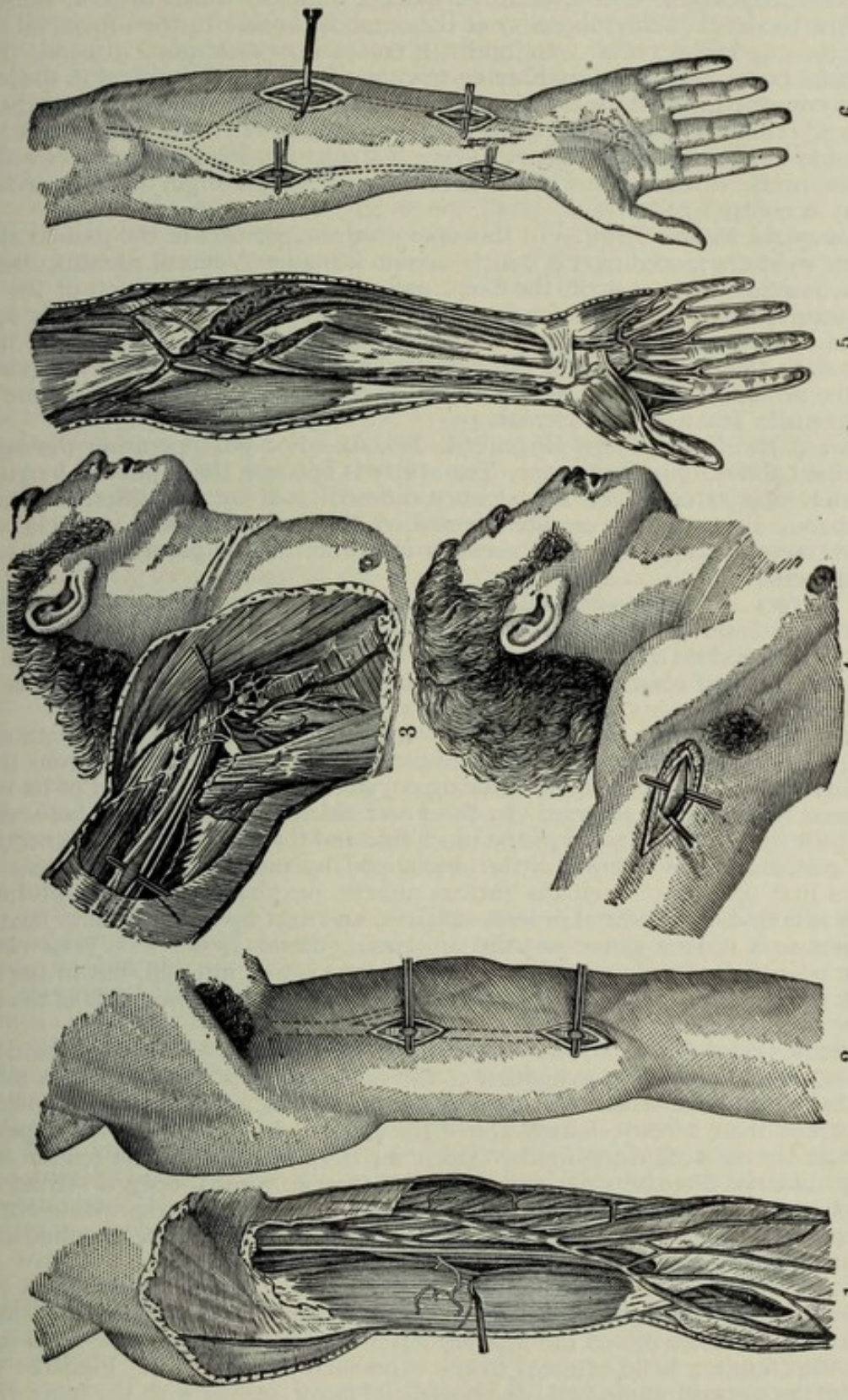


FIG. 265.—Ligations: 1, Anatomy, 2, ligation of the brachial artery. 3, Anatomy of the axilla. 4, Ligation of the third part of the axillary artery. 5, Anatomy, 6, ligation of the radial and ulnar arteries. (From Bernard.)

is incised, and the vessel is easily found and tied before it passes between the heads of the first dorsal interosseous muscle (Barker).

Ligation of the Lower Third.—In this operation (Figs. 264, 265, 6) the patient is placed supine, the arm is abducted, the forearm is supinated, is rested upon a table,

and is held by an assistant. The surgeon stands on the side operated upon, and cuts from above downward on the right forearm and from below upward on the left forearm. The line of the vessel should be determined, and may be indicated with iodin. An incision 1½ inches in length is made at a slight angle to this line and midway between the supinator longus and the flexor carpi radialis muscles, which incision must not extend below the level of the tuberosity of the scaphoid bone. In the superficial fascia watch for the superficial radial vein, and if it comes into view, push it aside. Incise the superficial fascia and locate each guide-tendon. Open the deep fascia in the length of the first cut; try to separate the veins, but if they strongly adhere, include them in the ligature. There is no special fascial sheath. The radial nerve will not be seen, but a division of the anterior cutaneous nerve is frequently found in relation with the vessel. The needle can be passed in either direction. A high origin of the superficialis volæ artery is confusing.

Ligation of the Middle Third.—In this operation the position of the patient should be the same as in the preceding. A 2-inch incision is made. Veins of the subcutaneous tissues are avoided. Lying upon the deep fascia is the anterior division of the musculocutaneous nerve. Open the fascia; find the inner edge of the supinator longus muscle and draw it outward, flexing the elbow partly if necessary. Be sure not to cut external to this muscle. Find the vessel where it is bound down by connective tissue to the pronator radii teres muscle, separate the veins, and pass the ligature from without inward. The nerve is external.

Ligation of the Upper Third (Figs. 264, 265, 6).—For this operation the incision is as described above, only higher up. The artery is between the supinator longus and the pronator radii teres, which are at once differentiated by the different direction of their fibers. The artery is usually covered by the supinator longus muscle, which must be retracted externally. The nerve is not seen. The ligature may be passed in either direction.

Ulnar Artery.—No one *line* will overlie the entire ulnar artery. The line of the upper third runs from the middle of the front of the elbow-joint to the point of junction of the upper and middle thirds of the ulna. The line of the lower two-thirds runs from the tip of the internal condyle of the humerus to the radial side of the pisiform bone (Figs. 264, 265, 5, 6).

Anatomy (Fig. 265, 5).—The ulnar artery arises from the brachial bifurcation and runs obliquely inward under the median nerve and a group of muscles from the internal condyle; it turns down the arm, being covered in the middle third of its course by the flexor carpi ulnaris muscle. In the lower third it is superficial, between the tendons of the flexor carpi ulnaris on the inner side and the flexor sublimis digitorum on the outer side, the vessel being a little overlapped by the flexor carpi ulnaris. This vessel rests first upon the brachialis anticus muscle, next upon the flexor profundus, to which it is bound by a distinct process of fascia, and next upon the annular ligament, which structure it crosses to become the superficial palmar arch. Two venæ comites attend the vessel. In the upper third the ulnar nerve is well internal, but in the lower two-thirds the nerve lies near the artery and to its ulnar side. The guide is the outer edge of the flexor carpi ulnaris.

Operations (Figs. 264, 265, 6).—*Ligation of the Lower Third.*—The position in this operation is the same as for ligation of the radial artery. Make a 2-inch incision to the radial side of the tendon of the flexor carpi ulnaris. This incision should not be taken lower than a point 1 inch above the pisiform bone. Avoid the superficial ulnar vein in the subcutaneous tissue. Open the deep fascia, find the tendon of the flexor carpi ulnaris, flex the wrist and draw the tendon inward, open a second layer of fascia, clear the vessel, separate the veins, and pass the ligature from within outward to avoid the nerve. On the artery is the palmar cutaneous branch of the ulnar nerve, and this branch must not be included in the ligature.

Ligation of the Middle Third (Fig. 265, 6).—In this operation the position is the same as in the preceding one, the incision being 3 inches long. Avoid the anterior ulnar vein and the branches of the internal cutaneous nerve in the superficial fascia. Open the deep fascia a little external to the superficial cut (Treves). Find the space between the flexor carpi ulnaris and the superficial flexor, feeling with the index-finger, and when the space is discovered flex the wrist, retract the flexor carpi ulnaris inward and the flexor sublimis digitorum outward, open the fascia, find the ulnar nerve, look external to it for the artery, clear the vessel, separate the venæ comites, and pass the needle from within outward. The ulnar artery should not be ligated in continuity in the upper third of its course.

Brachial Artery.—The *line* of the brachial artery is from the junction of the anterior and middle thirds of the outlet of the axilla, the arm being abducted and the forearm supinated, to the middle of the front of the elbow-joint (Fig. 264).

Anatomy (Fig. 265, 1).—The brachial artery is the prolongation of the axillary, and extends from the lower edge of the teres major muscle to ½ inch below the bend of the elbow, where it divides into the radial and ulnar arteries. It lies first to the inner side of the arm, but passes to the front of the elbow. It is crossed by no muscle, and is, in fact, superficial, barring its being somewhat overlaid in part of its course by the edge of the biceps muscle. The median nerve is external above, crosses over the vessel about the middle of the arm, and reaches the inner side of the artery. The coracobrachialis and biceps muscles are external, and both often overlap the vessel. The ulnar nerve is internal above, and the median nerve is internal below the middle. The basilic vein is to the inner side of the artery, being outside the deep fascia to near the middle of the arm, at which point it pierces it. The artery above is separated from the long head of the triceps by the musculospiral nerve and superior profunda artery and vein; it rests from above down on the inner head of the triceps, the coracobrachialis, and the brachialis anticus muscles. The artery is covered by skin, by superficial fascia, and by deep fascia. The internal cutaneous nerve lies in front of the artery, upon the deep fascia, until it pierces the fascia along with the basilic vein. The artery has venæ comites, and in its upper half has also the basilic vein to its inner side. The guide to the brachial is the inner edge of the biceps muscle. Just in front of the elbow-joint the artery lies in a triangle, the base of which is formed by an imaginary transverse line above the condyles, and the apex by the junction of the pronator radii teres and the supinator longus muscles. The outer side is the supinator longus, the inner side is the pronator radii teres, and the floor is formed by the brachialis anticus and the supinator brevis muscles. From within outward the triangle contains the median nerve, brachial artery, tendon of the biceps, the anastomosis of the superior profunda and radial recurrent arteries, and the musculospiral nerve.

Operations.—*Ligation at the Bend of the Elbow.*—In this operation (Figs. 264, 265, 2) the patient is placed supine, the arm is moderately abducted and extended, and is allowed to lie upon its posterior aspect. The forearm is supinated. The surgeon stands upon the side operated upon, and cuts from above downward on the right side and from below upward on the left side. The tendon of the biceps and the median basilic vein must be accurately located. An incision is made parallel to the inner edge of the biceps tendon and 2 inches in length, the center of this cut being in the crease of the elbow. On exposing the median basilic vein, retract it downward and inward, open the bicipital fascia, clear the artery of fat, separate the venæ comites, and pass the ligature from within outward to avoid the median nerve. The above operation is not frequently performed.

Ligation in the Middle of the Arm (Fig. 264).—In this operation the patient is placed supine, the arm is abducted, and the forearm is supinated. An assistant holds the forearm, but the arm should not rest upon the table, because, if it be allowed to do so, the inner head of the triceps will be forced forward and may overlie the artery, and thus complicate the operation. Locate the inner edge of the biceps, which is the guide. Make an incision 3 inches in length in the line of the artery. Incise the skin and fascia, flex the elbow slightly, retract the biceps outward, feel for the artery, open the sheath, separate its venæ comites, and, having located the median nerve, pass the ligature from it. In the middle of the arm the nerve is in front of the vessel, above the middle it is external to it, and below the middle it is internal to it. High up the arm the inner edge of the coracobrachialis is the guide rather than the biceps. Above the middle of the arm the basilic vein is beneath the deep fascia and passes along by the inner side of the artery; hence, high up the artery has three companion veins, the venæ comites and the basilic vein, and there is seen the ulnar nerve to the inside of the artery.

Axillary Artery.—To determine the *line* of the axillary artery place the arm at a right angle to the body, with the patient supine, and lay down a line from the middle of the clavicle to the humerus near the inner border of the coracobrachialis. The line of the third portion can be approximated by projecting the line of the brachial upward (Fig. 264).

Anatomy (Figs. 265, 3 and 268, 1).—The axillary artery is the continuation of the subclavian, and runs from the lower margin of the first rib to the inferior border of the teres major muscle. It is divided into three portions by the pectoralis minor muscle. The first portion is above, the second portion is behind, and the third portion

is below, the pectoralis minor. The position of the artery varies with the position of the limb. When the arm is parallel with the body the artery is far from the surface and forms a curve whose convexity is upward and outward. When the arm is at a right angle to the body the vessel is nearer the surface and straight. When the arm is raised above a right angle the artery comes near the surface and forms a curve with the convexity downward.

The first portion of the axillary artery is occasionally ligated. It lies upon the first intercostal muscle and the first serration of the great serratus muscle, and has behind it the posterior thoracic nerve; the brachial plexus is external and posterior to the vessel; on its inner side is the axillary vein; in front of it are the clavicle, the great pectoral muscle, the subclavius muscle, the costocoracoid membrane, the cephalic and acromiothoracic veins, and the external anterior thoracic nerve. The branches of the first part of the axillary artery are the superior thoracic and the acromiothoracic. The second part of the artery is not ligated. The brachial plexus surrounds the second portion. The third part is covered in front, above, by the great pectoral muscle, but is covered below by skin and fascia; behind, it has the tendon of the subscapularis, the latissimus dorsi, and the teres major muscles; the coracobrachialis is on the outer side; the axillary vein is on the inner side. It is important to remember that there may be three veins, one external and two internal. The axillary vein is formed by the venæ comites of the brachial artery joining, and this new vein effecting a junction with the basilic vein. The median nerve lies upon the axillary artery in the upper part of the third portion of the vessel's course, and passes to the outer side. The musculocutaneous nerve is external, but it is only seen high up; the ulnar nerve is internal; the lesser internal cutaneous and the internal cutaneous nerves are internal; the musculospiral and the circumflex nerves are behind. The branches of the third portion of the axillary artery are the subscapular and the anterior and posterior circumflex.

Operations.—*Ligation of the Third Portion* (Fig. 265, 4).—The position of the patient should be supine, with the shoulder raised and the arm abducted to a right angle. The surgeon stands between the patient's arm and side, with his back toward the subject's feet. An incision is made 3 inches in length. It begins half-way up the axilla opposite to the head of the humerus, and is taken downward and parallel to the lower edge of the great pectoral muscle and crosses the junction of the anterior and middle thirds of the outlet of the axilla. The integuments and fascia are incised. The vein or veins will be prominent to the inner side and may overlie the vessel. To the inner side with the veins are the ulnar and internal cutaneous nerves. The median nerve is upon, and the external cutaneous is to the outer side of, the artery. Feel for the pulsations of the artery, find the median nerve, and draw it outward, draw the nerves and veins which lie to the inner side inward, clear the artery from the venæ comites, and pass the ligature from within outward. Apply the ligature well below the circumflex branches.

Ligation of the First Part.—This operation (Fig. 268, 2) was first performed successfully in 1815 by Chamberlaine, of Jamaica. The patient is placed supine, the upper part of the body being raised, a sand-pillow being placed between the scapulæ to insure carrying back of the point of the shoulder, and the arm being brought down along the side. In operating on the left side the surgeon stands on the outer side of the left arm; in operating on the right side he stands to the right of the subject's head and leans over his shoulder. The incision, which is slightly curved downward, begins external to the sternoclavicular joint and ends internal to the margin of the deltoid, thus avoiding the cephalic vein. The incision is ½ inch below the clavicle (Fig. 267). Incise the skin, platysma myoides muscle, and deep fascia. In the outer angle of the wound watch for the acromiothoracic artery and the cephalic vein. Incise the pectoralis major muscle; draw the pectoralis minor muscle downward; retract the lower margin of the wound, cut through the costocoracoid membrane close to the coracoid process and the upper border of the lesser pectoral muscle. Bring the arm to the side so as to relax the structures. Find the brachial plexus, feel for the artery internal to it, clear the vessel, draw the vein internally, and pass the needle from within outward. This avoids the dangerous neighbor, which is the axillary vein. This operation is difficult, dangerous, and unusual, and in its performance the axillary vein, which has a close attachment to the costocoracoid membrane, is apt to be torn.

Subclavian Artery.—The subclavian artery was first successfully tied by Post, of New York, who applied a ligature about the third portion of the vessel in 1817. In 1809 Sir Astley Cooper attempted to tie the first part of the left subclavian, but abandoned the operation because he feared he had wounded the thoracic duct. The

first part of the subclavian was first tied by Colles in 1818 (Treves's "Manual of Surgery"), but the patient died. At the present day the first and second portions are rarely ligated. Professor Halsted in 1892 successfully tied the first portion of the left side for aneurysm. Schumpert tied it successfully for aneurysm. Stoneham had a successful case in 1902. I assisted Dr. Nassau, of St. Joseph's Hospital, Philadelphia, in a ligation of the first part of the right subclavian. The man suffered from a ruptured traumatic aneurysm of the third portion of the vessel. The operation was followed by recovery. Chilton produced a cure of an aneurysm of the third portion of the subclavian of the right side by tying the first portion, and twenty-four hours later tying the first portion of the axillary. Curtis, in 1897, and Allingham, in 1899, ligated the first part successfully. Neff, of Spokane, successfully ligated the first part of the left subclavian ("Annals of Surgery," Oct., 1911). I tied the first part of the right subclavian and the first part of the common carotid for innominate aneurysm. The aneurysm was apparently cured. I also tied the third part of the right subclavian and the first part of the carotid for an innominate aneurysm. The patient apparently recovered, but many months later developed an aneurysm at the point of carotid ligation. There is no *line* for this vessel.

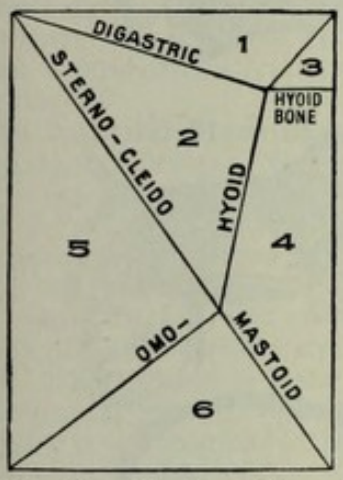


FIG. 266.—The triangles of the neck, right-sided view: 1, Submaxillary triangle; 2, "triangle of election," or superior carotid triangle; 3, submental triangle; 4, "triangle of necessity," or inferior carotid triangle; 5, occipital triangle; 6, subclavian triangle (after Keen).

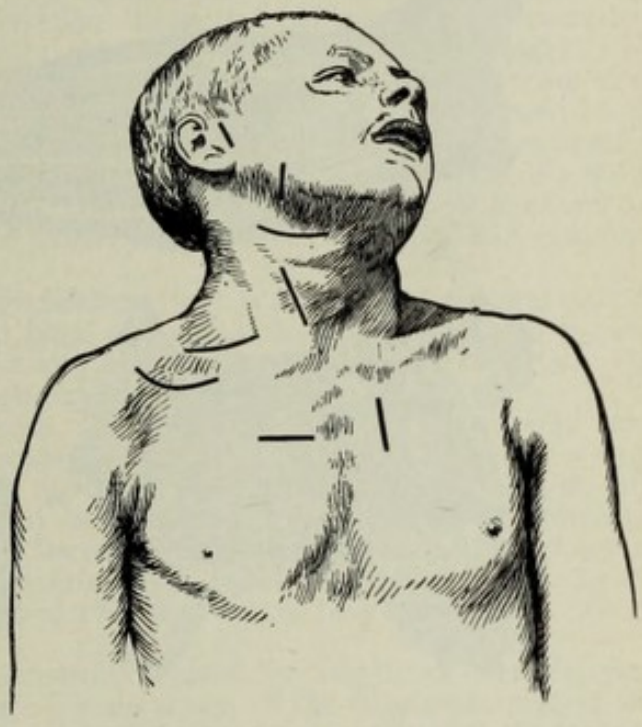


FIG. 267.—Position of the lines of incision of temporal, facial, lingual, common carotid (above the omohyoid), subclavian, axillary (first portion), and internal mammary arteries (MacCormac).

Anatomy (Fig. 268, 1).—The subclavian artery of the right side arises from the innominate; that of the left side, from the arch of the aorta. The subclavian is divided into three parts: the first part runs from the origin of the vessel to the inner border of the scalenus anticus muscle; the second part lies behind the scalenus anticus muscle, and the third part runs from the outer edge of the muscle to the lower border of the first rib. The third portion is contained in the subclavian triangle (Fig. 266), and is superficial. It rises, as a rule, to ½ inch above the clavicle. The subclavian vein is below the artery, being separated from it by the scalenus anticus muscles. The brachial plexus is above and external to the artery. The vessel rests upon the first rib, and behind it is the scalenus medius muscle. The suprascapular and transversalis colli arteries and veins and branches of the cervical plexus of nerves lie in front of the artery, and the external jugular vein crosses it at its inner side. The third portion gives off no branches.

Ligation of the Third Part (Figs. 267, 268, 2).—The patient is placed upon his back, the shoulders are raised, the head is extended and turned toward the opposite side, the arm is pulled down and held by pushing the forearm under the patient's back (Treves). This pulls down the clavicle, thus increasing the size of the subclavian triangle. The operator stands facing the shoulder, with his back toward the patient's feet. The skin over the subclavian triangle, at a point ½ inch above the clavicle,

is drawn down until it overlies the bone and is incised. This maneuver enables the surgeon to avoid the external jugular vein and to make an incision in the skin ½ inch above the collar-bone. The incision reaches from the anterior edge of the trapezius to the posterior border of the sternocleidomastoid (Figs. 267, 268, 2), and is about

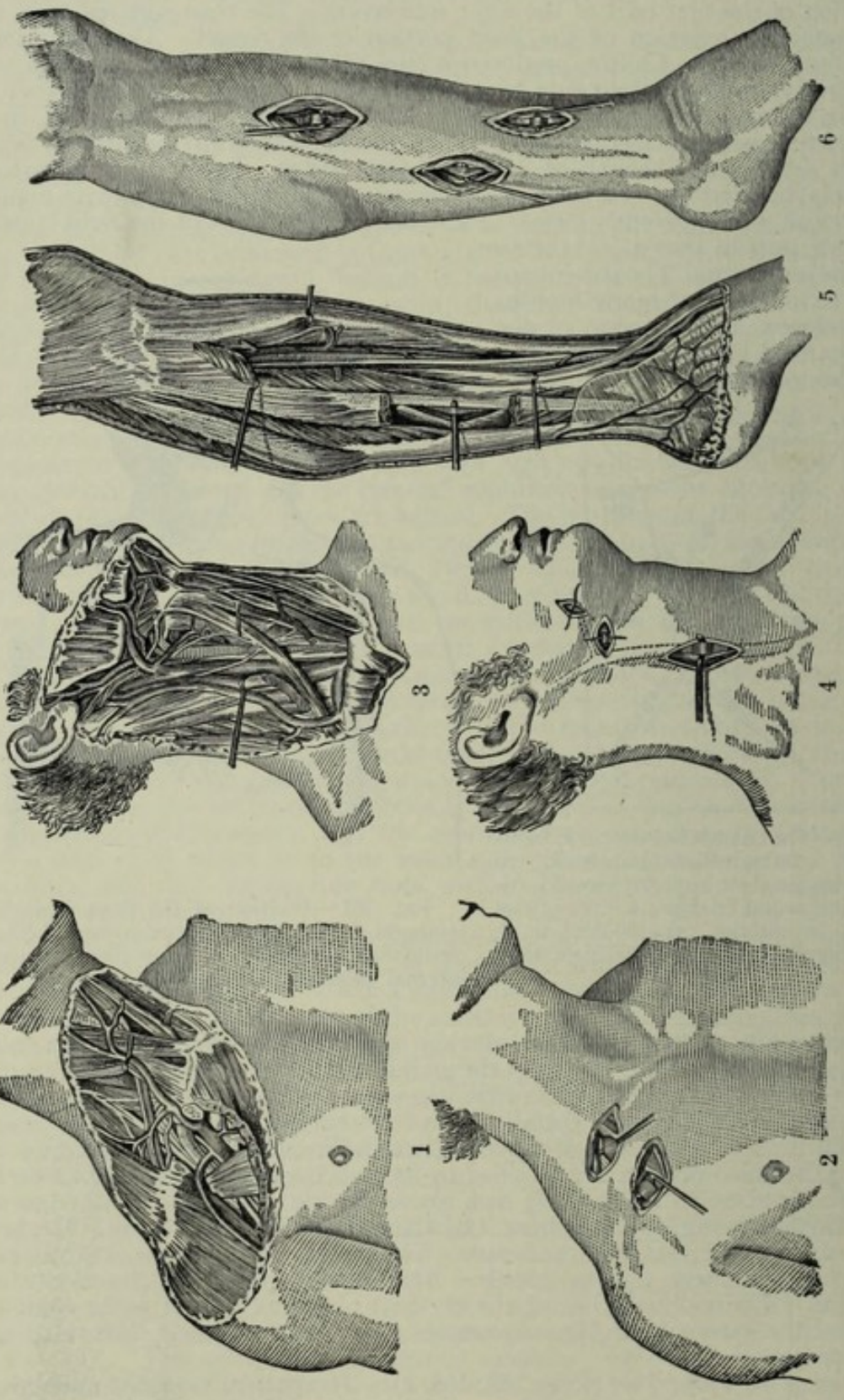


FIG. 268.—Ligations: 1, Anatomy, 2, ligation of the subclavian artery and first part of the axillary artery. 3, Anatomy of the neck. 4, Ligation of the carotid, lingual, and facial arteries. 5, Anatomy, 6, ligation of the anterior tibial and peroneal arteries. (From Bernard.)

3 inches long. This incision divides the skin, superficial fascia, the platysma myoides, the vein running from the cephalic to the external jugular, and some superficial nerves. The deep fascia is opened. The external jugular vein is drawn into the inner angle of the wound, and is not divided unnecessarily; if forced to divide the vein, tie with

two ligatures and cut between them. The surgeon seeks to find the outer edge of the anterior scalene muscle, and runs the finger down along it to the tubercle on the first rib. The posterior belly of the omohyoid muscle is drawn upward by an assistant. The surgeon, with a finger on the tubercle, recalls the facts that the vein is in front of the finger and the artery is behind it, and that the subclavian vein is on a lower plane than the artery. The artery is felt beating as it lies upon the rib. The artery is cleared and the lower cord of the brachial plexus is exposed. The vein must be guarded with the finger and the needle is passed from above downward, as the plexus, which is in more danger than the vein, is to be avoided. In this operation the transversalis colli and suprascapular arteries must not be cut, as they are necessary to the future anastomotic circulation. If the field of operation is too small, the trapezius or sternocleidomastoid, or both, should be partly divided transversely.

Results.—Before the days of antisepsis ligation of the subclavian was a very fatal operation. Poland estimated the mortality at 70 per cent. In most cases death was due to secondary hemorrhage. Koenig collected 20 cases of ligation of the first part of the right subclavian, with 19 deaths. Lilienthal believes that the mortality after ligating the first portion on the right side is now only 16 per cent. (quoted by Neff in "Annals of Surgery," Oct., 1911). According to Joseph D. Bryant, there have been 134 deaths in 250 ligations at various points of the subclavian ("Operative Surgery"). I have twice tied this vessel, with success. Gangrene seldom follows ligation of the subclavian. Poiret's statistics show that in 42 recoveries after ligation of various points there was 1 case of gangrene of the arm. In Von Bergmann's 90 ligations for gunshot wounds there was not a case of gangrene of the arm and only 3 of gangrene of the fingers.

The Internal Mammary Artery.—Anatomy.—It is a branch of the first part of the subclavian artery. It passes down back of the subclavian and internal jugular veins to reach the inner side of the chest wall beneath the cartilages of the ribs. The line of the artery is parallel to and ½ inch outside of the sternal margin.

Ligation is performed for hemorrhage. In aneurysm, which is excessively rare, ligation will not do. Extirpation is necessary (Fred. W. Rankin in "Annals of Surgery," Sept., 1924). The artery must be exposed at the point of injury and both ends must be tied. The vessel can be reached in any one of the five upper intercostal spaces. The incision is along the upper border of a rib and cartilage. Cut down to the intercostal muscle. On dividing that muscle the artery comes into view. In the first space it is accompanied by one vein, in the other spaces by venæ comites. Carefully avoid the pleura (Fig. 267).

The **vertebral artery** was first successfully ligated by Smyth, of New Orleans, in 1864. He had ligated the innominate for aneurysm of the subclavian and at the same time tied the common carotid. Secondary hemorrhage occurred. He arrested it by tying the vertebral.

Anatomy.—This vessel is the largest branch of the subclavian, and is the first branch coming from the first portion of the subclavian. The vertebral artery ascends and enters the foramen in the transverse process of the sixth cervical vertebra (in rare cases the fifth or the seventh), and ascends through foramina in the cervical vertebræ, passes behind the articular process of the atlas and over the posterior arch of this first vertebra, pierces the posterior occipito-atloid ligament, and enters the skull by way of the foramen magnum ("Gray's Anatomy"). It joins its fellow of the opposite side to form the basilar artery. At its point of origin the vertebral artery has in front of it the internal jugular vein and inferior thyroid artery. Near the spine it lies between the longus colli and scalenus anticus muscles, and on the left side has the thoracic duct to the left and in front.

Ligation.—The position of the patient is the same as for ligation of the carotid artery. Alexander thus describes the operation: "An incision 3 or 4 inches long is made in an upward and outward direction along the hollow which exists between the scalenus anticus and the sternomastoid muscles. The incision should begin just outside and on a level with the point where the external jugular vein dips over the edge of the sternomastoid muscle, or, if the vein is invisible, about ½ inch above the clavicle. The external jugular vein is drawn inward with the sternomastoid muscle. The connective tissue now appearing, the wound is opened by a blunt dissector until the scalenus anticus muscle, the phrenic nerve, and the transverse cervical artery are seen. It cannot be too well remembered that the pleura is at the inner side of the wound, while below lies the subclavian artery. It is now only necessary to separate the edges of the scalenus anticus and the longus colli muscles to see the vertebral artery

lying in the space between them. The artery is generally completely covered by the vein, which is drawn aside, and the artery is then ligatured" (quoted in Bryant's "Operative Surgery"). When the vessel is cleared and tied, branches of the inferior cervical ganglion are damaged and possibly included in the ligature, and as a consequence the pupil contracts. Jacobson tells us to remember that the phrenic nerve lies on the scalene muscle, the pleura is internal, the internal jugular, inferior thyroid, and vertebral veins are over the vessel, and the thoracic duct on the left side crosses it from within outward.

Results.—In 36 ligations of the vertebral artery there were 3 deaths (Joseph D. Bryant).

The Inferior Thyroid Artery.—Anatomy.—The inferior thyroid artery is a branch of the thyroid axis. It ascends the neck, passes back of the carotid sheath and the sympathetic nerve, and reaches the thyroid gland. The recurrent laryngeal nerve lies behind the artery. The phrenic nerve is external to the artery and near to it in the first part of its course (up to the point of origin of the ascending cervical branch). The ascending cervical branch takes origin just before the artery begins to dip behind the carotid. In front of the beginning of the inferior thyroid artery of the left side the thoracic duct crosses. The artery is ligated in the second part of its course (between its distribution and the origin of the above-named branch).

Ligation.—The position of patient and the incision are the same as for the ligation of the common carotid artery in the triangle of necessity (see page 436). After exposing the sternocleidomastoid muscle, retract it outward, and then draw outward the common carotid artery and also the internal jugular vein. The inferior thyroid artery will be found a little below the carotid tubercle. It is cleared and ligated. Treves advises ligation close to the level of the carotid so as to avoid the recurrent laryngeal nerve.

Innominate Artery.—The innominate artery was first ligated by Valentine Mott, of New York, in 1818. It was first successfully ligated in 1864 by Andrew Smyth, an Irishman by birth, but a resident of New Orleans. Smyth's operation was performed for aneurysm of the third part of the right subclavian artery. He tied the common carotid as well as the innominate, and ten days later tied the vertebral artery because of secondary hemorrhage. The patient left the hospital cured but for a small pulsating lump about as large as "a pigeon's egg" (Souchon in "New Orleans Med. and Surg. Jour.," March, 1921). Ten years later the man returned to the hospital with an aneurysm as large as when the operation was performed. Smyth tied the internal mammary artery, but no benefit ensued. The sac was evidently about to burst, so it was opened and a futile attempt was made to plug the opening of the diseased artery. "Plugging *en masse* was effected without avail." Death from hemorrhage occurred in forty-eight hours (Souchon, Ibid.). Souchon made the autopsy and prepared the specimen.

The return circulation was by the anastomosis between the perforating aortic intercostals and the branches of the subscapular "in the substance of the great serratus muscle, through which the blood flowed freely through the axillary into the sac" (Souchon, Ibid.). Souchon says that ligation of the axillary between the subscapular and the sac would have brought about cure. This famous specimen is in the Army Medical Museum in Washington.

Anatomy.—The innominate artery arises from the beginning of the transverse portion of the arch of the aorta, passes to the back of the right sternoclavicular joint, and divides into the common carotid and subclavian vessels. It rests upon the trachea. It has upon its outer side the pleura, the right innominate vein, and the pneumogastric nerve. Upon its inner side are the remnant of the thymus gland and the beginning of the left carotid artery. In front of it are the inferior thyroid veins of the right side, the left innominate vein, the sternohyoid and sternothyroid muscles, the remnant of the thymus gland, and sometimes a branch from the right pneumogastric nerve.

Ligation.—Place the patient supine, with the shoulders a little raised, and the head thrown back. Carry an incision from the upper margin of the sternum for 3 inches along the anterior margin of the sternomastoid. Make another cut of the same length along the upper border of the clavicle to meet the first cut. Dissect up the flap of skin and fascia. Divide the sternal origin and a part of the clavicular portion of the sternocleidomastoid muscle, and cut the sternohyoid and sternothyroid muscles just above their sternal origins (Joseph Bell). Retract the inferior thyroid veins. Divide the dense leaflet of cervical fascia. Find the common carotid artery, and trace back along this vessel until the innominate comes into view. Retract the left innom-

inate vein downward. The needle is passed from without inward to avoid the right innominate vein and right pneumogastric nerve. If the needle is kept close to the artery the pleura and trachea will not be injured.[1]

Results.—Burns, of Memphis, collected 45 cases and added 1 of his own, making 46 cases, with 9 recoveries ("Jour. Amer. Med. Assoc.," 1908). To these should be added Percy Sargent's successful case ("Lancet," May 6, 1911), making 47 cases and 10 recoveries. Hamann ("Annals of Surgery," 1914, lix) reported a successful case and collected the records of 53 ligations, 14 of which were successful. There is no note of gangrene in any of these cases. The ligation of this vessel, especially in the elderly, may cause serious brain damage by cutting off circulation or by embolism. Brain changes are not so common as after ligation of the common carotid. Burrell's case in 1895 is counted as a success, although death occurred on the one hundred and fourth day. Smyth's case lived ten years. Sargent's case lived seventeen months and then died of pneumonia and pericarditis. He tied the common carotid as well as the innominate. The case of Coppinger, of Dublin, was alive and well two years after operation. Mitchell Banks's case lived over three months. Dr. Sinclair's case was well three months after operation and the pulse had not returned to the wrist ("Brit. Med. Jour.," March 3, 1917).

Region of the Neck.—Anatomy.—The side of the neck is that space between the median line in front and the anterior edge of the trapezius muscle behind, which space is limited below by the clavicle and above by the body of the jaw and an imaginary line running from the angle of the jaw to the mastoid process. The sternocleidomastoid muscle divides this space into an anterior and a posterior triangle, and each of the triangles is subdivided by other structures, the anterior into four spaces and the posterior into two (Fig. 266).

The *anterior triangle* is bounded in front by the median line of the neck, behind by the anterior margin of the sternocleidomastoid muscle, and above by the body of the lower jaw and an imaginary line drawn from the angle of the jaw to the mastoid process. This space is subdivided into four smaller triangles—namely, the inferior carotid, the superior carotid, the submaxillary, and the submental.

The *inferior carotid triangle* is called the "triangle of necessity," because the common carotid artery in this region is ligated, not from choice, but through force of necessity. It is bounded in front by the median line, above by the anterior belly of the omohyoid muscle and the hyoid bone, and below by the anterior edge of the sternomastoid muscle. The floor of this triangle is composed of the longus colli, the scalenus anticus, the rectus capitis anticus major, the sternohyoid, and sternothyroid muscles.

The *superior carotid triangle* is known as the "triangle of election," because, if the carotid artery must be tied, the surgeon, whenever possible, elects or chooses to tie it in this triangle. In this region the carotid is superficial, and there can be tied either the external, the internal, or the common carotid artery, as the surgeon elects. The triangle is bounded behind by the anterior edge of the sternocleidomastoid, above by the posterior belly of the digastric, and below by the anterior belly of the omohyoid muscles. Its floor is composed of the inferior and middle constrictors of the pharynx, the thyrohyoid, and hyoglossus muscles.

The *submaxillary triangle* is bounded above by the body of the jaw and an imaginary line drawn from the angle of the jaw to the mastoid process, behind by the posterior belly of the digastric muscle and the stylohyoid muscle, and in front by the anterior belly of the digastric muscle. Its floor is composed of the mylohyoid and hyoglossus muscles.

The *submental triangle* is bounded on either side by the anterior belly of one digastric muscle; its base is the hyoid bone and its floor is the mylohyoid muscle.

The *posterior triangle* is bounded in front by the posterior border of the sternocleidomastoid muscle, behind by the anterior edge of the trapezius muscle, and below by the clavicle. The posterior belly of the omohyoid muscle subdivides it into two smaller spaces, the occipital and subclavian triangles.

The *occipital triangle* is bounded in front by the posterior edge of the sternocleidomastoid muscle, behind by the anterior border of the trapezius muscle, and below by the posterior belly of the omohyoid muscle.

The *subclavian triangle* is bounded above by the posterior belly of the omohyoid muscle, below by the clavicle, and in front by the posterior border of the sternocleido-

[1] See the exceedingly clear and terse account in that excellent book, "A Manual of Surgical Operations," by Joseph Bell.

mastoid muscle. Its floor is formed by the first rib and the first serration of the serratus magnus muscle.

Common Carotid Artery.—The common carotid was tied to arrest bleeding by Abernethy in 1798. The man died in thirty hours. It is usually said that this was the first case of ligation of this vessel, a statement which Gross denies ("A System of Surgery"). In 1805 Sir Astley Cooper tied the vessel for carotid aneurysm. The patient died on the nineteenth day. In 1808 he ligated the vessel successfully for aneurysm. The *line* of the common carotid artery is from the sternoclavicular articulation to midway between the angle of the jaw and the mastoid process, the head being turned toward the opposite side.

Anatomy (Fig. 268, 3).—The right common carotid arises from the innominate opposite the sternoclavicular joint; the left common carotid arises from the arch of the aorta. In the neck the two carotids possess identical relations. The common carotid runs upward and outward from behind the sternoclavicular articulation to a level with the upper border of the thyroid cartilage, at which point it divides into the external and internal carotid. The common carotid is contained in a sheath derived from the cervical fascia. This sheath also contains, in separate compartments, the internal jugular vein on the outer side of the artery and the pneumogastric nerve between the vein and artery, but more deeply placed. The anterior edge of the sternocleidomastoid muscle lies over the artery and is a guide. Low in the neck the common carotid is deep, being covered by skin, superficial fascia, platysma, deep fascia, and the sternocleidomastoid, sternohyoid, and the sternothyroid muscles. Above the omohyoid muscle the vessel is more superficial, being covered by the skin, superficial fascia, platysma, deep fascia, and the anterior edge of the sternocleidomastoid muscle. Upon the sheath (occasionally within it), above the crossing of the omohyoid muscle, lies the descendens noni nerve—the descending branch of the ninth pair of Willis (the hypoglossal). This nerve is a valuable guide to the sheath in the triangle of election.

The *sternomastoid* branch of the superior thyroid artery crosses the carotid artery a little below its bifurcation, and the superior thyroid vein also crosses it in this region; the middle thyroid vein crosses the artery near its middle, and the anterior jugular vein crosses low down. The common carotid rests upon the longus colli and rectus capitis anticus major muscles, the sympathetic nerve lying between the last-named muscle and the vessel, outside the carotid sheath. The recurrent laryngeal nerve passes behind the carotid below the omohyoid muscle, and the inferior thyroid artery passes behind the carotid just above the omohyoid muscle. The common carotid is in relation internally with the trachea, thyroid gland, larynx, and pharynx. To the outer side are the pneumogastric nerve (which is on a posterior plane) and the internal jugular vein. On the left side, low down in the neck, the jugular vein often lies in front or partly in front of the artery.

Ligation in the Triangle of Necessity.—In this operation the patient is placed supine, with the shoulders raised, a sand-pillow under the neck, and the head turned to the opposite side, with the chin raised. The operator stands upon the side operated upon. The incision, 3 inches long, at a slight angle to the arterial line, runs from the level of the cricoid cartilage downward and inward toward the sternoclavicular joint, following the inner border of the sternocleidomastoid muscle. The surgeon opens the deep fascia, draws the sternocleidomastoid outward, retracts the sternohyoid and sternothyroid muscles inward, and feels for the carotid tubercle of Chassaignac. This tubercle is the costal process of the sixth cervical vertebra, and lies directly under the artery. The tubercle is found about the point at which the omohyoid crosses the carotid. When the tubercle is found we know the situation of the artery, and that the triangle of necessity is below, and the triangle of election above, the tubercle. The operator draws the omohyoid muscle upward, opens the sheath of the artery on its inner side, clears the vessel, and passes the needle from without inward to avoid the internal jugular vein, remembering that the pneumogastric nerve is in the same sheath as the artery and vein, posterior and external to the artery. In this operation the inferior thyroid veins are much in the way, the anterior jugular vein crosses low down, and on the left side, at the root of the neck, the internal jugular vein may be in front of the carotid artery. If the incision is not sufficiently wide, partially divide the sternocleidomastoid or the sternohyoid and thyroid muscles. In the triangle of necessity the descendens noni nerve does not serve as a guide to the sheath of the vessels.

Ligation in the Triangle of Election (Figs. 267, 268, 4).—The *position* of the patient for this operation is the same as in the preceding one. An incision, 3 inches in length,

is made along the anterior edge of the sternocleidomastoid muscle in the line of the artery, the middle of this incision being opposite the cricoid cartilage (Fig. 267). In cutting the superficial fascia the surgeon avoids the external jugular vein, the course of which should be outlined before making the incision. The line of the external jugular is from the angle of the jaw to the middle of the clavicle. The operator opens the deep fascia, retracts the sternocleidomastoid muscle outward, feels for the carotid tubercle, draws the omohyoid muscle downward, finds the descendens noni nerve upon the sheath, opens the sheath at its inner side, and passes the needle from without inward. This incision permits ligation of either the superior thyroid or the external, internal, or common carotid, and if it be extended up a little there can be tied through it the lingual and even the facial and occipital arteries. (See Fig. 268, 4.)

Results.—It is generally stated that in from 20 to 25 per cent. of cases after ligation of the common carotid artery there is some intracranial complication. Delbet says that cerebral complications follow in one-fifth of the cases. Jordan says in one-fourth of the cases. Crile does not think they are nearly so frequent. Crile states that of the cases that develop cerebral trouble, one-half die. The cerebral troubles so often noted after ligation may be aphasic, paralytic, or mental. It was long believed that the cause was rapid cerebral softening from impaired blood-supply. Were such a cause responsible the trouble should be noted very soon after the operation. As a matter of fact it is seldom observed for twenty-four hours or longer. The phenomena occur suddenly and are probably due to embolism. I was obliged to tie the common carotid during an operation for tumor of the carotid body. The patient developed a sudden hemiplegia twenty-four hours later. (See Leonard Freeman in "Annals of Surgery," Sept., 1921.) The direct operative mortality, according to Crile, is only 3 per cent. Some modern operators regard the mortality as much higher than this. Occlusion of the artery by a removable metal band is much safer than ligation (page 375).

External Carotid Artery.—Burke ligated the external carotid in 1827 (Treves, from Chelius). The *line* of the external carotid artery is the upper portion of the common carotid line.

Anatomy (Fig. 268, 3).—The external carotid artery, which is one of the terminal branches of the common carotid, arises on a level with the upper border of the thyroid cartilage and runs to the level of the neck of the condyle of the lower jaw. At its point of origin it is covered only by skin, platysma and fascia, and the edge of the sternomastoid, but as it ascends it passes beneath the digastric and stylohyoid muscles and into the parotid gland. The glossopharyngeal nerve, styloid process, and stylopharyngeus muscle lie between the external and internal carotid arteries. The hypoglossal nerve crosses the vessel just below the digastric muscle, and the facial and lingual veins cross it a little below the nerve. The first branch is the superior thyroid, which arises from the very beginning of the trunk. The lingual arises on a level with the greater cornu of the hyoid bone. The facial and occipital take origin above the lingual. Any one of them can be ligated through the incision made for ligation of the external carotid.

Operation.—Place the patient in the same *position* as for ligation of the common carotid. The point of election is between the superior thyroid and the lingual arteries. Make an incision 3 inches in length at a slight angle to the arterial line, from near the angle of the jaw to opposite the middle of the thyroid cartilage. Cut through the skin, superficial fascia, platysma and deep fascia, and retract the sternocleidomastoid muscle outward. Watch for the digastric muscle, find the hypoglossal nerve, and feel for the greater cornu of the hyoid bone. Open the sheath a little below the hyoid cornu and pass the needle from without inward. Ligation of the external carotid has been neglected because ligation of the common carotid is easier.

Results.—Crile believes the operative mortality to be 2 per cent.

Internal Carotid Artery.—The internal carotid was tied by Keith, of Aberdeen, in 1851 (Ashhurst's "International Encyclopedia of Surgery"). The *line* of the internal carotid is parallel with and ½ inch external to the line of the external carotid.

Anatomy (Fig. 268, 3).—The internal carotid artery, the other terminal branch of the common carotid, arises on a level with the upper border of the thyroid cartilage and enters the carotid canal. The first inch of the artery is the only point where a ligature is ever applied, this point being covered only by skin, platysma, fascia, and the sternocleidomastoid muscle; higher up the artery is more deeply placed. It rests upon the vertebræ and the rectus capitis anticus major muscle. The internal jugular

vein is in the same sheath and external to the artery; the pneumogastric is in the same sheath, between the artery and the vein, but posterior to both. The superior cervical ganglion of the sympathetic lies behind the origin of the internal carotid, and between the ganglion and the artery is the superior laryngeal nerve.

Operation.—In this operation the *position* of the patient is the same as for ligation of the external carotid. The incision is of the same length and direction as that for ligation of the external carotid, and is ½ inch external. The sternocleidomastoid muscle is drawn outward, the external carotid artery is found and drawn inward, the internal carotid is found and cleared, and the needle is passed from without inward. The internal carotid is known by its more external position and by the fact that it gives off no branches.

Results.—There is the same danger of cerebral complications after this operation as after ligation of the common carotid. The operative mortality is probably as great.

Superior Thyroid Artery (Fig. 268, 3).—This branches off from the external carotid below the level of the greater cornu of the hyoid bone, in the triangle of election. It is primarily superficial, runs first upward and inward, next downward and forward, passes underneath the omohyoid, sternohyoid, and sternothyroid muscles, and reaches the thyroid gland.

Ligation.—The position of the patient and of the surgeon is the same as for ligation of the carotid. The artery may be reached through the incision employed for ligation of the external carotid. Gross made an incision beginning at the edge of the hyoid bone, and running downward and outward to the sternomastoid muscle. The skin and superficial and deep fasciæ are divided, and the artery is found deeply placed in the triangle of election between the carotid sheath and the thyroid gland.

Lingual Artery.—Sir Charles Bell ligated the first part of the lingual artery in 1814. The operation beneath the hyoglossus muscle was devised by Pirogoff in 1836 (Treves's "Manual of Operative Surgery")

Anatomy (Fig. 268, 3).—The lingual artery arises from the external carotid opposite the greater cornu of the hyoid bone, passes beneath the digastric and stylohyoid muscles, reaches the margin of the hyoglossus muscle, passes under that muscle, and emerges from beneath it to run along the under surface of the tongue. The point of election for ligation is where the artery is beneath the hyoglossus muscle. Its guide is the hypoglossal nerve, which lies upon the muscle, but at a slightly higher level than the artery.

Operation.—In this operation the patient is placed recumbent with the shoulders raised and the face turned away from the side to be operated upon. The surgeon stands upon the affected side. A curved incision is made from a little external to the symphysis of the lower jaw, downward and outward, to just above the greater cornu of the hyoid bone, and upward and outward to just in front of the facial artery at the lower edge of the lower jaw. The skin, the superficial fascia and platysma, and the deep fascia are incised. The submaxillary gland is cleared and retracted well upward. The fascia beneath the gland is divided by a transverse incision. The posterior edge of the mylohyoid muscle and the bellies of the digastric muscle are sought for and identified. One of the digastric tendons is retracted down and out (Treves). The hyoglossus muscle is cleared with a dissector; the hypoglossal nerve and ranine vein are found and drawn a little upward. The hyoglossus muscle is divided transversely a little above the hyoid bone and below the level of the hypoglossal nerve. The artery is found under the muscle and the needle is passed from above downward.

Facial Artery.—Anatomy (Fig. 268, 3).—It arises from the external carotid a little above the lingual, runs upward and forward beneath the body of the inferior maxillary bone, passes along a groove in the posterior and upper surface of the submaxillary gland, crosses the body of the lower jaw at the lower anterior edge of the masseter muscle, and passes forward and upward to the angle of the mouth and side of the nose.

Ligation (Fig. 268, 4).—The facial artery is rarely ligated in the cervical portion, but may be reached through the incision employed for ligation of the external carotid. The vessel may be tied before it crosses the submaxillary gland, the stylohyoid and digastric muscles being drawn aside. The vessel is reached in the facial portion of its course by a 1-inch cut at the anterior edge of the masseter muscle (Figs. 267, 268, 4). Branches of the facial nerve are pushed aside. The needle is passed from behind forward to avoid the vein (Jacobson).

Temporal Artery.—The line of the temporal artery passes "upward over the root of the zygoma, midway between the condyle of the jaw and the tragus" (Jacobson).

Anatomy.—The temporal artery arises from the external carotid behind the condyle of the jaw and in the parotid gland, passes over the zygoma, and divides into two terminal branches.

Ligation.—The patient is placed recumbent and the head is turned to the opposite side. An incision 1 inch in length is made (Fig. 267), the superficial structures and dense fascia are divided, the vein is retracted backward, and the needle is passed from behind forward.

The **occipital artery** (Fig. 268, 3) takes origin from the posterior surface of the external carotid, below the digastric muscle and opposite the point of origin of the facial artery. It ascends beneath the digastric and stylohyoid muscles and parotid gland; the hypoglossal nerve hooks around it from behind forward. It crosses the internal carotid artery, the internal jugular vein, the pneumogastric and spinal accessory nerves; passes between the mastoid process of the temporal bone and the atlas; grooves the temporal bone; penetrates the trapezius muscle, and ascends over the occiput.

Ligation.—This vessel can be ligated near its origin through the same incision as is employed to reach the external carotid. The hypoglossal nerve is avoided. To tie back of the mastoid process place the patient in the same position as for ligation of the carotid. Carry an incision from the tip of the mastoid upward and backward, reaching a point midway between the mastoid and the occipital protuberance (Jacobson). Cut the skin, the fascia, the sternocleidomastoid, the splenius capitis, and possibly a portion of the trachelomastoid muscles. Bring the head toward the operator in order to relax the structures, retract the edges of the wound, and clear the artery where it lies between the mastoid process and the transverse process of the atlas (Jacobson). An electric forehead light is of great assistance in finding the vessel. Pass the needle away from the vein or veins (there are often several).

Dorsalis Pedis Artery.—The *line* of the dorsalis pedis artery is from the middle of the front of the ankle-joint to the middle of the base of the first interosseous space.

Anatomy (Fig. 269, 1).—The dorsalis pedis is a continuation of the anterior tibial artery, and it runs from the bend of the ankle to the proximal extremity of the first interosseous space, where it divides into the dorsalis hallucis and the communicating arteries. The artery rests, from above downward, upon the astragalus, scaphoid, and internal cuneiform bones, and at its point of bifurcation lies between the heads of the first dorsal interosseous muscle. It may lie in some persons a little external to this course. It is held upon the bones by a distinct layer derived from the deep fascia. This artery is covered by skin, by superficial and deep fascia, and by the annular ligament above, and is sometimes partly overlaid by the extensor proprius pollicis muscle, and is crossed, just before its bifurcation, by the innermost tendon of the extensor brevis muscle. The inner tendon of the extensor communis digitorum is to the outer side of the vessel; the tendon of the extensor proprius pollicis is to the inner side, and is a guide. The artery is ligated in the dorsal triangle of the foot—a space which is bounded above by the lower edge of the annular ligament, externally by the inner tendon of the extensor brevis, and internally by the tendon of the extensor proprius pollicis. The artery has venæ comites; the anterior tibial nerve lies, as a rule, to its inner side, but may be found upon the artery or to its outer side, and the inner division of the musculocutaneous nerve is external to the vessel in the superficial parts.

Operation (Fig. 269, 2).—In this operation the patient is placed supine with the leg and foot extended. Heath flexes the leg partly and rests the sole of the foot directly upon the table. The surgeon stands below the extremity and cuts from above downward. Make an incision 2 inches in length along the arterial line, beginning opposite the lower edge of the annular ligament and running along by the tendon of the extensor proprius pollicis; cut through the skin and superficial and deep fascia; have the toes extended; retract the tendon of the extensor proprius pollicis inward, and the tendon of the extensor communis digitorum outward; clear the artery, find the nerve, try to separate the venæ comites, and pass the needle from the nerve.

Anterior Tibial Artery.—To locate the *line* of the anterior tibial mark a point midway between the head of the fibula and the tuberosity of the tibia, drop 1 inch, and draw a line from the second point to the middle of the front of the ankle-joint.

Anatomy.—The anterior tibial artery is one of the terminal branches of the popliteal. It arises opposite the lower border of the popliteus muscle, passes forward between the two heads of the posterior tibial muscle, comes to the front of the leg through an opening in the interosseous membrane, and runs down to the middle of

the front of the ankle-joint. In the upper two-thirds of its course it rests upon the interosseous membrane, to which it is fastened by firm fascia; in the lower third it lies first upon the front of the tibia and then upon the anterior ligament of the ankle-joint. For its upper two-thirds the artery has the tibialis anticus muscle just external to it; at the junction of the middle and lower thirds the extensor proprius pollicis comes from the outside and lies either upon the artery or to its inner side for the rest

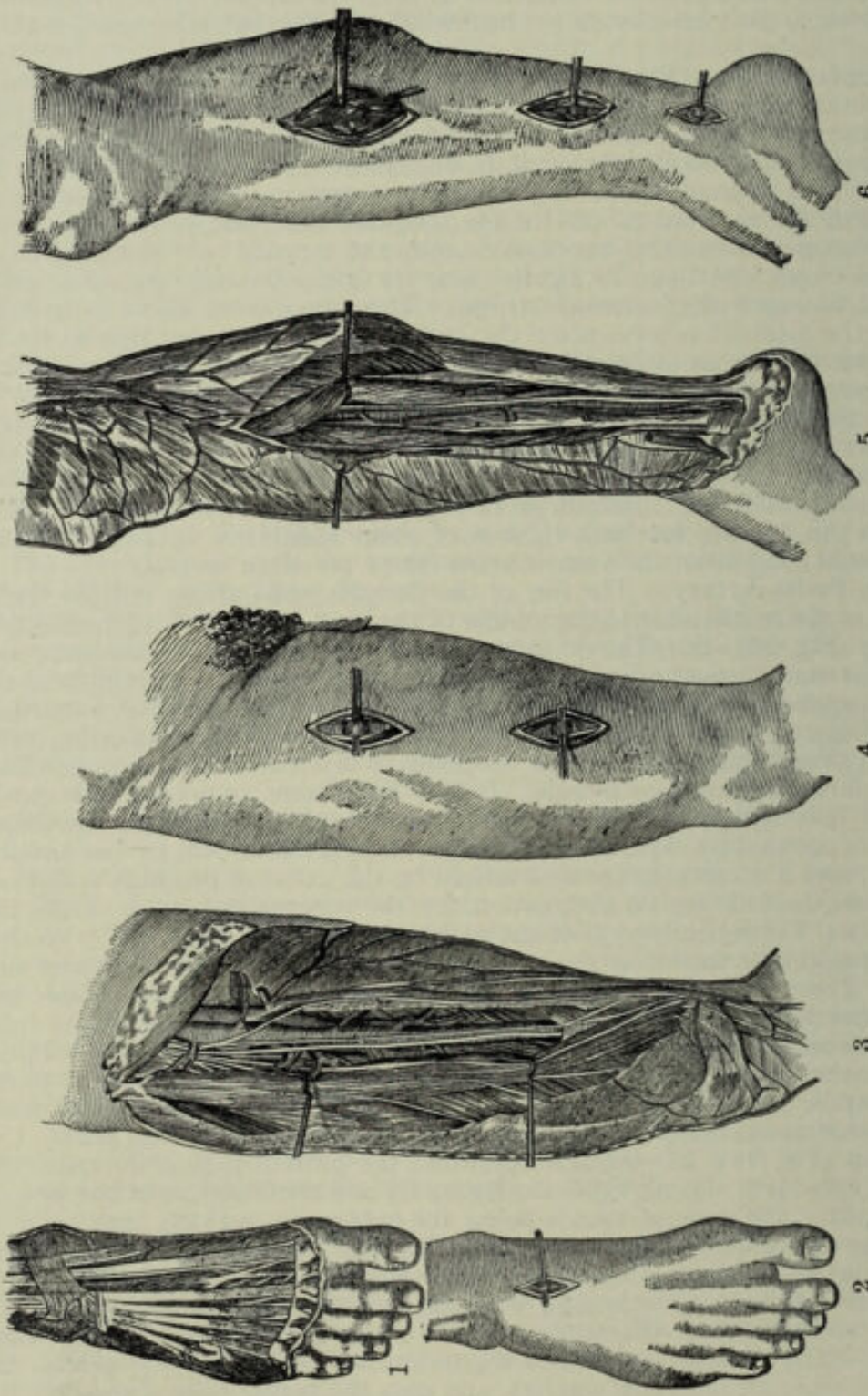


FIG. 269.—Ligations: 1, Anatomy, 2, ligation of the dorsalis pedis artery. 3, Anatomy, 4, ligation of the femoral artery. 5, Anatomy, 6, ligation of the posterior tibial artery. (From Bernard.)

of its course. Externally in its upper third is the extensor communis digitorum; in the middle third is the extensor proprius pollicis; in the lower third, the proprius pollicis having crossed to the inner side, the extensor communis digitorum again becomes the outer boundary. The artery is covered by skin and by superficial and deep fascia. In its upper third it is deeply placed between the muscles; in its middle third it is less overlaid by muscle; in its lower third it is superficial except where it is crossed by

the extensor proprius and where it is covered by the annular ligament. The artery has venæ comites. In the lower three-fourths of its course it is accompanied by the anterior tibial nerve, which in its course in the upper third of the leg is external to the artery; in the middle third it is external and a little in front of the artery; and in the lower third it is external to or upon the artery.

Operations.—The ligations of the anterior tibial are: (1) of the lower third; (2) of the middle third; (3) of the upper third. In all these ligations the patient is placed recumbent with the leg extended, and the surgeon stands to the outer side of the extremity, cutting from above downward on the right side and from below upward on the left side.

Ligation of the Lower Third.—Make an incision 3 inches long in the line of the artery and over the annular ligament. This incision is external to the tibialis anticus muscle and ½ inch from the outer border of the tibia (Barker). Divide the skin and fascia, retract the tendon of the tibialis anticus inward, and the tendon of the extensor proprius pollicis outward, along with the tendons of the extensor communis. Flex the ankle-joint to relax the tendons and clear the artery. Draw the nerve external and pass the ligature from without inward. In order to recognize the muscles in this as in other ligations, rely largely upon the finger while the muscles are being moved.

Ligation of the Middle Third.—In this operation the procedure is similar to the above. Remember that the nerve lies in front of the vessel and that the extensor proprius pollicis muscle is external. The nerve is retracted outward and the needle is passed from the nerve. A good rule for detecting the artery is to find the outer edge of the tibia and by this locate the interosseous membrane, and then, by passing out along this membrane, discover the artery.

Ligation of the Upper Third.—Make an incision 3 inches long in the arterial line. On opening the deep fascia, do not rely on the eye for finding the muscular interspace, as often the latter cannot be seen, and neither a white nor a yellow line is reliable. Place the index-finger deep in the wound and have the tibialis anticus and extensor communis digitorum muscles successively rendered tense by an assistant. In opening the interspace use the handle of the knife. Relax the muscles, retract the tibialis anticus inward and draw the extensor communis digitorum outward. Find the interosseous membrane where it is attached to the edge of the tibia, and the artery will be found upon this membrane, between the tibia and the nerve. Clear the vessel and pass the ligature from without inward to avoid the nerve.

Posterior Tibial Artery.—The *line* of the posterior tibial is from the middle of the popliteal space to a point midway between the tip of the inner malleolus and the point of the heel.

Anatomy (Fig. 269, 5).—The posterior tibial is the larger of the two terminal branches of the popliteal. It arises opposite the lower border of the popliteus muscle, passes down between the deep and superficial flexor muscles to midway between the tip of the malleolus and the point of the heel, and divides into the external and internal plantar vessels. In the upper third of its course it is very deeply placed midway between the tibia and fibula; in its middle third it is less deep, having passed inward; and in its lower third it is superficial. At the ankle the artery is beneath the annular ligament. From above downward the posterior tibial artery rests upon the posterior tibial muscle, the flexor longus digitorum muscle, the posterior surface of the tibia, and the internal lateral ligament of the ankle-joint. For the first inch or two of the course of the artery the posterior tibial nerve is to the inner side; the nerve then crosses to the outer side, and remains in that relative position throughout the rest of the course of the artery. When the knee is partly flexed and the leg is laid upon its outer surface the artery is between the operator and the nerve, and the nerve is between the artery and the table. Back of the malleolus, in the first compartment, lies the posterior tibial muscle; in the next compartment is the flexor longus digitorum muscle; in the next compartment are the artery and nerve; and in the most posterior is the flexor longus pollicis muscle.

Operations.—*Ligation Back of the Malleolus.*—In this operation the patient is placed recumbent, with the thigh abducted and the leg flexed and resting upon its outer surface. The surgeon stands to the outer side. Make a 2-inch semilunar incision corresponding in its curve to the malleolus and ½ inch posterior to its margin (Fig. 270). Cut down to the annular ligament, incise the ligament, and find the artery and venæ comites. Clear the vessel and pass the needle from behind forward (to avoid the nerve, which is here posterior and external). Do not make the preliminary incision nearer the malleolus than ½ inch, or the sheath of the tibialis posticus muscle will

surely be opened. In closing the wound, suture the ligament by buried sutures of catgut before closing the superficial parts.

Ligation in the Middle of the Leg.—In this operation the patient is placed in the same position as for the ligation back of the malleolus. Feel for the inner border of

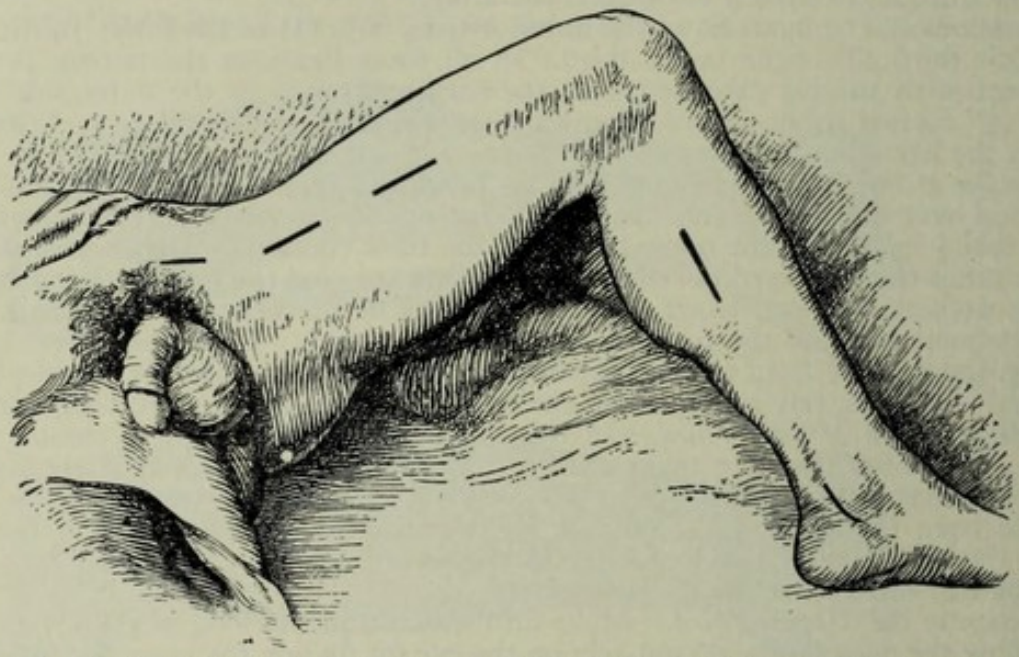


FIG. 270.—The lines indicate the incision to be made for the ligature of the common femoral, of the femoral in Scarpa's triangle and in Hunter's canal, and of the posterior tibial in the calf and behind the malleolus (MacCormac).

the tibia, and make an incision 4 inches long 1 inch behind the osseous border, parallel with it, and extending through skin and superficial and deep fascia (Fig. 270). Draw the gastrocnemius muscle away from the tibia. Incise the soleus muscle, but not the fascia beneath the soleus; cut this fascia, after dropping the handle of the knife

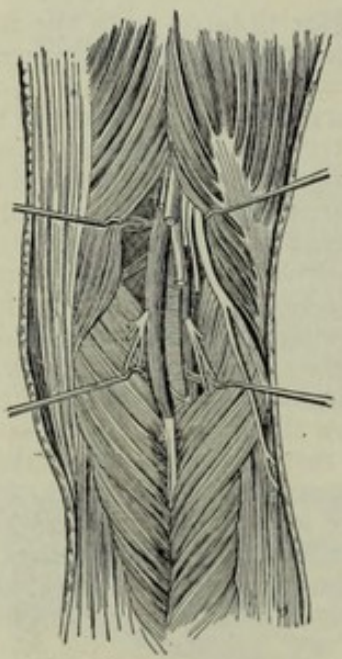


FIG. 271.—Anatomy of popliteal artery (Bernard and Huette).

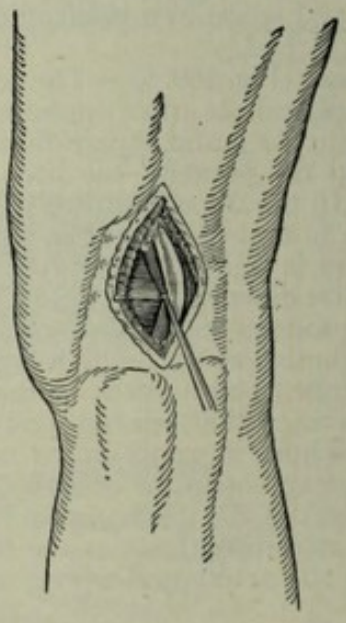


FIG. 272.—Ligation of popliteal artery in its upper third (Bernard and Huette).

so that the blade is at right angles with the plane of the tibia. Clear the artery; pass the needle from without inward.

The **popliteal artery** is almost never ligated in continuity. It can be tied at the upper portion of the popliteal space, at the lower portion of the popliteal space, or at the inner side of the thigh.

Anatomy (Fig. 271).—The popliteal artery is the continuation of the femoral, and runs from the opening in the adductor magnus muscle to the lower margin of the popliteus muscle. This vessel runs downward and outward behind the knee-joint and in the popliteal space. The ham, or popliteal space, is a lozenge-shaped space, which above the joint is bounded on the outer side by the biceps muscle, and on the inner side by the semitendinosus, semimembranosus, gracilis, and sartorius muscles, while below the joint it is bounded externally by the plantaris and outer head of the gastrocnemius muscles, and internally by the inner head of the gastrocnemius muscle. The floor of this space is formed by the surface of the femur, the posterior ligament of the knee-joint, the head of the tibia, and the popliteus fascia. The internal popliteal nerve passes down the middle of the popliteal space; it is superficial to the vessels in the upper half of the space, and is external to them; it is internal to the vessels in the lower half of the space. The external popliteal nerve is in the outer side of the space. The popliteal vein is between the nerve and the artery. Above the knee-joint it is to the outer side of the artery, but below the knee-joint it is to the inner side. The artery lies deeply in the space.

Ligation in Upper Third.—Place the patient prone. The surgeon stands to the outer side of the limb and makes a vertical incision 3 inches in length along the outer margin of the semimembranosus muscle, exposes the popliteal nerve, retracts the muscle inward and the nerve outward, exposes the artery, separates it from the other structures, and passes the needle from without inward (Fig. 272).

Ligation in Lower Third.—Make a 3-inch vertical incision between the heads of the gastrocnemius muscle. Avoid the external saphenous vein and nerve, and retract them with the popliteal nerve. Separate the artery from the vein and pass the needle from within outward.

Femoral Artery.—The *line* of the femoral artery is from midway between the anterior superior spine of the ilium and the symphysis pubis to the adductor tubercle on the inner condyle of the femur, the thigh being abducted and resting upon its outer surface (Fig. 270).

Anatomy (Fig. 269, 3).—The femoral artery is the continuation of the external iliac trunk; it extends from the lower border of Poupart's ligament to the opening in the adductor magnus muscle, and hence occupies the upper two-thirds of the thigh. The artery for its first 5 inches is superficial, lying in Scarpa's triangle, a space which is bounded externally by the sartorius muscle and internally by the adductor longus, its base being Poupart's ligament and its floor being composed of the psoas, iliacus, pectineus, and adductor longus muscles, and often the adductor brevis. The artery enters the triangle as the common femoral, but after a 2-inch course it divides into the profunda (which passes deeply) and the superficial femoral. The latter vessel is the one alluded to in this section.

At the base of Scarpa's triangle the vein is internal, the artery is between, and the nerve is external (V. A. N.). At the apex of the triangle the vein is internal and a little posterior. At the apex of the triangle the superficial femoral passes under the sartorius muscle and enters into Hunter's canal, which occupies the middle third of the thigh and which terminates at an opening in the adductor magnus muscle. Hunter's canal is bounded externally by the vastus internus muscle, internally by the adductors longus and magnus, and its roof is fascia which stretches from the adductor longus to the vastus internus. In Hunter's canal the vein is behind the artery in the upper part, but external to it in the lower part, and is firmly attached to the artery. There may be two veins. Inside Hunter's canal, but outside the femoral sheath, is the long saphenous nerve, which crosses the artery from without inward.

A way to remember the relation of the femoral vein to the femoral artery is to recall the fact that the relation of the vein to the artery is always contrary to the relation of the sartorius muscle to the artery: when the sartorius muscle is external to the artery the vein is internal, as at the base of Scarpa's triangle; when the sartorius muscle is crossing in front toward the inside of the artery, the vein is passing at the back to the outside, as at the apex of Scarpa's triangle; when the muscle is over the artery the vein is back of it, as in the upper third of Hunter's canal; and when the muscle is to the inside of the artery the vein is to the outside, as in the lower two-thirds of Hunter's canal. In a ligation at the apex of Scarpa's triangle the inner edge of the sartorius is the guide. In a ligation in Hunter's canal the long saphenous nerve is the guide.

Operations.—*Ligation of the Superficial Femoral at the Apex of Scarpa's Triangle.*—In this operation the *position* of the patient is supine, with the thigh and leg partly

flexed, and the thigh abducted, everted, and rested upon its outer surface on a pillow. The operator stands to the outer side of the extremity. From a point corresponding to the middle of Scarpa's triangle, and 2½ inches below Poupart's ligament, make a 3-inch incision in the arterial line (Fig. 270). Cut the skin and superficial fascia. The saphenous vein will not be seen unless the incision is internal to the arterial line; if this vein is seen, draw it inward. Open the fascia lata, find the inner border of the sartorius muscle, and draw it outward. The fibers of this muscle run downward and inward, thus distinguishing it from the adductor longus, whose fibers run downward and outward. Open the common sheath for the artery and vein, and then incise the individual arterial sheath. Clear the artery and pass the ligature from within outward (Fig. 269, 4).

Ligation of the Superficial Femoral in Hunter's Canal.—It was first performed for aneurysm by John Hunter in 1785. In this operation the *position* of the patient is the same as in the ligation at the apex of Scarpa's triangle. Make a 3-inch incision in the middle third of the thigh, parallel with the arterial line and ½ inch internal to it (Barker—Fig. 269, 4). Incise the skin and superficial fascia, look out for the internal saphenous vein, open the fascia lata, find the sartorius muscle, and retract it inward, thus exposing the roof of Hunter's canal, which is to be opened for 1 inch or more. Within the canal is seen the long saphenous nerve, usually upon the sheath. Open the sheath of the artery, clear the vessel, and pass the needle from without inward.

Results.—Ligation at the apex of Scarpa's triangle is a method for treating popliteal aneurysm. It is a very successful procedure. I have performed it four times with success and have assisted other operators in three successful cases. In one of my cases of popliteal aneurysm gangrene followed ligation of the femoral. Syme successfully ligated the femoral about the middle twenty-three consecutive times, and in Guy's hospital the same operation was done twenty-four times, with one death ("Practice of Surgery," by Thomas D. Bryant). The common femoral and the deep femoral are seldom ligated except for hemorrhage.

Iliac Arteries.—The *line* of the common and external iliac arteries is from a point ½ inch below and ½ inch to the left of the umbilicus to midway between the anterosuperior spine of the ilium and pubic symphysis. The upper third of this line represents the common iliac, and the lower two-thirds the external iliac (Fig. 270).

Anatomy (Fig. 263, 4).—The common iliac arteries arise from the aorta opposite the left side and lower border of the fourth lumbar vertebra, and extend to the upper margin of the right and left sacro-iliac joints, where they each bifurcate into an external and an internal iliac. The common iliac arteries lie upon the fifth lumbar vertebra, are covered with peritoneum, and are crossed by the ureters. In women the ovarian arteries cross the common iliacs. Each common iliac vein lies to the right side of its associated artery. The right common iliac artery has in front of it, besides the peritoneum and ureter (in women also the ovarian artery), the ileum, branches of the superior mesenteric artery and branches of the sympathetic nerve. The left common iliac artery has in front of it, in addition to structures common to both sides (ureter, ovarian artery, sympathetic branches), branches of the inferior mesenteric artery, and the sigmoid flexure with its mesocolon. The internal iliac artery runs from the sacro-iliac joint to the upper margin of the great sacrosciatic foramen. It is very rarely ligated (only for gluteal aneurysm, for uncontrollable hemorrhage from the gluteal or sciatic arteries, or to produce atrophy of the prostate gland). The external iliac artery runs from the sacro-iliac joint along the pelvic brim, upon the inner edge of the psoas muscle, to Poupart's ligament. The external iliac vein is internal to the artery. On the right side, high up, it passes behind the artery. The external iliac artery has in front of it peritoneum and subserous tissue (Abernethy's fascia). The ileum crosses the right, and the sigmoid flexure crosses the left, external iliac artery. The genital branch of the genitocrural nerve crosses the artery low down, and the circumflex iliac vein crosses it just before it terminates in the femoral. The spermatic vessels and the vas deferens in the male, and the ovarian vessels in the female, lie upon the artery near its termination. Sometimes the ureter crosses the vessel near its point of origin.

Ligation of the Iliac Arteries After Abdominal Section.—The best method for ligating the common, the internal, and sometimes the external iliac is by abdominal section. The patient is placed in the Trendelenburg position. The abdomen is opened in the midline below the umbilicus or in the semilunar line of the diseased side. The median incision is to be preferred in order that the deep epigastric artery may not be injured.

This artery is a very important anastomotic branch. The intestines are lifted toward the diaphragm, and are held up by gauze pads. The edges of the incision are retracted. The vessel to be tied is located and the point for ligation is selected. The posterior layer of the peritoneum is opened over the selected point, the vessel is cleared, and the threaded Dupuytren's aneurysm needle (Fig. 261) is passed in a direction away from the vein. In ligating either common iliac pass the needle from right to left. In ligating the external iliac pass the ligature from within outward. It is not necessary to suture the posterior layer of peritoneum. The abdomen is closed without a drain. In these operations be sure to push the ureter out of the way. The common iliac was first tied by William Gibson, then of Baltimore, later of Philadelphia, in 1812. This was a transperitoneal operation and was performed for hemorrhage the result of a wound. The patient died. The operation has been performed by Garviso, of Montévideo, in 1837, Post in 1840, Goldsmith in 1860 (see Stephen Smith in "Amer. Jour. Med. Sciences," vol. xl, 1860), and by Dennis, Hearn, Marmaduke Shield, Tee, Mitchell Banks, the author, and others.

Results.—Bryant ("Operative Surgery") alludes to 5 reported cases of transperitoneal ligation of the common iliac artery, with 1 death.

Ligation of the Common Iliac Artery by the Extraperitoneal Method.—The common iliac artery was first successfully ligated through an extraperitoneal incision by Valentine Mott, of New York, in 1827. The patient is placed recumbent or in the Trendelenburg position. The body is then turned a little to the opposite side and the thighs are partly flexed. Bryant says there are two linear guides for this artery. *Crampton's line* is drawn from "the apex of the cartilage of the last rib downward and a little forward nearly to the crest of the ilium, then carried forward parallel with it to a little below the anterosuperior spine" ("Operative Surgery," by Joseph D. Bryant). *McKee's line* is "drawn from the tip of the cartilage of the eleventh rib to a point 1½ inches within the anterosuperior spine, then curved downward, forward, and inward, and terminating abruptly above the internal abdominal ring" (Ibid.).

The incision can be begun just external to the internal abdominal ring and be curved upward and outward as in ligation of the external iliac, but Cramptom's incision gives more room. The superficial tissues are divided down to the transversalis fascia, this structure is nicked and divided, and the exposed and unopened peritoneum is rolled upward and inward. The muscular guide is the inner border of the psoas magnus muscle. By its side an artery is felt. If the sacrovertebral prominence is above the vessel touched, the artery is the external iliac; otherwise it is the common iliac. If the external iliac is the vessel first exposed, follow it up to find the common trunk. When the common iliac is found, separate the fatty tissue about it and pass the ligature from the right toward the left in order to avoid the associated vein.

Results.—Joseph D. Bryant tells us that this vessel has been ligated by the extraperitoneal method 69 times, with only 16 recoveries, but it is to be remembered that many of these operations were in pre-antiseptic days. The artery has been tied 80 times, with 56 deaths (70 per cent.).

Twenty-one of these operations were done since 1880; there were 10 deaths (mortality of nearly 48 per cent.). In these 21 cases gangrene occurred 7 times. (See William J. Gillette in "Annals of Surgery," July, 1908.) Halsted estimates the mortality of ligation at 46 per cent. In the days before asepsis it was over 80 per cent. Tee ("Lancet-Clinic," 1915, cxiii) says there are only on record 18 cases in which gangrene did not occur, 16 were performed for aneurysm, 2 for hemorrhage. Gradual occlusion by a metal band is safer than ligation. Halsted prefers ligation of this vessel to ligation of the external iliac, holding the larger an artery and the nearer it is to the heart, the less is the danger of gangrene. Tee (Ibid.) reports a successful case. The man was well two years after operation.

Extraperitoneal Ligation of the Internal Iliac Artery.—This operation was first performed by Stevens, of Vera Cruz, in 1812 ("Practice of Surgery," by Thomas Bryant). It is done for gluteal aneurysm. The incision and the method of exposing the vessel are identical with like steps in the ligation of the common iliac. The transperitoneal method is better and should be associated with obliterative endo-aneurysmorrhaphy.

Results.—Of 26 ligations of this vessel recorded, 18 were fatal, but only a few of the cases were done antiseptically (Joseph D. Bryant's "Operative Surgery"). D'Antona of Naples collected all cases of ligation of the internal iliac from 1869–1903. There were 25 cases with 10 deaths ("Archiv. Inter. Chir.," vol. i., 1903–1904).

Ligation of the External Iliac by Abernethy's Extraperitoneal Method (Fig. 263, 4).—The external iliac artery was first ligated by Abernethy in 1796, for aneurysm of the groin. The operation failed. A second case was also fatal. He did the first successful operation in 1806. Later he again operated successfully. The patient is placed recumbent with the thighs extended during the first incisions; but in the later stages of the operation the thighs are flexed a little to relax the abdominal structures. The operator stands to the outer side. The surgeon will find the artery by the side of the psoas muscle. Mark a point 1 inch above and 1 inch external to the middle of Poupart's ligament, and another point 1 inch above and 1 inch internal to the anterosuperior

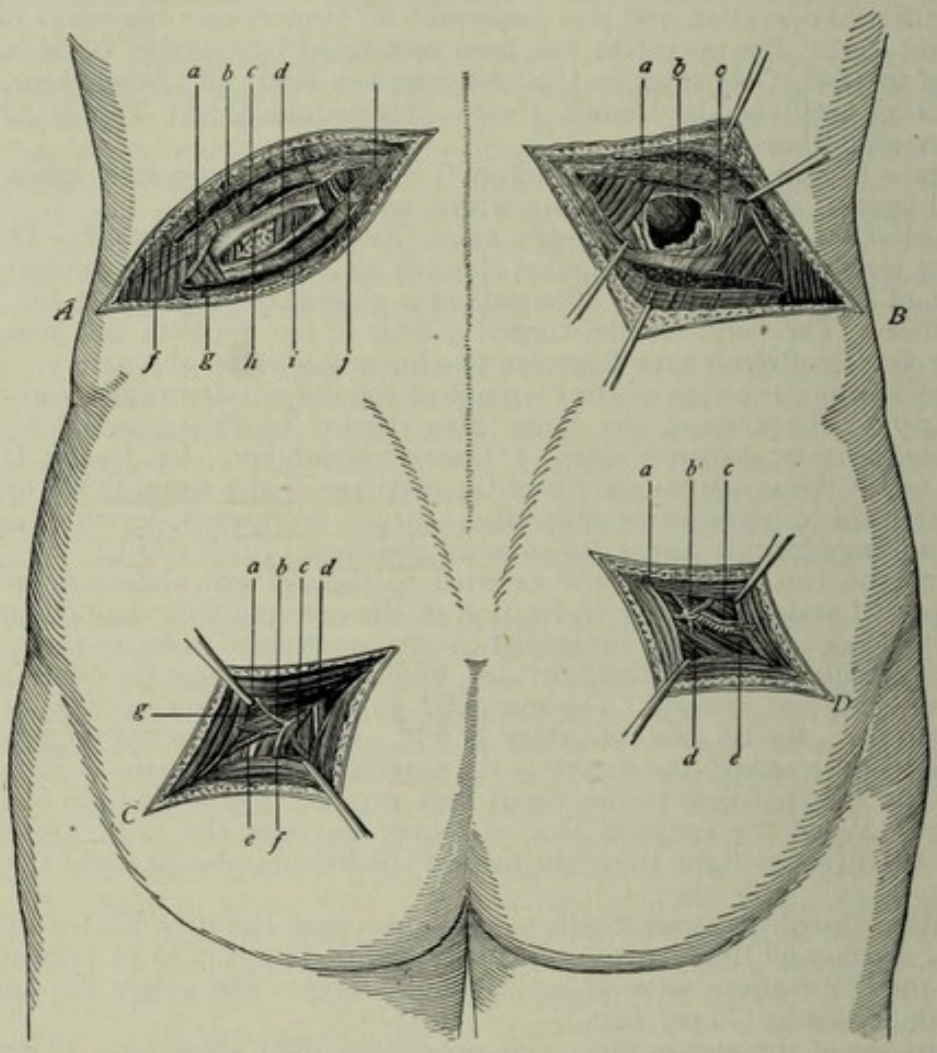


FIG. 273.—*A*, Nephrotomy: *a*, Last dorsal n.; *b*, latissimus dorsal m.; *c*, serratus post. inferior m.; *d*, middle layer of lumbar fascia; *e*, outer layer; *f*, ext. oblique m.; *g*, int. oblique m.; *h*, perinephritic (extraperitoneal) fat; *i*, quadratus lumborum m.; *j*, erector spinæ m. *B*, Nephrotomy: *a*, First lumbar n.; *b*, kidney; *c*, transversalis fascia. *C*, Ligature of the sciatic and internal pudic arteries, and exposure of the great sciatic, small sciatic, and internal pudic nerves: *a*, Gluteus maximus m.; *b*, inf. gluteal n.; *c*, sciatic a.; *d*, int. pudic a. and n.; *e*, great sciatic n.; *f*, small sciatic n.; *g*, pyriformis m. *D*, Ligature of the gluteal artery and exposure of the superior gluteal nerve: *a*, Gluteus maximus m.; *b*, gluteal a.; *c*, superior gluteal n.; *d*, pyriformis m.; *e*, gluteus medius m. (Kocher.)

iliac spine (Barker). Join these two points by a curved incision 4 inches long and convex downward. Cut the skin, the fat, the two oblique muscles, and the transversalis muscle; open the transversalis fascia, separate the peritoneum toward the vessels, and draw it inward by a broad retractor, and look for the artery along the pelvic brim. The anterior crural nerve is seen to the outer side of the artery, the external iliac vein is to the inner side of the artery, and the genitocrural nerve is upon the artery. Clear the artery near its middle and pass the ligature from within outward. In Sir Astley Cooper's method of ligation the inguinal canal is opened; in Abernethy's method the inguinal canal is not opened.

The Gluteal Artery.—This vessel is a continuation of the posterior division of the internal iliac. It emerges from the great sacrosciatic foramen at the upper border of the pyriformis muscle. It rests upon the gluteus minimus, divides into three branches, and is covered by the gluteus maximus muscle. The superior gluteal nerve lies inferior to the artery (Fig. 273). The artery was first ligated by John Bell, of Edinburgh (see his "Principles of Surgery," 1801).

Ligation.—The patient should be prone. The surgeon stands to the outer side. The incision corresponds to a line drawn from the posterosuperior iliac spine to the upper border of the great trochanter (Fig. 274). Divide the skin, fascia, gluteus maximus muscle, and the fascia over the gluteus medius muscle, and retract the gluteus medius upward. Feel for the great sacrosciatic foramen, and at this point the artery is found above the pyriformis muscle. Clear the vessel and pass the needle from below upward (Kocher's "Operative Surgery"). There is practically no mortality from this operation.

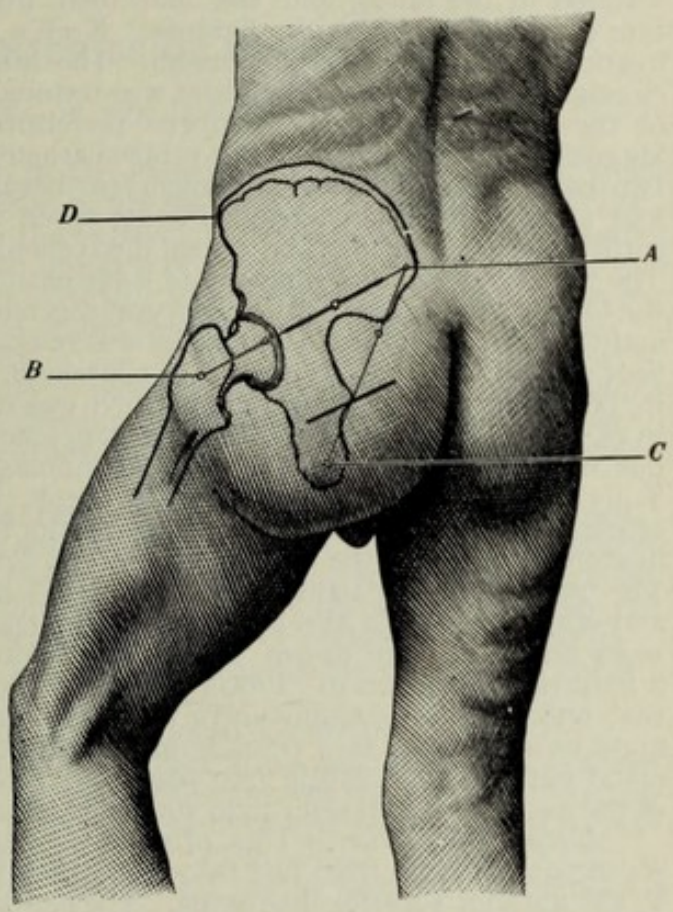


FIG. 274.—Position and direction of the superficial incisions which must be made in order to secure the gluteal artery and the sciatic and pudic arteries: *A*, Posterior superior iliac spine; *B*, great trochanter; *C*, tuberosity of the ischium; *D*, anterosuperior iliac spine; *A–B*, iliotrochanteric line, divided into thirds. This line corresponds in direction with the fibers of the gluteus maximus muscle. The incision to reach the gluteal artery is indicated by the darker portion of the line. Its center is at the junction of the upper and middle thirds of the iliotrochanteric line, and exactly corresponds with the point of emergence of the gluteal artery from the great sciatic notch. *A–C*, ilio-ischiatic line. The incision to reach the sciatic artery and internal pudic is indicated by the lower dark line. It is also to be made in the direction of the fibers of the gluteus maximus muscle. The center of the wound corresponds to the junction of the lower with the middle third of the ilio-ischiatic line (MacCormac).

The Sciatic Artery.—This artery is the larger of the terminal branches of the anterior division of the internal iliac artery. It passes to the lower portion of the great sacrosciatic foramen, lying back of the internal pudic artery, and resting upon the sacral plexus of nerves and pyriformis muscle (Gray). It leaves the pelvis between the pyriformis and coccygeus muscles, and passes downward between the ischial tuberosity and great trochanter. It is covered by the gluteus maximus muscle, rests upon the gemelli, internal obturator, and quadratus femoris muscles, has the great sciatic nerve external to it, and the small sciatic nerve external and posterior (Fig. 273).

Ligation.—The patient lies prone. The surgeon stands to the outer side. The incision "corresponds to the middle two-thirds of a line extending from the posterior inferior iliac spine to the base of the great trochanter."[1] MacCormac advises the incision shown in Fig. 274. Divide the skin, fat, fascia, and the gluteus maximus muscle. Find the artery at the lower border of the pyriformis muscle and trace it to its point of emergence from the pelvis. Pass the ligature from without inward. There is practically no mortality from this operation.

Internal Pudic Artery.—This artery is one of the terminal branches of the anterior trunk of the internal iliac. It passes to the lower margin of the great sacrosciatic foramen, and leaves the pelvis between the pyriformis and coccygeus muscles, crosses the ischial spine, and again enters the pelvis by the lesser sacrosciatic foramen. The vessel is accompanied by the internal pudic nerve (Fig. 273).

[1] Kocher's "Operative Surgery," by Stiles.

Ligation.—The position of the patient and the incision are the same as for ligation of the sciatic artery (Fig. 274). The artery is found below the ischial spine. Pass the needle from below upward to avoid the nerve. There is practically no mortality from this operation.

Ligation of the Abdominal Aorta.—This operation was first performed by Sir Astley Cooper in 1817. The patient lived but a few hours. The first 20 ligations recorded were uniformly fatal. Nine of these cases were aseptic operations. The patient of Monteiro, of Rio Janeiro, lived for ten days. The circulation was entirely restored in the limbs, and the man died from hemorrhage resulting from ulceration produced by a septic ligature. Keen's case lived for forty-eight days after ligation just below the diaphragm. The urinary secretion was plentiful and the circulation in the lower extremities was restored, death resulting from cutting through of the ligature. Robert T. Morris performed distal ligation below an aneurysm. He encircled the aorta with a soft-rubber catheter and clamped it with forceps. Twenty-two hours after operation the aneurysm began to shrink, and in three hours more had apparently disappeared. Twenty-seven hours after operation the clamp and catheter were removed. The patient died of septicemia fifty-three hours after operation. The necropsy disclosed gangrene of a bit of intestine which had been in contact with the forceps, but the dissecting aneurysm was filled with solid clot, the aorta was patent, and the circulation in the extremities was re-established ("Amer. Jour. Med. Sciences," Sept., 1900). Carl A. Hamann, of Cleveland, tied the abdominal aorta just above its bifurcation for a pelvic tumor which was diagnosticated aneurysm. The patient lived for six months. There was no gangrene of the lower extremities. Death was due to hemorrhage from a bed-sore ("Annals of Surgery," August, 1910). George Tully Vaughan ("Annals of Surgery," Sept., 1921) ligated the abdominal aorta for saccular aneurysm at the level of the superior mesenteric artery. He applied a distal ligature just below the inferior mesenteric artery, using cotton tape ½ inch broad. The tape was slowly tightened in a surgeon's knot until pulsation ceased in the iliacs and almost ceased in the aorta below the ligature. The patient lived for over two years and died from causes unconnected with the aneurysm which was filled with a hard clot (Vaughan in "Proceed. Com. Surgery Assoc.," 1922). These cases prove that under certain circumstances the operation is feasible, and in desperate cases it must be considered as a possible means of treatment. Halsted and Matas prefer a metal band to the ligature (see page 373). Gradual occlusion and partial occlusion of the aorta are much safer than sudden closure.

Murray's Operation.—This procedure aims to avoid opening the peritoneum. An incision is made from just below the tip of the tenth rib to a point 1 inch internal to the anterior superior iliac spine. The peritoneum is separated from the abdominal wall until the vessel is reached. Cooper's operation by abdominal section is the preferable procedure.

Operation by Abdominal Section (Cooper's Operation; Instruments Required.—Those used in any ligation, with the addition of an aneurysm needle with a large curve and a very long handle. With an ordinary instrument it is extremely difficult to pass the ligature. It would be a great advantage to use an instrument which, after being passed under the vessel, could have a central eyed shaft projected, as is the center shaft of a Bellocq cannula. Floss silk is probably the best ligature material.

If the patient is much exhausted, an assistant should infuse salt solution in a vein during the operation. In Keen's case there was profound shock, but the moment the ligature was tightened it passed away.

The patient should be placed upon his back. The surgeon stands to the right of the patient and opens the abdomen in the median line, a little above the level of the aneurysm. The intestines are packed aside, the posterior layer of the peritoneum is divided, the surface of the aorta over a small area is cleared of nerves, the plexuses being separated with a blunt dissector.

The needle is passed from right to left. A double ligature of floss silk should be passed and the ends should be tied with a stay knot. The wound is closed and dressed.

It has been suggested—I think by Wyeth—that it might be wise to tighten the ligature only partially at first, completing the occlusion of the artery after a day or two. Such a procedure would certainly give a better chance for the collaterals to dilate and restore circulation in the legs. A metal band is better still. By means of the band the blood flow is partially arrested.

Unfortunately, in an aneurysm, the vessel will usually be extensively diseased, and ligation will be out of the question. If, however, a normal region is found, the

chance of success in a case of aneurysm will be greater than in a case of hemorrhage from a branch of the aorta, because, in a case of aneurysm, the probabilities are that the collaterals are somewhat distended before a ligature is applied.

Operation Upon the Thoracic Aorta.—Tuffier endeavored vainly to suture the sac of a thoracic aneurysm so as to reduce its lumen ("Bull. et mém. Soc. de chir. de Par.," 1907, xiv). Krummel operated upon a ruptured aneurysm of the lower part of the thoracic aorta. He sutured the sac. The circulation in the legs was restored, but the patient died ("Deutsch. med. Woch.," 1914, xl).

XVIII. DISEASES AND INJURIES OF BONES AND JOINTS

Diseases of the Bones

Atrophy of bone is a diminution in the amount of bony matter without change in osseous structure. It arises from want of use (as seen in the wasting of the bone of a stump) or from pressure (as seen in the destruction of the sternum by an aneurysm of the aorta). *Eccentric* atrophy is the thinning of a long bone from within, the outer surface being perhaps unchanged. It is usually a senile change. *Concentric* atrophy means a thinning of the outer surface of the shaft, causing a lessened diameter. It is usually linked with eccentric atrophy.

Hypertrophy of bone may be due to increased blood-supply (as seen in chronic epiphyseal inflammation), the bone growing much more than does its fellow. It may arise from excessive use or from strain (as seen in the increased size of the fibula when the tibia is congenitally absent).

Osteopsathyrosis, Osteogenesis Imperfecta (*Idiopathic Fragilitas Ossium*).—In this condition fractures may occur without known injury, and frequently unite with great deformity because they escaped recognition and were not splinted. The condition is congenital and some cases are hereditary. The bones of the skull may ossify partly or may remain membranous. The victims of this defect seldom reach maturity. It has been thought by some observers that adrenal disease is the cause. The condition is not due to syphilis, rickets, scurvy, or osteomalacia.

In 10 per cent. of the cases the disease is obviously hereditary.

The bones contain insufficient calcium, osteoblasts are not found, and ossification is late or absent. After birth the long bones chiefly suffer fractures, the skull very seldom. Intra-uterine fractures may involve the skull or long bones. In 1900 Eddows pointed out that a victim of fragilitis osseum has a blue sclera. Blue sclera may exist without bone disease (in certain blood diseases and tuberculosis), but when the bone disease arises it is certain that it was transmitted from a person with blue sclera (Edgar A. Van der Veer and Arthur M. Dickinson, "Annals of Surgery," November, 1921). There may be many fractures. In some cases the liability to fracture disappears at or beyond thirty.

Van der Veer and Dickinson (Ibid.) point out that bones may bend rather than break, that sprain fractures are common, that the growth of many such persons is stunted, and that teeth crumble because of absence of enough mineral matter.

No known drug is of any use in treatment. Fractures are to be splinted. Griffith and Ostheimer collected 193 cases up to 1913 and a number have since been reported (Glover, "Archives of Surgery," and Davis, "Archives of Surgery," November, 1922).

Achondroplasia.—This is a congenital condition in which the epiphyses of the long bones ossify prematurely, the growth of the limbs being interfered with gravely. A victim of this condition has a body of normal size, but very short limbs. The skull is seldom involved. It is thought that the state bears some relation to cretinism. In the condition known as *hereditary deforming chondrodysplasia* irregularly shaped, symmetric hyperostoses form about the epiphyseal lines. The ankles, knees, hips, wrists, elbows, shoulders, cranium, and other bones may be involved (Ehrenfried in "Jour. Amer. Med. Assoc.," Feb. 17, 1917). Growth becomes very much stunted, great joint disability may be caused, pain may arise from pressure upon nerves, and lack of development of a bone (for instance the ulna) may cause marked deformity (Ehrenfried, Ibid.).

Tumors of Bone (*See Tumors*).—Bones give origin to both innocent and malignant tumors. Osteoma, chondroma, fibroma, or endothelioma may arise. Secondary cancer and sarcoma are well known. For multiple myeloma see page 471. A bone may become cystic. Gummata are frequently met with.

Primary Sarcoma of Bone.—These tumors are common, are very destructive, frequently call for mutilating operations, and are, as a rule, very fatal. Some arise from bone-cells, others from bone-marrow. Bone-cell tumors (osteogenic tumors) possess to a greater or less degree the power of bone formation.

Ewing ("Neoplastic Diseases") makes the following classification:

1. Osteogenic sarcoma:
   (*a*) Fibrocellular, usually periosteal.
   (*b*) Telangiectatic, involving marrow cavity, bone, and periosteum.
   (*c*) Sclerosing.
2. Benign giant-cell sarcoma.
3. Myeloma.
4. Endothelioma.



FIG. 275.—Bone aneurysm: Central telangiectatic sarcoma of femur (author's case).

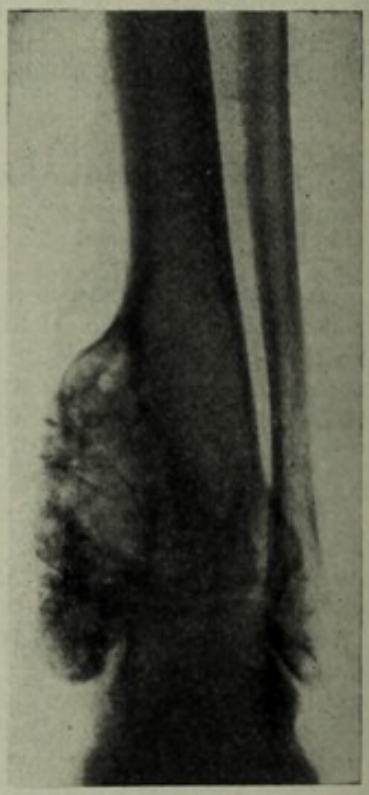


FIG. 276.—Sarcoma of the lower end of the tibia (U. S. Naval Hospital, League Island, Pa.; skiagraphed by Lieut. George U. Pillmore, Medical Corps, U. S. Navy).

Osteogenic Sarcoma; Periosteal Sarcoma.—Particular seats of this tumor are in the ends of the long bones, but it may arise from any bone. The tumor originates in the deeper layer of the periosteum and forms a large tumor encasing the shaft.

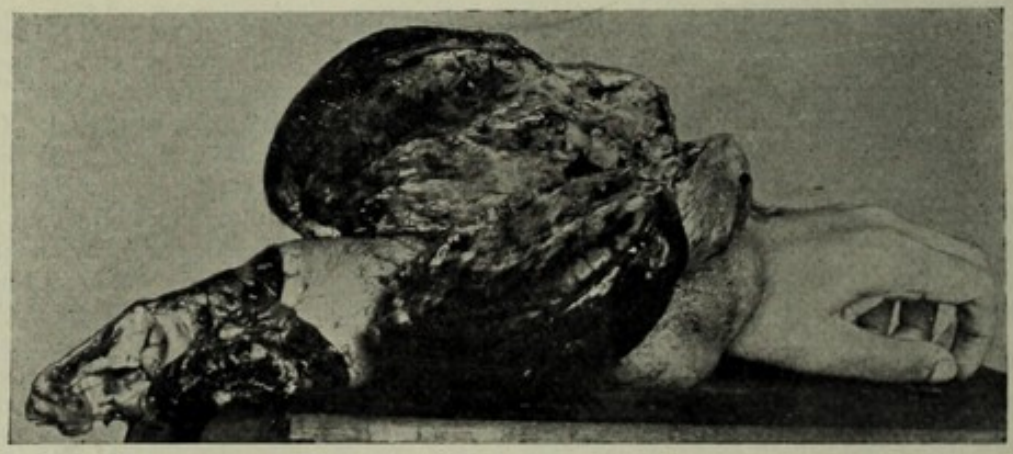


FIG. 277.—Osteosarcoma of forearm (Dr. Allen J. Smith).

For a considerable time the shaft remains sound, but sooner or later becomes involved and undergoes spontaneous fracture. When the growth breaks through the periosteum it invades muscles, fascia, and eventually skin. In some cases there is a thin capsule of bone, in others partial ossification into bony trabeculæ. Cartilage formation is common.

Cysts may develop. A few periosteal sarcomata show many round-cells, but most of the growths are composed of spindle-cells. Giant-cells of a particular type may be met with. The soft and very cellular growths are dreadfully malignant. Metastasis is early to the lungs.

Telangiectatic Sarcoma (*Bone Aneurysm*).—These cellular bone tumors contain numerous blood-vessels, rapidly destroy the shaft and enter the marrow cavity, break through the periosteum, and attack muscle and fascia. Though the tumor enters the marrow cavity it does not start there, but originates from bone and vascular structure. Spontaneous fracture is an early sign. More or less bone is formed in the tumor. If the periosteum does not give way early it may form an egg shell of bone over the tumor. Such a shell is so thin that it crackles on pressure. A bone aneurysm, if not covered by a shell, pulsates and gives a bruit. In some cases the vascular element is so great, the solid element so trivial, the whole mass so soft, that it has been mistaken for genuine aneurysm. Metastasis to the lungs is common. Bone aneurysm is most often met with in the head of the humerus, the lower end of the humerus, the head of the femur, the lower end of the femur, and the head of the tibia.

Clinically osteogenic sarcomata frequently follow trauma, are most usual before the thirty-fifth year, may be met with in young children, produce pain and cachexia, undergo early metastasis to the lungs, are very apt to recur after operation (even after amputation). Probably less than 8 per cent. are cured even by very early amputation.

Benign Giant-cell Sarcoma.—If the giant-cells predominate, the tumor is usually in the long bones and is a central growth, but it may be periosteal. The mass looks like currant jelly. It is most common in the ends of the long bones, but is frequent in the maxillæ. These growths destroy the cancellous tissue. The periosteum may form a shell over them. They may destroy the shaft, but do not involve muscle or fascia and do not undergo metastasis. A central growth without a shell may pulsate. Local removal cures benign giant-cell sarcoma.

Diagnosis and Treatment of Bone Sarcoma.—Clinical and *x*-ray evidence is often uncertain. Bloodgood, after an immense experience, insists on the value of exploration and the examination of frozen sections. Bloodgood takes a large section and at once smears the parts from which the section was removed with a 50 per cent. solution of chlorid of zinc, to prevent diffusion of cells. If the growth is of the small cell or spindle-cell type amputation may be called for. If the growth is of the giant-cell type curet, insert radium needles, and leave the wound open (see Coley in "Annals of Surgery," March, 1924).

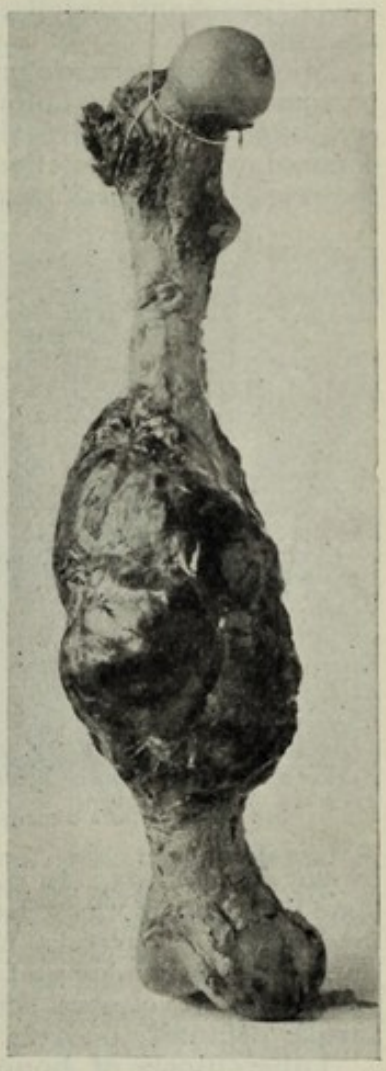


FIG. 278.—Periosteal sarcoma of femur (Dr. A. C. Wood).

Cysts and Cystomata of Bone.—One variety of cyst is found in the jaws (dentigerous cysts, see page 306). The other variety occurs usually in the medullary canal of long bones and very seldom in short bones and flat bones. "It differs from the dentigerous cyst in the absence of a connective-tissue capsule. The fluid is usually hemorrhagic. Islands of cartilage may be found in the bone capsule" (Bloodgood in "Progressive Medicine," Dec. 1, 1907). The condition known as *fibrous osteitis* is prone to cause cyst formation. The disease is said to have been discovered by Eddowes in 1900, but some give credit to Spurway in 1896. It is also called *Albers-Schönberg disease*. Fibrous osteitis is a very chronic inflammatory condition in which medullary substance is replaced by cellular and vascular connective tissue which in places becomes fibrous. Bone thins, and between the bone and periosteum like tissue forms. It may lead to the formation of a cyst or of cysts or a giant-cell sarcoma. It arises particularly in children and is most commonly found in the femur, tibia, and humerus. It may escape recognition until fracture occurs. In 1910

Bloodgood collected reports of 89 cases of bone cyst and 69 of them were related to fibrous osteitis.

Barrie ("Surgery, Gynecology, and Obstetrics," 1914, xix) has presented strong evidence to prove that a basis for various solitary lesions in the long bones is *hemorrhagic osteomyelitis*.

If the condition retains throughout its course hemorrhagic granulation tissue he calls it chronic hemorrhagic osteomyelitis and places in this group giant-cell sarcoma which he regards as a regenerating inflammation. If fibrous tissue appears and cystic formation begins he names the condition chronic fibrocystic osteomyelitis.

A *bone-cyst* slowly expands and thins the shaft of the bone, and in some cases fracture of the bone is the first evidence of the trouble. Fracture may be caused by very trivial force. Union takes place after fracture, but the enlargement remains. The *x*-ray picture may not enable us to make the diagnosis, because it closely resembles the picture of any medullary growth possessed of a bony capsule and producing osseous absorption.

Many bone-cysts are produced by softening of solid neoplasms (giant-cell sarcoma, myxoma, medullary fibroma, chondroma). Occasionally cysts form in osteomalacia and osteitis deformans, the condition arising from softening. Hydatid cysts and dermoid cysts are sometimes encountered. A true cystoma of bone, except in one of the jaws, is a surgical rarity. In the jaws cystomata are not very uncommon. The diagnosis of a bone-cyst is confirmed by exploratory incision. A solitary cyst is treated by curetment and packing or by filling the curetted cavity with Mosetig-Moorhof bone-wax (page 460).



FIG. 279.—Spina ventosa (Dr. J. A. Kelly).

Multiple cysts may be treated by resection and bone-grafting (Tyler in "Med. Herald," 1914, xxxiii).

Syphilis of Bone.—Secondary syphilis may attack the bones (see page 272). Tertiary syphilitic lesions are considered on page 275.

Actinomycosis of bone is most usual in the jaw, but may attack the orbit, ribs, sternum, or limbs (see page 254). Actinomycosis of bone may arise secondarily after infection of superficial parts by the streptothrix. In the jaw the fungus obtains entrance to the interior of the bone through a tooth socket. In some cases of bone actinomycosis the fungus reaches the bone by the blood. Actinomycosis leads to the production of granulation tissue, the bone is expanded and becomes carious, and a quantity of new bone is sometimes produced. In vertebral actinomycosis, although the condition resembles tuberculosis, angular deformity does not occur.

Tuberculosis of bone (*tuberculous osteomyelitis*) tends especially to appear in the cancellous ends of long bones. In about one-fifth of the cases it is primary, that is, only one focus can be found. In such cases the point of entry shows no lesion, or the lesion at that point may have healed. In some cases the bacilli enter through the tissue. The blood or lymph carries the bacteria to the region where they lodge and develop.

Healthy marrow is almost immune to infection, it has such a high degree of resistance (Fraser, "Jour. Amer. Med. Assoc.," Jan. 2, 1915).

The bacilli grow readily in diseased marrow. The common disease which precedes infection is gelatinous degeneration, the result of endarteritis, and endarteritis can be produced by the toxemia of distant tuberculosis (Fraser, Ibid.). Such a blood-vessel ruptures easily, giving rise to hemorrhage, and in that area of extravasation bacteria are prone to lodge. Trauma may be an exciting cause. It ruptures the diseased blood-vessels or creates a point of least resistance. Long after apparent healing the disease process may awaken into activity and trauma is often the cause of the awakening. In one of König's cases trouble began anew after sixty years. The

disease is especially apt to attack the epiphysis and spread to the joint, although in some cases it spreads to the shaft. In exceptional cases it begins on the diaphyseal side of the epiphysis. Primary tuberculosis is rare in the shafts of long bones, but is not uncommon in the shafts of short bones. When the shaft of a short bone is distended by a tuberculous process the condition is called *spina ventosa* (Fig. 279). In a bone focus the original tubercle necroses, other tubercles form and necrose, the separate areas unite, and a bone cavity forms. This cavity is surrounded by granulation tissue and the cavity contains tuberculous granulations, necrotic tubercles, and perhaps bone sequestra. The cavity is the result of rarefying osteitis and no new bone forms unless there is a sequestrum or are sequestra. A sequestrum causes irritation and irritation leads to bone formation. The sequestra in tuberculous osteomyelitis are not completely loose, but are still attached at some point. The bone may sclerose from the action of osteoblasts, osteoclasts may soften the bone by removing the lime salts, or the bone may become "worm-eaten." Sclerotic bone means a healing process. Softened bone means a spreading process. A sequestrum in tuberculous osteomyelitis is usually wedge shaped, the base being toward the joint. A sequestrum is due, König thinks, to the obstruction of a terminal artery by a tuberculous embolus or by the intra-arterial growth of bacilli ("Die Tuberculose der Menschlichen Gelenke, swiel der Brustward und des Schaedels"). In a certain number of cases tuberculosis infiltrates a spongy bone with great rapidity because of rapid caseation. This condition is known as *infiltrating progressive bone tuberculosis*.

The vertebræ are the most common seats of bone tuberculosis. Next in order come the lower end of the femur, the cranium and face, the hip, the sternum and ribs, foot, humerus, pelvis, tibia and fibula, ulna, radius, and scapula.

Primary tuberculosis of the patella is very seldom seen. According to Murphy this immunity is due to the fact that the patella is a sesamoid bone without any epiphyseal loop circulation ("Surgery, Gynecology, and Obstetrics," vi, 1908). (See Tuberculous Arthritis, page 582).

Thickening of the periosteum and beneath the periosteum is one of the first signs of osseous tuberculosis. This results from hyperemia, and connective tissue, or even new bone, may form. I do not mean that the periosteum is attacked primarily. It is not. The initial lesion is osteomyelitis and the periosteal thickening is only a sign of the deeper lesion. If bone production should be marked we would question the diagnosis of uncomplicated tuberculosis and would suspect tuberculosis with syphilis or syphilis alone.

Caries sicca (Volkmann's caries) is a condition without suppuration, in which the joint cavity is obliterated and in which the articular extremity of the bone undergoes "sclerosis and concentric atrophy" (Senn in "Tuberculosis of Bones and Joints"). It is most common in the shoulder-joint and is a form reasonably curable by conservative means.

Osteitis, Periostitis, and Osteoperiostitis.—It is not wise to consider alone acute inflammation of medulla, bone, or periosteum. Acute periostitis almost always is soon accompanied by at least some degree of osteomyelitis, and acute inflammation about the epiphysis is soon followed by inflammation of bone, medulla, and periosteum, that is, by acute osteomyelitis. **Osteitis,** or **inflammation of bone,** may be due to traumatism, to a constitutional malady or diathesis, to the extension of inflammation from some other structure, to certain fevers, to cold, to phosphorus or mercury, to infection, or to working in pearl button factories. In inflammation of bone the exudate and leukocytes pass into the Haversian canals, spaces, and canaliculi. The bone corpuscles proliferate and the bone undergoes thinning (rarefaction), not because of pressure, but because of absorption by voracious leukocytes and osteoclasts. This process of rarefaction enlarges all the bony spaces, and by destroying septa throws many of the spaces into one. If the surface of a bone inflames, the periosteum will be separated more or less by exudation, and the bone will be covered with little pits or erosions made by the leukocytes. Inflamed bone is so soft that it can be readily cut with a knife.

Osteitis may terminate in *resolution* or it may terminate in *sclerosis*, the mass of proliferating cells being converted first into fibrous tissue and next into dense bone which contains a very few small cancellous spaces. If the exudation is under the periosteum, the bone will be thickened at this point, bone stalactites marking the points of passage of the vessels. Osteitis may terminate in *suppuration*, this condition being often called *caries*. In tuberculous osteitis caseation of the inflammatory products is very apt to arise (*tuberculous caries*, the *strumous caries* of our predecessors). Acute

osteitis may terminate in *necrosis*, the inflammatory exudate compressing the vessels in their bony canals, a portion of the bone being, in consequence, deprived of nutritive material. The portion cut off from nutritive fluid dies *en masse* (necrosis). Osteitis is usually associated with more or less periostitis. A simple acute periostitis without involvement of the bone may arise from traumatism or strain; but in all severe cases of periostitis, in all chronic cases, in all cases due to syphilis, rheumatism, measles, scarlatina, or enteric fever the bone is involved at the same time or subsequently. In syphilitic states gummatous degeneration frequently ensues.

Pearl workers' osteitis may arise in those who polish mother of pearl. It occurs particularly in youths before fusion of the epiphyses. It arises in the diaphysis near the epiphysis. The bones of the limbs are most apt to suffer, but the bones of the face or chest may be attacked. The attack begins with pain and moderately elevated temperature and the fever may persist for several weeks. The condition may apparently get well and yet begin again when the patient returns to work. The lesions are often symmetric and always multiple (Broca). It is a condensing osteitis and undergoes spontaneous cure if the patient gives up the occupation (Deturk in "Archives Générales de Chirurgie," Nov., 1908). It is thought to be due to dust entering the lungs and reaching vessels in the bone. The dust is composed of carbonate of lime and conchiolin.

Symptoms of Osteitis and Osteoperiostitis.—As a chronic process *osteitis* is most commonly found in the femur. The history may exhibit a record of an antecedent injury or chilling of the body. Pain is severe, boring or aching in character, deep seated, worse at night, and aggravated by a dependent position of the part. The symptoms closely resemble those of periostitis, with which disease it is almost sure to be linked. Tenderness exists on percussion and sometimes on pressure. Subperiosteal swelling, fusiform in shape, is noted; cutaneous edema and discoloration are observed if a superficial bone is inflamed. In syphilis atrophic osteitis may attack the cranial bones and produce softening or even perforation, or osteophytic osteitis may arise, exostoses being formed. *Osteoperiostitis* may be acute or chronic, circumscribed or diffused, and may terminate in resolution, organization, or suppuration. It arises from cold, blows, wounds, strains, the spread of adjacent inflammation, specific febrile maladies, pyogenic infection, syphilis, rheumatism, or tuberculosis. The symptoms are pain (which is worse at night and which is aggravated by motion, pressure, or a dependent position), swelling, edema, and discoloration of the soft parts. Pain in the syphilitic form is not so severe as in other varieties. *Acute diffuse osteoperiostitis* has been called *acute necrosis*. It is very improbable that a violent, diffuse, pyogenic inflammation can attack the periosteum without the bone and medulla becoming involved, in fact, it is always described as a pyogenic inflammation of bone and periosteum commonest in children about the age of puberty. The condition is really acute osteomyelitis (page 461). In *simple acute periostitis* a swelling is felt upon the osseous surface. The swelling is firmly fixed and is very tender, but the bone itself is not enlarged. There is some local heat, discoloration, often fever, and the patient complains of an aching pain, which is worse at night.

Periostitis due to strain demands some special attention. Sir James Paget, years ago, pointed out that muscular exertion might cause periostitis. C. T. Dent has written a valuable article upon this subject.[1]

It is common to hear football players complain of some trouble with the knee-joint. Examination finds tenderness over the tubercle of the tibia with slight swelling of the joint. Dent points out that pain is felt on straightening the leg, not on rotating it. The same observer states that omnibus drivers suffer from periostitis of the fibula due to pressing forcibly against the foot-board; those who ride may develop periostitis of the adductor insertion (riders' bone); the victims of flat-foot may labor under periostitis of the inner tuberosity of the os calcis; bar-keepers, from working a beer-pump, may get periostitis of the scapula, pain being marked on contracting the biceps; a housemaid may develop periostitis at the points of bony origin of the great pectoral from the chest, the condition being due to sweeping and scrubbing.[2] Chauffeurs are liable to periostitis of the fibula.

Treatment of Osteitis and Osteoperiostitis.—In syphilitic forms the local treatment consists in rest, elevation of the part, the application of iodin and mercurial ointment, and bandaging. Specific treatment is given by the stomach, hypodermically or intravenously. Operation is rarely justifiable. In other forms, if the case be recent and severe, put the patient to bed, place the limb in a splint and elevate it, employ

[1] "Practitioner," Oct., 1897. [2] Ibid.

cold, apply a bandage, and give salines and iodid of potassium internally. Later use ichthyol inunctions locally and apply a hot-water bag. Morphin is administered for pain. If these means fail, counterirritate by iodin and blue ointment or blisters, and apply heat locally. In severe cases take a tenotome and slit the periosteum subcutaneouly to relieve tension; this procedure often quickly relieves the pain. Some cases demand longitudinal osteotomy, which is performed by taking Hey's saw and dividing the bone longitudinally into the medullary canal. If pus forms, drain at once.

Acute diffuse osteoperiostitis requires early and free incisions through the periosteum and bone, antiseptic irrigation, drainage, rest and elevation of the limb, and strong supporting and stimulating treatment. Amputation is sometimes demanded, as when the patient grows weaker and weaker even after incision, and when a joint is seriously involved. If necrosis affects the entire shaft, which separates from its epiphyses, and new bone has not yet formed from the periosteum, make a subperiosteal resection of the shaft.

Chronic periostitis is often syphilitic. A *node* is a chronic inflammation of the deep periosteal layers. Nodes occurring early in the secondary stage remain soft and soon pass away under treatment, but those occurring two years or more after infection are apt to cause a bony deposit. A node may soften, leaving a sinus, at the bottom of which is a piece of dead bone. Gumma of the periosteum is one form of node which is apt to produce caries or necrosis.

Osteoplastic periostitis accompanies chronic osteitis and causes the deposit of new bone, which undergoes sclerosis. The chief *symptom* is aching pain, which is worse when the patient is warm in bed, and is aggravated by damp and wet. A hard swelling is found at the seat of pain (often over the tibia, ulna, clavicle, or sternum). The soft parts are uninflamed and move freely unless softening or suppuration has occurred. Tenderness is manifest.

Treatment of Chronic Periostitis and Osteoplastic Periostitis.—For the nodes of early syphilis administer mercury by the plan usually followed in secondary syphilis; for the nodes of late syphilis give mercury and large advancing doses of iodid of potassium. Blisters, blue ointment, and iodin are applied to the skin over the area of periostitis in both forms, and subcutaneous division of the periosteum is of value. If suppuration occurs, incise antiseptically and drain.



FIG. 280.—Chronic abscess in the great trochanter ("American Textbook of Surgery").

Chronic Abscess of Bone, or Brodie's Abscess.—This condition is sometimes due primarily to tuberculous infection, symptoms being absent for a longer or shorter time and arising because of secondary infection with staphylococci. It is always chronic, never acute. A very acute inflammation, such as is induced by virulent pyogenic organisms, causes acute osteomyelitis rather than an acute abscess. After typhoid fever an area of suppuration may slowly form in the head of a long bone due to action of typhoid bacilli. Non-virulent staphylococci may be responsible and the condition may follow long after a staphylococcus osteomyelitis. In 84 per cent. of cases of Brodie's abscess this is the history (Alexis Thomson). The same author says the latent period between the osteomyelitis and the abscess varies from one to fifty-seven years. Chronic abscess of bone was first described by Sir Benjamin Brodie, and is often called *Brodie's abscess*. It occurs in the cancellous structure of the ends of long bones—usually in the head of the tibia, sometimes in the femur (Fig. 280) or humerus. It seldom occurs in the shaft of a long bone. A chronic abscess of bone may follow a slight injury, which constitutes a point of least resistance. Bacteria lodge and multiply; bone rarefaction leads to the formation of a cavity, suppuration arises, and the surrounding bone thickens and hardens because of growth from the periosteum. The abscess is apt to break and often breaks into a joint, as the joint surface is not covered by periosteum and no barrier of bone is there formed. Brodie's abscess may induce necrosis.

Alexis Thomson thus describes Brodie's abscess ("Edinburg Med. Jour.," April, 1906):

In the first or quiescent stage there is a cavity filled with serum and lined with a membrane like the periosteum of young bones. The outer layer of the membrane is forming new bone of a spongy nature, "further away the old bone is sclerosed and the medullary canal obliterated."

When the mature stage or abscess stage arises the lining membrane is converted into granulation tissue, and the cavity becomes filled with staphylococcus pus. The outer layer of granulations erodes the bone and the abscess progressively enlarges. As the bone is eroded within, new bone is formed by the periosteum and the bone enlarges. If pus formation is more rapid than bone erosion there is tension and pain, but if bone erosion is sufficiently rapid to prevent tension there is little or no pain. Finally, the abscess perforates the bony shell "on the periosteal surface or into an adjacent joint."

Symptoms.—There are attacks of boring pain, worse at night and aggravated by motion and pressure and a dependent position. The pain is intermittent, may be absent for many days at a time, and is in many cases thought to be rheumatic. The tenderness is marked, even when there is an intermission in the spontaneous pain. The patient is apt to believe the pain is in the joint, but examination demonstrates that the tenderness is in the bone. If the head of the tibia or the great trochanter is the seat of disease, percussion over that region develops pain most certainly. At times pain in the bone becomes excruciating and tenderness acute. There is more or less loss of function in the limb and in far advanced cases the bone is enlarged. There may be thickening of the bone and soft parts, edema and discoloration of the skin over the seat of trouble, and attack after attack of synovitis in the nearest joint. Irregular fever and sweats are usually noted, but there may be no fever. The harassing pain causes sleeplessness, exhaustion, and emaciation. When the pus breaks through the bone abscess develops in the soft parts. If this abscess bursts or is opened, pain ceases (Thomson). The *x*-rays aid greatly in making the diagnosis.

Treatment.—In treating bone abscess trephine the bone at the point of greatest tenderness, and if the abscess is missed, follow the advice of Holmes and perforate the wall of bone with the trephine, opening in several directions, to discover the pus. It is often easy to open into the abscess with a chisel or gouge. After opening the cavity scrape its walls, remove dead bone, thoroughly dry with gauze, touch with pure carbolic acid, and pack with iodoform gauze. If the abscess opens into a joint, trephine the bone, and also open, irrigate, and drain the joint.

Caries was a term once used universally to signify suppuration or molecular death of bone. In some cases caries means suppurative osteitis; in others, tuberculous osteitis; in still others, gummatous osteitis. Typhoid fever is occasionally followed by a carious condition of bone. Osteitis is apt to become purulent when the bone is exposed to the air, when rest is not secured, when the health of the individual is below normal, when a foreign body such as a bullet is in the bone, or when tuberculosis or syphilis exists. The term is seldom used today except loosely, and then usually to signify tuberculous disease of bone. When caries arises the softened and granulating bone breaks down and is eventually discharged through a sinus. After drainage is secured, organization, sclerosis, and healing may result. In these cases new bone may form and a cure follow.

Tuberculous or *strumous caries* (*caseous osteitis*), a condition produced by the caseation of the products of a tuberculous osteitis, seldom shows any tendency to self-cure, neither organization nor sclerosis takes place, and new bone seldom forms unless an operation is performed. The interior of bones, especially of the carpus and tarsus, is entirely softened and destroyed and thin shells only are left.

Caries necrotica is a condition in which small but visible portions of soft and dead bone are cast off; *caries sicca* is molecular death of bone without liquefaction or suppuration.

The caseating masses in tuberculous caries contain tubercle bacilli. If a tuberculous collection is evacuated and infection with pus organisms occurs, genuine suppuration takes place, and constitutional infection causes septic fever and may cause death. Pyogenic osteitis may affect any part of any bone; but caseous osteitis (tuberculous caries) tends to arise, especially in cancellous structure (heads of long bones, vertebral bodies, ribs and sternum, and bones of the carpus and tarsus). Tuberculous osteitis of the shaft of a long bone occasionally, but rarely, arises. Tuberculous osteitis is apt to cause tuberculous disease in an adjacent joint. Tuberculous osteitis may be followed by the formation of a cold abscess.

Symptoms.—In the beginning the evidences of caries are usually those of osteitis,

but the first sign noted may be a fluctuating swelling due to pus or to caseated tubercle. After a time, at any rate, a fluctuating swelling is discovered. If not opened, the softened mass breaks externally, voids its contents, and leaves a sinus from which flows purulent or caseated matter which after a time becomes thin, reddish, and irritating to the skin, contains small portions of gritty bone, and has a foul smell. The opening of the sinus fills up with edematous granulations. A probe carried to the bottom of the bone finds bone which is sieve-like (worm-eaten), and which on being struck gives a muffled note rather than the clear, sharp note of necrosis; the bone is rough, is bared, and is so soft that the probe can usually be stuck into it. In old cases of caries amyloid disease may arise.

Treatment.—If syphilis exists, give iodid of potassium in advancing doses and a mild mercurial course. If tuberculosis exists, give iodid of iron, arsenic, cod-liver oil, and nourishing foods, and recommend ocean air and living in the open air. Locally, in all cases, insist on rest and at once secure drainage, enlarging the opening, if necessary, and inserting a tube, and even making additional openings; syringe often with antiseptic fluids and dress antiseptically. If the case is seen before spontaneous evacuation has occurred, open under strict antiseptic precautions. When a chronic sinus exists there arises the question of operation. Incomplete operations are worse than useless, for they may be followed by diffuse tuberculosis or pyemia. If the gouge is used, try to remove *all* carious bone. The diseased bone is white, crumbles, and does not bleed; the non-carious bone is pink and vascular. Scrape away all granulations, swab the cavity with pure carbolic acid, and pack it with iodoform gauze. Instead of gouging away bone there may be used the actual cautery, sulphuric acid, or hydrochloric acid. In severe cases excision is required, and in some rare cases amputation may be necessary. Caries of the spine is considered under Diseases of the Spine.

Necrosis is the death of visible portions of bone from circulatory impediment or the direct action of bacterial toxins. It is analogous to gangrene. One cause of necrosis is traumatism (such as the tearing off of periosteum) which deprives the bone of blood. Inflammation of the periosteum further lessens the nutrition. Acute inflammation in bone causes necrosis, the excessive exudation in the canals and spaces occluding the blood-vessels by pressure. The occlusion of vessels by bacterial thrombi or emboli may lead to necrosis, or the direct action of toxins may first inflame and finally destroy a portion of the bone. A thin shell of bone only may necrose from periosteal separation, or an entire shaft may die from acute pyogenic osteomyelitis or diffuse infective periostitis. Osteomyelitis is the most usual cause of necrosis. Necrosis is most frequently met with in the diaphyses of the long bones, caries in the cancellous tissue of bones. The ribs may become carious, but very rarely become necrotic. A sequestrum may, but does not often, form in a vertebral body, in the cancellous head of a long bone, in the carpus, or in the tarsus. If a sequestrum arises from tuberculous osteomyelitis it is seldom found completely detached, but still retains some vascular connection. In tuberculous osteomyelitis of a long bone the sequestrum is wedge shaped with its base toward the joint, and is due to infarction of terminal arteries. A fragment of dead bone is a foreign body; the healthy bone adjacent to it inflames and softens; granulations form, and this line of granulation, like the line of demarcation of gangrene, tends to separate the dead part from the living, the white dead bone being surrounded by the red zone of granulation tissue. A bit of dead bone is called a *sequestrum*, and nature tries to cast it off. A superficial sequestrum is known as an *exfoliation*.

Nature's method of casting off a sequestrum is as follows: Suppuration takes place at the line of demarcation, osteitis extends for a considerable distance around this line, the periosteum shares in the inflammation, and new bone forms. A cavity is made within by suppuration, and a box or case is formed without by ossification, the now entirely loosened sequestrum being so encased that it cannot escape. The pus finds its way through the new bone, and there is presented the condition so often seen by the surgeon—namely, a case of new bone known as the *involucrum*, a *cavity* containing pus and the dead fragment or *sequestrum*, and a discharging sinus or *cloaca* (Fig. 281). Nature may eventually cast off the fragment, but the surgeon should not wait for the completion of this slow process.

When a portion of the bone surrounding the medullary canal dies the condition is called *central necrosis*. In some rare cases necrosis occurs without apparent suppuration, a painless swelling of bone simulating sarcoma. This condition is known as *quiet necrosis*, and has been described by Sir James Paget and Mr. Morrant Baker. Mercury is an occasional cause of necrosis. The fumes of phosphorus may cause necrosis of the lower jaw in those with decayed teeth. Necrosis may be produced also by frost-

bites and burns. Many fevers (measles, typhoid, scarlet fever, etc.) are occasionally followed by necrosis. Syphilis and tuberculosis are occasional causes.

The **symptoms** of necrosis are at first those of osteitis or osteomyelitis. The abscess, when formed, opens itself or is opened by the surgeon, and a sinus or sinuses form in the soft parts, as happens in caries. As a matter of fact, were cases of acute osteomyelitis operated on early, extensive necrosis would be rare. If surgeons followed the rule of removing hopelessly damaged bone at the primary operation for osteomyelitis it would seldom be necessary to do extensive operations for dead bone at a later period. When a firm sequestrum exists a probe introduced into the sinus strikes upon hard bone with a clear, ringing note, and often finds a sinus or sinuses in the bone. In superficial necrosis the discharge is slight and the probe shows the limitations of the disease. In extensive necrosis the discharge is profuse, much new bone forms, several sinuses appear far apart, and the probe must pass through a considerable thickness of new bone before it finds the bit of dead bone. In a chronic case in which there was an involucrum the surgeon formerly did not operate until the dead bone was separated from the living by a line of demarcation, unless there was general sepsis. He waited until the sequestrum was loose unless the patient was being poisoned during the wait. Thought today is against such long delay as was formerly the custom. In youth dead bone loosens quickly, but in old age slowly. An exfoliation becomes loose sooner than the sequestrum of central necrosis. In diffuse periostitis the necrosed shaft loosens quickly. Necrosed portions of the upper extremity loosen more rapidly than those of the lower. In a young adult two or three months will be required to loosen a necrosed fragment in the lower extremity and from six weeks to two months in the upper. A loose sequestrum may be moved by the probe, and when struck gives a hollow note. In protracted cases of necrosis there is always danger that amyloid disease may arise.

Quiet necrosis is a rare condition which has led to some deplorable but pardonable mistakes because it resembles ossifying sarcoma. It follows injury, particularly fracture. The bone enlarges greatly. There is little or no pain and no fever. The diagnosis can only be made by exploratory incision, and it may even be necessary to remove portions for microscopic study before a conclusion can be reached.

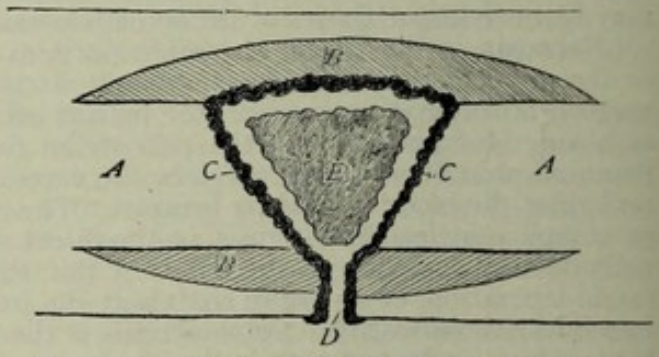


FIG. 281.—Diagram illustrating the formation of a sequestrum: *A*, *A*, Sound bone; *B*, *B*, new bone; *C*, *C*, granulations lining involucrum; *D*, cloaca; *E*, sequestrum.

Postfebrile necrosis is most usually caused by typhoid fever. The bacilli of typhoid cause chronic osteomyelitis, and this may be followed by necrosis. Scarlet fever, measles, influenza, pneumonia, and other febrile processes may also induce necrosis. It is certain that bacilli accumulate in the bones during typhoid fever. Bone disease is occasionally noted before the fever has been diagnosticated, sometimes during the activity of the fever, most often during convalescence, and sometimes bone disease arises months or even years after the fever. Bacilli lodged in the bones may remain for long periods apparently inactive and finally pass away; or after a slight strain or injury these organisms may induce bone disease. *Typhoid bone disease* is often multiple, many bones being involved successively.[1] Not unusually after typhoid fever trauma or muscle strain causes periostititis and osteitis, and at such a point necrosis may occur. Either exfoliation or central necrosis may follow typhoid fever. The shaft of the tibia is involved in 86 per cent. of cases and both bones may be involved. Several or many bones may be attacked (ribs, costal, cartilages, sternum, phalanges, skull, scapula, femur, etc.). (See Sabrazerin, "Gaz. hebd. d. sc. méd. de Bordeaux," April 8, 1923. Abstract in "Brit. Med. Jour.," June 2, 1923.)

In the history of cases it is frequently noted that the causal fever was protracted or that there had been a relapse. Over 60 per cent. of the cases occur in childhood or in youth.

Bacilli of typhoid may be the sole cause, but mixed infection may take place. Bone infection by typhoid bacilli purely is a chronic condition, but mixed infection may cause an acute or a subacute condition. Chronic infection tends to the formation of

[1] Keen's "Surgical Complications of Typhoid Fever."

an abscess. Some believe that paratyphoid bacilli produce bone disease, others deny it. I have seen one undoubted case in the Naval Hospital at League Island.

Treatment.—An exfoliation should be removed as soon as it becomes loose, the seat of trouble should be touched with pure carbolic acid, and packing of iodoform gauze should be inserted. The treatment of central necrosis comprises free incisions for drainage, removal of the sequestrum and disinfection, antiseptic dressing, frequent cleansing, rest, nourishing food, stimulants, and tonics. When a sequestrum exists the operation of *sequestrectomy* should be performed. The extremity is drained of blood, an Esmarch band is applied, the bone is exposed by a longitudinal incision, the periosteum is reflected on each side, the involucrum is broken through, and the opening is enlarged with the chisel, gouge, and rongeur. The dead bone should be removed by sequestrum forceps. The medullary cavity on each side of the sequestrum is usually blocked with bone. These bone blocks must be broken through in order that new blood-vessels may form and enter the old cavity. The cavity is to be scraped by a sharp spoon, the lateral edges of the involucrum are cut down until the cavity which formerly contained the sequestrum is very shallow, the wound is irrigated with hot salt solution, dried, painted with pure carbolic acid and then with alcohol, again irrigated with salt solution, and firmly packed with iodoform gauze. Remove the Esmarch band, tie the vessels in the soft parts, suture the wound, and apply dressings. It was long the rule of surgery to remove a sequestrum only when loose, and wait if necessary for it to become loose. This rule has been abandoned in favor of early operation. If possible a sequestrum should be removed before the involucrum has become rigidly ossified. If we wait until the involucrum is rigid we may be sure that the osteogenetic layer of the perioeteum has struck work and the bone cavity will have to be filled by artificial means. If we operate from the sixth to the ninth week the osteogenetic layer is hardening, but is not rigid, is still active, and the cavity will probably heal. The simple removal of a sequestrum—*i. e.*, the operation of *sequestrectomy*—often fails to effect a cure, and even in the most satisfactory cases healing requires a very long time. "The involucrum always contains pyogenic germs that may live in its small foramina and crevices almost indefinitely. For this reason, and on account of the denseness of bony structure, it is well-nigh impossible to disinfect it" (Dr. J. Shelton Horsley in the "Medical Record," Oct. 20, 1900). Because of the difficulty of curing a case when an involucrum has formed, Dr. Cushing has warmly advocated early operation in osteomyelitis; that is, operation before an involucrum has formed, and when the osteoblasts of the periosteum are extremely active. He points out that if an involucrum has formed, the sequestrum and involucrum should be removed after stripping the periosteum from this region. If the periosteum is found not to be infected, it may be stitched together at the gap where the bone has been removed, so that a periosteal cord exists between the two ends of the bone; and the soft parts above this may be closed. If the periosteum is found to be infected, we agree with Cushing that the cavity should be packed with gauze. The cavity that is left by the removal of a sequestrum and the chiseling of the walls of the involucrum, if large, may be filled by various methods more or less satisfactory. In some cases of wide-spread necrosis due to diffuse infective osteoperiostitis or to osteomyelitis, extensive resection, or even amputation, may be necessary. After removing a sequestrum from a limb devoid of a splint bone always apply splints to the extremity. If the entire shaft of the tibia requires removal the length of the limb may be maintained by implanting the head of the fibula into the head of the tibia. Otherwise extension must be used during repair.

Treatment of Bone Cavities.[1]—Before filling a bone-cavity try to disinfect it. This can be done only relatively. It may be swabbed with pure carbolic acid, followed in one minute by alcohol, or can be mopped with pieces of gauze wet with boiling water. Schede does not pack the bone cavity, but allows it to fill up with blood-clot after the wound in the soft parts has been closed by sutures. The blood-clot obliterates the dead space in the bone, acts as a support for granulations from the margins, and is slowly eaten up by phagocytes. Unfortunately, it is an excellent culture-medium and it often fails of its purpose. Sherman arrests hemorrhage, fills the gap with normal salt solution, and sutures the soft parts without drainage. Some advocate filling the gap with transplanted fat, others with a pedicled flap of muscle. The surgeon may try to fill the cavity by smoothing down the bone edges until the cavity has become a trough, taking flaps of skin from the sides of the wound, separating them freely from the fascia beneath, and holding them within the bone cavity by inversion sutures

[1] The views of Macewen and Murphy on repair of bone will be found on pages 56 and 57.

or fastening them to the bottom with tacks (*Neuber's operation*). Bayer turns in a fold of skin and periosteum and holds it in place by a roll of gauze sutured firmly upon the wound. Another operation consists in breaking the edges of the involucrum and turning them in. Some surgeons insert decalcified bone-chips. The cavity in the bone is made as sterile as possible and is well dusted with iodoform, the bone-chips are dried and inserted into the cavity, a capillary drain is employed, the periosteum is stitched over the opening, and the soft parts are sutured; but if this cannot be done, iodoform packing is used to keep the chips in place. This method we owe to the genius of Senn. Senn's method often fails because of the impossibility of completely sterilizing the walls of the bone cavity. Attempts have been made to fill bone cavities as a dentist fills teeth—with gutta-percha, plaster-of-Paris, copper amalgam, etc., but every one of these materials acts as a foreign body in the bone (James E. Moore, on "The Treatment of Bone-cavities," "Jour. Amer. Med. Assoc.," May 20, 1905). Schleich uses formalin-gelatin to fill bone cavities. The difficulty in every case is the impossibility of completely sterilizing the walls of the cavity. Dressman has advised for this purpose the use of boiling oil, but it is apt to cause superficial necrosis. In some cases the cavity has been healed by the insertion of Thiersch skin-grafts. This method has been advocated by J. P. Lord ("Jour. Amer. Med. Assoc.," May 31, 1902). Von Mosetig-Moorhof's method is one of the best ("Zeitschrift für Chirurgie," 1903, xxx, 433). He pours into the cavity a melted material which completely fills the cavity, which will not act as a culture-medium or as a foreign body, which is gradually absorbed, and which "possesses the inhibitory and medicinal properties of iodoform without causing iodoform intoxication" (James E. Moore, loc. cit.). Mosetig-Moorhof's material consists of 60 parts of iodoform, 40 parts of spermaceti, and 40 parts of oil of sesame. These materials are mixed by heating gradually up to 100° C. On cooling, a solid mass is formed. When the surgeon wishes to use it he heats it up to 50° C. and stirs it while heating (Moore), and pours it into the cavity in the bone. On entering the cavity it at once solidifies. A capillary drain is introduced, the periosteum is sutured with catgut, and the other soft parts are sutured with silkworm-gut. Usually union by first intention is secured. Even if the wound gaps the wax is apt to hold. Mosetig-Moorhof has used this material in 4000 cases without ill effect. Cases of poisoning and at least 1 case of death have been reported (Durvergey in "Presse Médicale," July 1, 1911). Bismuth paste is preferred by some to the Mosetig-Moorhof wax. Many attempts have been made to fill the defect by *bone-grafting*. The first case of satisfactory transplantation from one of the lower animals with the retention of a vascular attachment was reported by A. W. Morton in "American Medicine," July 12, 1902. The patient suffered from a compound comminuted fracture of both bones of the right leg. The fracture in the fibula united, but the tibia underwent necrosis, and it was necessary to remove 5 inches of the lower end of the bone. Some days later the periosteum was raised from the ends of the bone and these ends were freshened. The left leg of a dog was amputated just above the tarsus, the bones being sawed so that the ulna was 1 inch longer than the radius. The lower end was partly bared of periosteum, and the ulna of the dog was forced into the cavity of the tibia of the man, and wired to that bone with silver wire. The incision in the man's leg was then sutured, and powerful tendons in each leg of the dog were divided. Each of the dog's other legs was wrapped separately in a plaster-of-Paris bandage, and the entire animal and the leg of the man were then put up in a plaster-of-Paris dressing. Five weeks later the cast was removed, and the bones were sawed and placed in contact with the astragalus. Union took place, and the man was fortunate enough to obtain a useful leg. In some cases a bone defect may be supplied by transference of another bone. Nichols reported 11 cases and insisted on the necessity of preserving the periosteum ("Jour. Amer. Med. Assoc.," Feb. 3, 1904). Huntington has reported a case similar to Case No. 2 in Nichols's list. The patient was a boy of seven. A large piece of the entire thickness of the tibia was lost as a result of acute osteomyelitis. There was a gap of 5 inches between the ends of the bone, and the leg was a mere flail. Eight months after the beginning of the osteomyelitis the fibula was sawed opposite the lower end of the upper fragment of the tibia and the upper end of the lower fragment of the fibula was fixed in a cup-shaped depression in the lower end of the upper fragment of the tibia. Six months later union was solid, but in order to improve the weight-bearing power of the limb, nine months after the first operation, the lower end of the upper fragment of fibula was fastened to the upper end of the lower fragment of tibia. The result was excellent. The shortening is only ¾ inch ("Annals of Surgery," Feb., 1905).

Albee's operation of bone-grafting has proved of great value in filling bone defects. In some cases a piece of the tibia may be used, in others a rib (see page 652).

Osteomyelitis.—By this term we mean inflammation arising in and about the blood-vessels and attacking the marrow of bone. It may attack the soft tissues and cells in the Haversian canals, in the cancellous spaces, or in the medullary cavity. It may be acute or chronic, localized or diffused. Simple osteomyelitis is not due to bacteria. If localized it usually depends upon a traumatism (fracture, contusion, wrench of an epiphysis). Simple diffuse osteomyelitis may arise in a victim of rickets or osteitis deformans. An acute simple inflammation may cause softening and permit bending. A chronic inflammation causes sclerosis.

Acute infective or **pyogenic osteomyelitis** is an acute and diffuse inflammation of the bone-marrow due to pyogenic organisms. Infection from staphylococci may be limited to a portion of one bone. Streptococcus infection causes wide-spread involvement of a bone or of several bones. Acute osteomyelitis may be due to mixed infection with bacilli of typhoid and pyogenic organisms, or bacilli of tubercle and pyogenic organisms, a typhoid process or a tuberculous process serving to establish a point of least resistance. The gonococcus and the pneumococcus occasionally produce acute osteomyelitis. In a case of gonorrheal arthritis in which I resected the wrist-joint cultures of gonococci were obtained from the interior of the bone removed.

It was at one time believed that osteomyelitis was due to a specific organism, but Pasteur proved that micrococci are the cause, and Ogston demonstrated pyogenic bacteria in pus obtained from cases of osteomyelitis. In some cases there is pure staphylococcus infection (aureus or albus), both aureus and albus may be present, there may be mixed infection with streptococci and staphylococci, streptococci and several sorts of bacilli, or staphylococci and bacilli. Mixed infections with streptococci are more malignant than staphylococcus infections. Most cases of osteomyelitis are due to staphylococci. Trauma is a common predisposing cause. It creates an area of tissue damage which captures bacteria from the blood. Ullman was unable to induce experimentally osteomyelitis without first creating by bone injury a point of least resistance. When he applied a ligature to a rabbit's leg for fourteen hours distinct changes were found to occur in the marrow of the bones. These changes consisted chiefly in extravasation and localized hemorrhages. When the marrow was in this condition, if virus were injected into the animal, osteomyelitis resulted because the bones presented points of least resistance, vulnerable points in which pus cocci lodged and multiplied.

The pyogenic organisms may gain entrance directly by way of a wound (a gunshot wound, a compound fracture, an amputation). The causative organisms may reach the bone by way of the blood, having entered the blood originally through the lymphatic system or from a focus of suppuration in the skin, the subcutaneous tissue, or a deeper part. Staphylococcus infection commonly depends on cutaneous suppuration.

Pus organisms may pass into the blood from the tonsils or respiratory organs (Kraske); the intestinal canal (Kocher); the genito-urinary tract; or from excoriations, bruises, small wounds, or suppurations in the skin. Certain fevers strongly predispose to the disease by preparing the soil, as it were, for the growth of pyogenic bacteria. Typhus fever, smallpox, malarial fever, scarlet fever, measles, influenza, and diphtheria lessen the vital resistance of bone-marrow. Typhoid fever is not unusually followed by chronic osteomyelitis, due solely to typhoid bacilli. If mixed infection with pus organisms occurs, acute osteomyelitis arises. Vital resistance of marrow is lessened by exhausting diseases, overexertion, unhealthy and, especially, putrid food. We know that various infections produce various reactions in marrow, and in this changed marrow vital resistance is probably lessened or even seriously impaired. Longcope made a study of the marrow in 26 fatal cases of enteric fever, and he invariably found numerous lymphoid cells, phagocytes of large size, and multiple foci of distinct necrosis. The cells whose function is to form blood were noted to be undergoing hyperplasia. In persons dead of perforation and general peritonitis there were numerous foci of necrosis, and also wide-spread degenerative changes in the blood-making cells and pronounced edema and congestion of the marrow ("A Text-Book of Pathology," by Alfred Stengel). When organisms gain entrance directly by a wound (as in a compound fracture) the endosteum, the medulla, and the cancellous tissue inflame and suppurate, and the entire length and thickness of the bone may be involved. The periosteum becomes infiltrated, detached from the bone, and retracted from the edges of the wound in the

bone. The soft tissues around the bone may inflame, suppurate, or slough. More or less necrosis inevitably occurs.

Acute pyogenic osteomyelitis without a wound is often called *acute epiphysitis*. Acute epiphysitis is a bad term. The process does not start in the epiphysis. Tuberculosis may start in the epiphysis, but not a pyogenic inflammation (Moore, "Annals of Surgery," August, 1916). This condition is most common in infants or children of one or two years of age, but is not uncommon in older children (from ten to seventeen years), and even occurs in adults. It is vastly more common among males than females. The upper end of the tibia and the lower end of the femur are the regions most prone to attack. The hip is seldom attacked. It is most common during the period of active growth of bone. It is frequently preceded by one of the predisposing causes before mentioned (an exanthematous fever, etc.). In some cases a strain or bruise is followed by pyogenic infection, because the damaged tissue extends a hospitable welcome to micro-organisms which are traveling in the body fluids and pass through the injured area. The most usual antecedent injury is a twist. As Ollier showed, a twist damages the weakest structure, which is the soft, new bone. In at least half of the cases a history of trauma can be obtained. In some cases there doubtless was trauma, even though we can obtain no history of it. In some cases chilling of the surface of the body is a predisposing cause. In others no predisposing cause is discoverable.

The compact bone suffers secondarily, but is never attacked primarily. New tissue is more susceptible to infection than old tissue, and the disease, as a rule, begins near the epiphyseal line, where new bone is being formed. This point was spoken of by Ollier as "the zone of election of pathologic processes." Warren points out that in a growing bone near the epiphyseal cartilage there exists a newly formed spongy tissue, very vascular and connected with the cartilage by a spongy layer of tissue, which is not yet bone, and which does not possess a cartilaginous structure. It is in this portion of the skeleton that the most active changes take place during the period of growth. The medullary substance is very vascular at this point; it is red and without fatty tissue. It communicates with the medullary canal and with the periosteum by a number of vascular channels. The epiphyseal cartilage itself is intimately blended with the periosteum. The diaphyseal side of the cartilage produces much more bone than is found in the epiphyseal margin. There is also an active growth of bone in the periosteum, and it is in these regions and in the medullary canal that the inflammatory process originates.[1] The end of the diaphysis is very vascular, but the bloodstream is sluggish because of the large size of the capillary loops ("Practice of Surgery" by Spencer and Gask). The lower end of the femur and the upper end of the tibia are the regions most commonly attacked; but the upper end of the femur and the lower end of the tibia may suffer, and other bones may be attacked, especially the humerus, radius, ulna, and inferior maxilla. The adjacent joint not unusually becomes involved. Though the inflammation begins in the spongy tissue or medulla, it passes to the canals and spaces of the compact bone. The inflammatory exudate in the canals compresses the vessels and cuts off nutrition from certain areas. Suppuration begins, clots form in the medulla from thrombophlebitis, and the clots in the vessels of the Haversian canals become septic. A small sequestrum forms at the seat of origin of the disease, and the pus about the sequestrum is apt to empty into the medullary canal, causing diffuse osteomyelitis, or into the adjacent joint, causing suppurative inflammation of the articulation.

Marked constitutional symptoms arise from absorption of toxins (suppurative fever), and sometimes true septic infection or even pyemia arises.

Very extensive necrosis may follow osteomyelitis if the patient recovers. Fracture of the bone may occur (Fig. 282). An acute pyogenic osteomyelitis may involve the medulla, may break into the adjacent joint, or may become localized in the head of a bone and cause an abscess containing fragments of bone or a distinct sequestrum. The walls of such an abscess are composed of sclerosed bone.

When the medullary canal is involved in a pyogenic inflammation, a part or the whole of the medulla may suffer. The condition may result in central necrosis or in suppurative periostitis and death of the shaft of the bone. The mortality of acute osteomyelitis is high. In the 309 cases collected by Kennedy the mortality was 34 per cent. ("Brit. Med. Jour.," July 20, 1912). The earlier the operation, the less the mortality. Operation within forty-eight hours of the initial chill has a mortality of less than 10 per cent.

Symptoms.—Osteomyelitis secondary to a wound of the bone may occur in a per-

[1] Warren's "Surgical Pathology."

son of any age. If a wound exists—for instance, a compound fracture—the diagnosis is evident. The constitutional symptoms of septic absorption are positive: there is a profuse, offensive, purulent discharge containing bone fragments and tissue sloughs; the periosteum is red, thick, and separated; there are swelling over the bone, great tenderness, and violent boring, gnawing, or aching pain. Osteomyelitis occurring without a wound, the condition often known as acute epiphysis, occurs in the young, and particularly in children under three years of age.

The symptoms of acute osteomyelitis without a wound of the bone usually come on suddenly and especially at night, and the attack may be so acute as to cause death by systemic poisoning before a diagnosis is arrived at. The disease is generally ushered in by a chill, which is followed by septic febrile temperature. The history will sometimes contain the statement that a blow had been received, that a febrile process had existed, or that the patient had been suddenly chilled after having been overheated (sitting in a draft or in a cellar on a hot day, possibly swimming when very warm, etc.). There is violent aching pain in the bone and acute tenderness near the joint. Within seventy-two hours of the initial chill, if operation has not been performed, there will usually be pus in the medullary cavity and a quantity of hopelessly damaged bone. Early in a case *x*-rays are of no help in diagnosis. The soft parts, which at first are healthy in appearance, after a time discolor, swell, and present distended veins, and may become glossy and edematous because pus is gathered below. The medullary cavity becomes filled with pus. An abscess sometimes reaches the surface and may break spontaneously. The neighboring joint swells, and may become filled with pus; the periosteum and the shaft are involved for a considerable distance; each epiphysis may become affected, the shaft between being comparatively uninvolved, and the epiphyses may separate, displacement and shortening taking place. Extensive necrosis may occur. This disease is often mistaken for rheumatism because of the joint swelling, occasionally for typhoid fever because of the fever, and in some cases for erysipelas because of the redness of the skin. It gives a very grave prognosis. Sometimes an osteomyelitis shows milder symptoms and is slower in progress (subacute). These cases are very often mistaken for rheumatism. But in rheumatism the joint is the part involved from the beginning, while in osteomyelitis the joint is involved secondarily after obvious

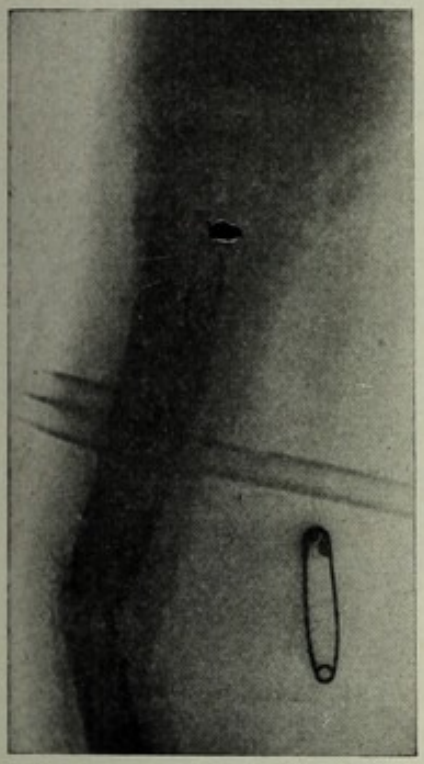


FIG. 282.—Fracture of femur after acute osteomyelitis.

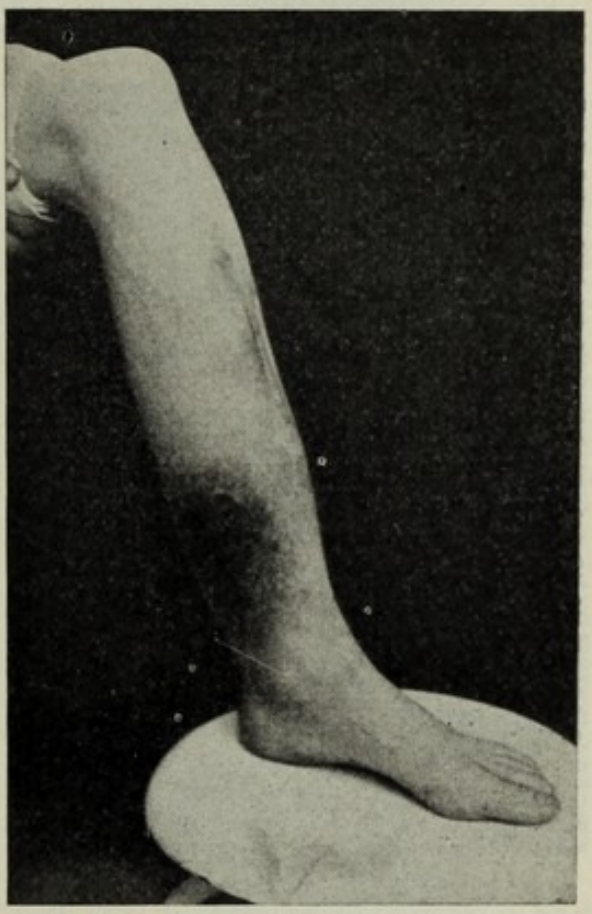


FIG. 283.—Chronic osteomyelitis of the tibia.

evidence of inflammation well clear of the articulation. Further, the symptoms of rheumatism will be rapidly improved by the use of the alkalies or the salicylates. In the hip osteomyelitis is usually mistaken for inflammation of the joint. Diagnosis cannot be made with certainty without operation.

Treatment.—If osteomyelitis arises secondarily to a wound, apply a tourniquet, sterilize the parts, enlarge the wound, expose and curet the medullary cavity, remove loose fragments of bone, irrigate the medullary cavity with a hot solution of corrosive sublimate or hot salt solution, scrape it with bits of gauze held in the bite of a forceps, paint with pure carbolic acid, pack lightly with iodoform gauze, dress with hot antiseptic fomentations, and secure rest for the parts by splints and bandages. The constitutional treatment is the same as that for septicemia. In some cases amputation is necessary. Acute osteomyelitis without a wound is a most serious condition, rapidly progressive, apt to be quickly fatal, and requiring prompt and radical treatment. Operation should be done as soon as possible after the initial chill. Murphy has insisted upon this for years. Cushing, Le Conte, and others warmly advocate it. I always practise it when possible. Within seventy-two hours, perhaps within forty-eight hours of the initial



FIG. 284.—Case started as acute septic condition of tibia and was operated upon four months before Dr. Dorrance operated upon it as a chronic osteomyelitis.

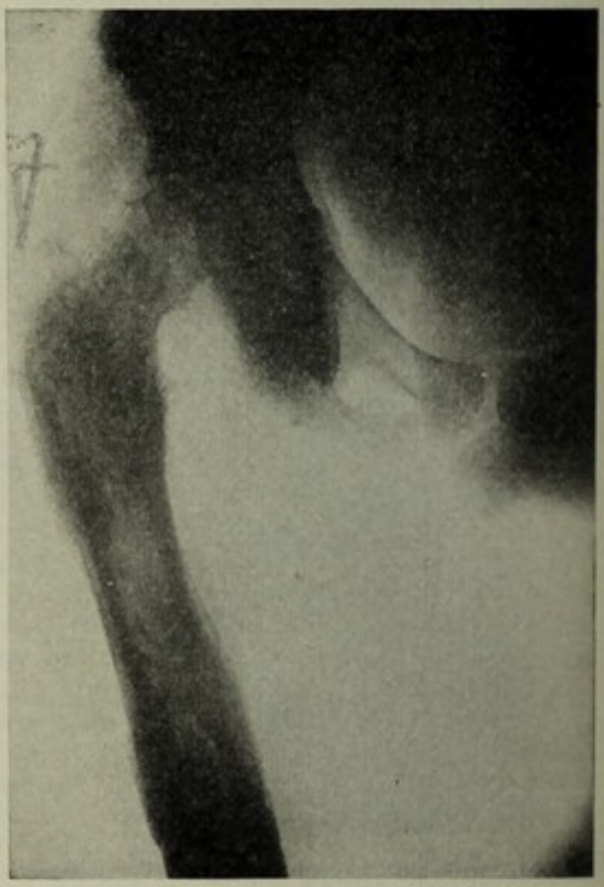


FIG. 285.—Chronic osteomyelitis of the femur.

chill, there will be pus in the medullary cavity and a quantity of bone will be hopelessly damaged. Operation consists in opening the medullary cavity by means of a burr, trephine, or chisel. At such an early stage drainage is all that is necessary, as dead bone has not as yet formed. Very early operation anticipates pus formation. It is not desirable to curet the cavity because the medulla is needed in regeneration. A delay of a very few hours will be responsible for pus and dead bone. When dead bone forms, the medullary cavity must then be freely opened and curetted. The former custom was to pack with iodoform gauze and wait for the formation and loosening of a sequestrum. It is safer and wiser to remove dead bone freely at the primary operation (Le Conte, "Boston Med. and Surg. Jour.," June 1, 1911). When the active symptoms have passed, the pus has drained externally, and dead bone has formed, the best time to remove the sequestrum will be from the sixth to the ninth week after the attack. If a needle be pushed through it, it will be found that the involucrum is not yet rigid. Operation done at this stage will probably be followed by healing of the cavity without artificial aids. In any case if the joint is involved it must be drained. In the hip enter the joint by an anterior incision and remove dead bone if

there be any, but save all of the neck possible. In all cases employ rest, anodynes, strong supporting treatment, and other remedies advised in septicemia. In a neglected or prolonged case very extensive necrosis occurs and a formidable operation may be required. Even amputation may be necessary. It may be necessary to remove the entire shaft, a bloody and dangerous operation. When dead bone exists and reparative power is not present in the periosteum some method must be employed to fill the bone cavity (page 459).

Chronic osteomyelitis is uusally linked with periosteitis. Pus may or may not form. There may be only thickening of and pain in the bone. Such a condition can be caused by attenuated bacteria or by bacteria of ordinary power acting on tissue possessed of a very high vital resistance. It may eventuate in osteosclerosis with filling up of the medullary canal, in limited suppuration, in chronic abscess of the cancellous tissue (Brodie's abscess), or in necrosis. A tuberculous inflammation is one form of chronic osteomyelitis (see page 452). Syphilis, typhoid fever, etc., pneumonia, and influenza may cause it, and it can be caused by glanders, leprosy, and actinomycosis.

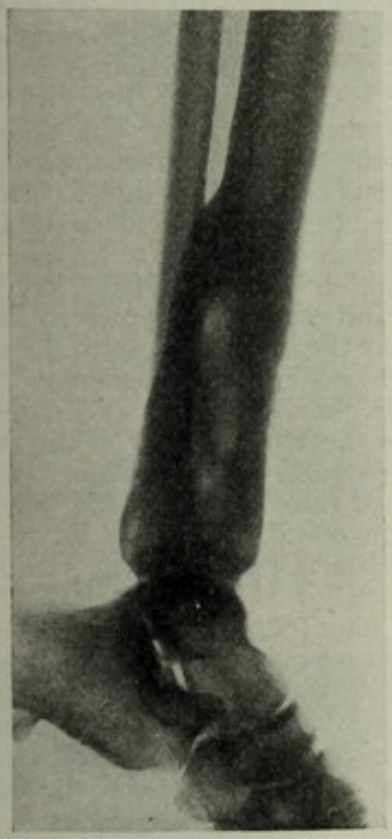


FIG. 286.—Chronic osteomyelitis of the lower end of the tibia (U. S. Naval Hospital, League Island, Pa.; skiagraphed by Lieut. George U. Pillmore, Medical Corps, U. S. Navy).

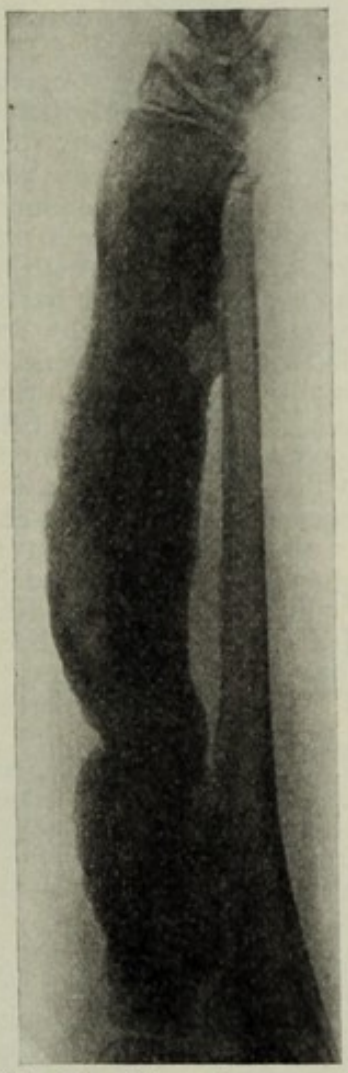


FIG. 287.—Dr. Nassau's case of chronic osteomyelitis of the radius (radiographed by Dr. Sender).

The typhoid bacillus under certain conditions is pyogenic. Fränkel taught this some years ago, and Keen proves it in his work on "The Surgery of Typhoid Fever." Osteomyelitis due purely to typhoid bacilli is chronic. When the medulla contains typhoid bacilli pus infection is apt to take place, and if such a mixed infection arises acute osteomyelitis develops. Typhoid osteomyelitis is most apt to arise in the ribs, femur, tibia, humerus, ulna, radius, and metatarsus. It may begin during convalescence or as late as six or seven years after the fever (page 458).

In chronic osteomyelitis there are pain, tenderness, and swelling, but no marked constitutional symptoms. In some cases the real trouble is not identified until an abscess forms (see Necrosis). There is a form of chronic osteomyelitis which is nearly always mistaken for rheumatism. J. C. Stewart describes it fully ("N. Y. Med. Jour.,"

March 25, 1911). It is sometimes preceded by a fever, sometimes by a trivial traumatism, but usually comes on insidiously and endures indefinitely as a chronic condition. Stewart shows that the bone enlarges because of subperiosteal production of new spongy bone. The marrow cavity fills with tissue resembling red marrow. The thick bone is tender at points, there is aching pain, and a trivial rise of temperature toward night.

Treatment.—If an abscess exists, at once evacuate it by incising the soft parts and chiseling the bone. Do not wait for an involucrum to form, but promptly incise, disinfect, and drain. If dead bone is present, it must be removed. In the insidious form, so often mistaken for rheumatism, expose and cut through the new bone formation and open the marrow cavity. A case of chronic osteomyelitis may be operated on several times and by different surgeons. The final operation which cures may happen to be the most trivial of all, yet to that operation goes all the credit. It is well if possible to make the first operation sufficiently extensive to be thorough.

Osteomalacia, or Mollities Ossium.—In this disease the bones are partly decalcified, and consequently soften and bend. Masses of new uncalcified bone-tissue are formed. Many bones are usually involved, but the bones of the head are not obviously affected. It is commoner beyond than before middle age, though it may occur in infancy, and a case has been reported in which the disease arose at the age of seventy. It is more frequently met with in women than in men, and pregnancy seems to bear more than a casual relation to its production. The disease is particularly apt to arise when pregnancies are rapidly repeated (Marquis, "L'Obstetrique," June, 1910). In osteomalacia the medulla increases in bulk and becomes more fatty, and the osseous matter is absorbed gradually, first from the cancellous tissue and then from the compact tissue. Some observers believe that this curious condition is due to lactic acid in the blood, an abnormal amount of acid having been produced and absorbed because of disorder of the primary assimilation. That acidosis plays a part in this disease seems reasonably sure (Novak and Poges in "Wien. klin. Wochen.," 1913, xxvi). The observers above cited state that normal pregnancy and osteomalacia present like conditions of acidosis, and they reach the conclusion that the disease is due to the ovarian changes similar to but more intense than those which occur during pregnancy. Studies in metabolism show that the body loses calcium and gains sulphur. Volkmann maintained that some inflammatory condition disturbs the blood-supply of the medulla, and von Recklinghausen asserted that arterial hyperemia is responsible. Hönnicke suggests that the disease is due to hypersecretion of the thyroid gland. The probability that the parathyroids play a part in calcium metabolism leads us to suspect them of causal influences. In some cases of osteomalacia tumors of the parathyroids have been found.

Fehling, influenced by finding that improvement may follow removal of the ovaries, set forth the view that the disease is due to overaction of the ovaries, causing reflex dilatation of the blood-vessels of bone. The answer to this theory is the fact that the disease can occur in the male. Some have thought that the disease is of bacterial origin. It is most common in those who dwell in damp or dark habitations. It may arise after a soaking and "taking cold." It is a rare disease in England and America, but is much more common in Germany.

The **symptoms** of osteomalacia are as follows: many points of pain which are often thought to be due to rheumatism; deformities from twisting and bending of bone; sometimes lactic acid and occasionally an excess of calcium salts in the urine. There is no fever early in the case, but later there may be a hectic fever. When the disease comes on after childbirth the iliac bones suffer first. Severe pain arises in the pelvis and back and the pain radiates into the thighs; the pain is worse at night, and is greatly aggravated by pressure or movements. Finally, standing and walking become unbearably painful. The earliest pain may be in the sacrum and be felt only when supine. Pains eventually become generalized throughout the skeleton. Pain in the bony walls of the thorax makes respiration difficult. Great deformity occurs because the partly decalcified bones bend. Many of these patients become fat. Fractures occur from very slight force. In the majority of cases the disease is not cured, but grows progressively worse until the patient dies, after several years, from exhaustion. In some cases the disease is arrested and the osteoid tissue calcifies.

Treatment.—In treating osteomalacia in women insist that pregnancy must not occur. In all cases put braces and supports upon distorted limbs to prevent further bending and fracture. Advise hygienic surroundings and nourishing food, and insist on the value of fresh air. Among the medicines that can be used may be mentioned

cod-liver oil, lime salts, extract of the pituitary body, preparations of phosphorus, and bone-marrow. In women the removal of the ovaries sometimes produces great improvement. It has been asserted that the production of anesthesia by means of chloroform may be of benefit.

Acromegaly.—In 1886 Marie reported 2 cases with acquired and symmetric enlargement of the face, hands, and feet. He named the condition acromegaly. This curious disease is, in all probability, due to hypersecretion or perverted secretion of the anterior portion of the pituitary body. There is a hypertrophy or a hyperplasia of this body. As a result of the perverted secretion or accentuated secretory activity there is accelerated growth of the skeleton. It was once thought that tumor of the pituitary was the sole cause of acromegaly, but it is now known that whereas a cyst or tumor may be the cause, many cases occur without either. Cases of adiposis dolorosa may show hypophyseal symptoms. Gigantism is probably acromegalic. (For a masterly discussion of this subject see "The Pituitary Body and its Disorders," by Harvey Cushing.) Acromegaly is a disease which causes progressive and often great enlargement of both the bones and soft parts of the extremities and face, and the enlargements are symmetric. The cranium becomes triangular in shape, with the base below, at the lower jaw. The lower jaw projects in advance of the upper jaw, the nose becomes prominent and thick, the supraorbital ridges are accentuated (Fig. 288), and the costal cartilages and inner ends of the clavicles become protuberant. Later the larynx, ribs, shoulder-blades, and vertebræ suffer, and the back becomes markedly humped (cervicodorsal hump). The hands and feet are affected in advanced cases (Figs. 289, 290). As a rule, the thyroid gland is enlarged, and an *x*-ray examination may detect an enlarged pituitary fossa. Severe and uncontrollable headache is sometimes a distressing feature of the disease. In some cases there is marked somnolence. A fireman who suffered from acromegaly would go to sleep almost the moment he sat down. Early there is low assimilation of carbohydrates, often with glycosuria. Glycosuria arises because the glandular secretion tends to inhibit the internal secretion of the islands of Langerhans and early in the case the pituitary furnishes an excessive amount of secretion. The disease is not regularly progressive, but exhibits episodes of rapid increase, and periods in which the condition remains stationary or may even retrogress. In a pro-



FIG. 288.—Face in acromegaly. Note enlarged superciliary ridge, thickened lips, massive jaw, and general grossness (Church and Peterson).

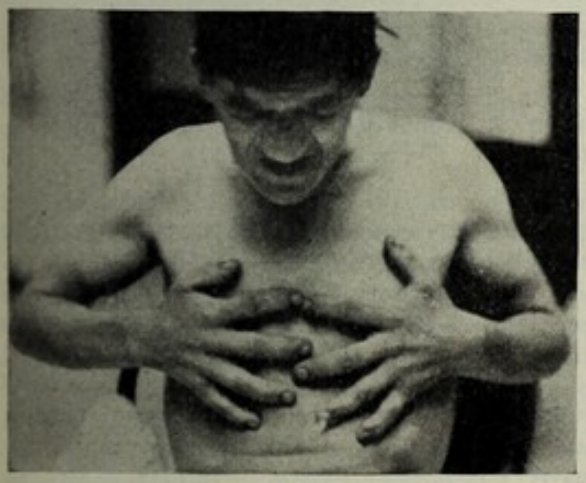


FIG. 289.—Dr. A. Newlin's case of acromegaly due to pituitary tumor (Newlin, Pennsylvania Hospital case).

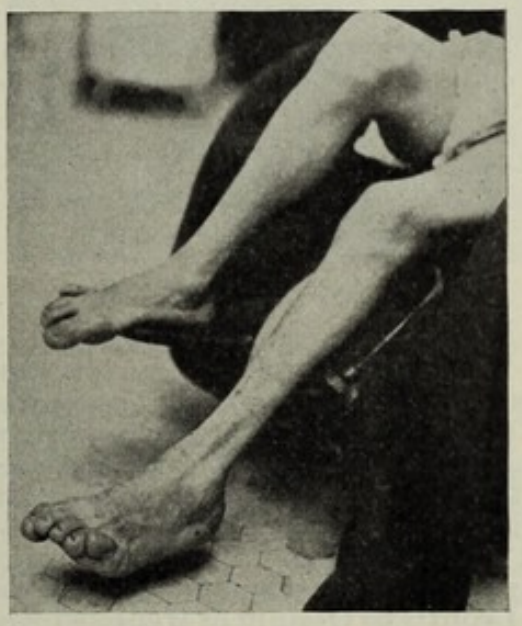


FIG. 290.—Case of acromegaly due to pituitary tumor (Newlin, Pennsylvania Hospital case).

longed case signs of *pituitary insufficiency* are noted. viz.: such high assimilation of carbohydrates that it is difficult or impossible to cause alimentary glycosuria. Perhaps such a patient can take 400 gm. of glucose during two hours and yet it will not appear in the urine. In youthful acromegaly puberty is delayed. In the male the axillary hair is scanty, the beard is scanty or absent, the facial outline is feminine, the pubic hair is arranged in a triangle with the base above, the mammary glands are enlarged, the body hair is scanty, the form is feminine, the fingers taper, and the voice is high pitched. There may be epileptiform seizures. Polyuria and polydipsia may be noted. Sexual perversion may develop. The skin is soft like velvet. In both males and females the fingers are short and the skin upon them is thick and furrowed. The nails are very brittle. The *x*-ray shows enlargement of the sella. In all suspected cases an *x*-ray picture should be taken. If a tumor is present or if the gland is hypertrophied the plate will show an enlarged sella turcica. A tumor causes rapid blindness. The disease slowly but surely causes death. Medical treatment is of no avail in cases of pituitary overactivity (*hyperpituitarism*). If there is evidence of hypophyseal insufficiency (*hypopituitarism*) administer hypophyseal extract.



FIG. 291.—Leontiasis ossium.

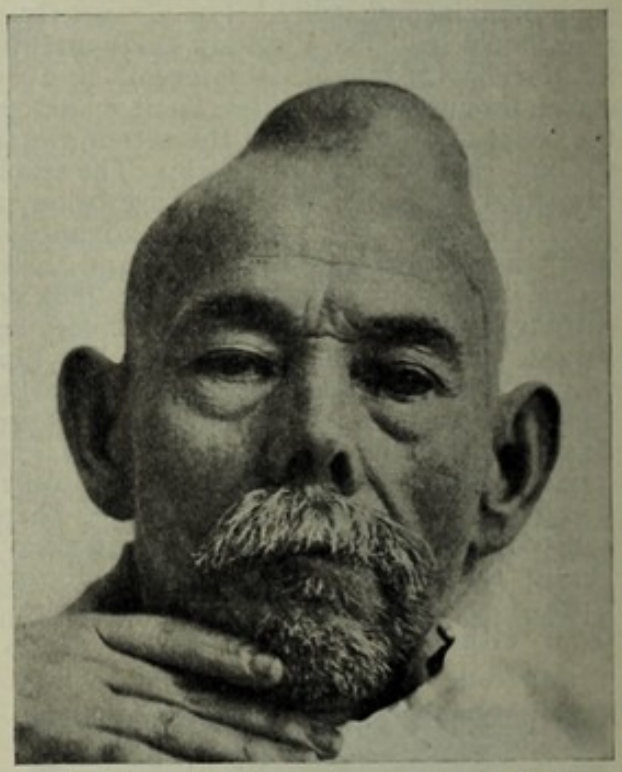


FIG. 292.—Dr. Gibbon's case of endothelioma of dura with bone destruction and cranial hyperostosis.

If there is hyperpituitarism, it is justifiable to extirpate the gland partially, on the same principle as we partially extirpate the thyroid in a case of exophthalmic goiter. In Cushing's case the operation of partial extirpation of the pituitary body relieved subjective discomforts and modified acromegalic conditions. If there are evidences of tumor of the hypophysis it is justifiable to undertake its removal by operation. This has been accomplished successfully by Hochenegg, Von Eiselsberg, Brochardt, not Cushing, Sir Victor Horsley, and many others. In the cases of Hochenegg and Cushing only were pressure symptoms relieved, but acromegalic conditions were greatly benefited.

Leontiasis Ossium or Hyperostosis Cranii (*Virchow's Disease*).—In 1700 Malpighi described a skull so affected. This is a rare condition, there being not over 40 cases on record, and the name is used to include several different conditions. It begins at or near puberty as a hypertrophy usually roughly symmetric and knobby, limited to the facial and cranial bones. The facial involvement is much greater than the cranial. The soft parts are not involved. I do not say always symmetric. I operated upon a case involving the facial and cranial bones of one side. The hypertrophy progressively increases, and produces distinct deformity of the jaw like a tumor, whereas acromegaly enlarges all of the proportions of a bone (Fig. 291). It is slow in progress,

now seeming to cease advancing, now advancing with greater rapidity. The subjective symptoms are due to pressure. Violent headache is usual. It may produce blindness, new bone pressing upon the optic nerves. Its course is progressive and it causes death usually in the fourth decade of life. There are two forms, creeping periostitis and diffuse osteitis (see the very valuable article by R. Lawford Knaggs in "British Jour. of Surgery," Oct., 1923). I have made free use of it.

1. **Creeping Periostitis.**—It is due to bacteria (Knaggs, Ibid.). Great masses of new bone form. It has a local beginning, usually in a sinus or the nasal fossæ, and next involves the superior maxillary bone, palate, and lower jaw. Often it does not spread beyond the face. The spread is very slow, but inexorable. The fossæ and sinuses become blocked, the lacrimal duct obstructed, mastication is interfered with,



FIG. 293.—Paget's disease.

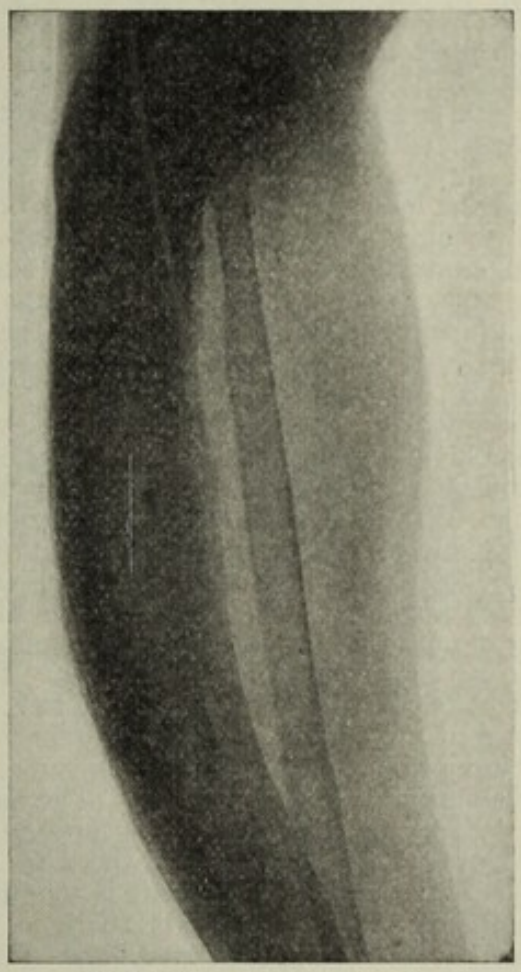


FIG. 293A.—Paget's disease.

the eyes bulge forward, the optic nerve is stretched and compressed, and the cornea ulcerates. In some cases cerebral symptoms arise.

2. **Diffuse Osteitis of Face and Skull.**—The inflammation starts in the medulla, the bones enlarge greatly, but no new bone is deposited from the periosteum, the bone is vascular and softened, the cortex is thinned, bony ridges and fossæ disappear (Knaggs, Ibid.). The enlargement tends to "equable" distention and the face looks as though badly swollen. It is apt to be wide-spread, but only part of a bone or one bone may suffer. Bones of the skull may become 2 or 3 inches thick. Treatment of leontiasis is very unsatisfactory. Horsley obtained some degree of amelioration by operating and removing masses of bone. (See E. D. Telford in "Med. Chron.," 1914, lix.)

Cranial Hyperostosis (Fig. 292).—(See page 768.)

Osteitis Deformans (*Paget's Disease*—Fig. 292).—This disease was first described by Sir James Paget in 1876. Higbee and Ellis state that up to January, 1911, 158 cases have been reported ("Jour. Med. Research," vol. xxiv, No. 1). Packard and Steele were of the opinion that many reported cases were not genuine instances of the disease, some being ordinary osseous tumors, others being cases of enlargement after fracture, and still others being instances of mollities ossium ("Amer. Jour. Med. Sciences," Nov., 1901). Many of the reports are purely clinical. The disease does

not appear to be hereditary, although in 14 instances 2 or more cases occurred in the same family (DaCosta, Funk, Bergeim and Hawk, in "Report of Jeff. Med. College and Hospital for 1915"). It is usually associated with wide-spread arterial sclerosis. Sixty-seven per cent. of reported cases were in males. There is no evidence that gout, rheumatism, or disease of the nervous system play any part in causation. Lannelongue and Fournier considered the condition parasyphilitic, but there is no real evidence of such origin, in fact, a great majority of cases reported during recent years showed a negative Wassermann reaction. Some observers claim to have found micro-organisms in the bone. In 2 of my cases bacteria could not be demonstrated. It has been asserted that heat or cold may be causal and that the condition has begun after injury to a long bone. A possible cause is disturbance of some internal secretion. The enlarged thyroid in Askanazy's case led him to suggest the theory. In 1 of my cases the thyroid was atrophied, in 2 it was obviously enlarged. In 2 the *x*-ray indicated pituitary enlargement. No parathyroids were found at autopsy in the patient of Higbee and Ellis. These two observers suggest that Paget's disease may be due to absence of parathyroid secretion and the consequent formation of substances which abstract calcium from the bones. In this disease great quantities of new bone are formed, but calcification does not occur. The material undergoes absorption, and the medullary substance of the bone becomes extremely vascular and filled with white blood-cells and also with giant-cells. The bones lengthen and thicken. The long bones bend and the bones of the skull bulge. An *x*-ray picture shows great thickening of the bones of the skull and perhaps some of the jaws. The bending of the long bones has been believed to depend upon the weight of the body acting on uncalcified new bone, but fracture is not particularly apt to occur. It is now maintained that the bending and bulging are active processes, "since the bending is always well marked in those bones which are fixed at both ends by muscles and ligamentous attachements, *e. g.*, the clavicle, radius, and tibia, the accompanying bone (fibula or ulna) acting as the string to the bow" (Gruner, Scrimger, and Foster, in "Archives of Internal Medicine," June, 1912). It is extremely rare before the age of forty, and usually begins between forty and fifty or later, but cases are reported which began between eight and twenty. The enlargement of the bones is usually accompanied by pain in the back and legs, which may be severe. Headache is unusual. Enlargement may be first detected in the cranium, but is more often first found in some other bone—for instance, the clavicle, the tibia, the spine, or the radius. The tibia in most cases suffers first and other bones become involved later. In fact, in some cases the bones of the head do not enlarge at all; but, taking all the reported cases, the skull is affected more frequently than any of the other bones. In some cases the enlargement of the bones seems to be symmetric; in others it is not. The man finds that at intervals he has to buy a hat of larger size; the forehead is prominent and extremely broad. The posterior part of the head bulges less than the sides and front. In the disease known as leontiasis ossium the chief enlargement is manifested in the face; in Paget's disease there is no enlargement of the bones of the face, or else these bones are trivially involved. In Paget's disease the thickened bones are smooth, in leontiasis ossium these are knobby. Packard and Steele point out that the diagnosis is extremely difficult when but a single bone is involved; but that if two or more bones are involved we should think of Paget's disease as the condition, especially if we are able to exclude syphilis, cancer, and sarcoma. In mollities ossium the head is not involved at all, and there is not nearly so much thickening of the bone. The two authors before quoted show that in acromegaly the cranium is a triangle with its base below at the lower jaw, the orbital arches being distinctly involved, but that in Paget's disease the involvement is chiefly of the calvarium. The patient actually diminishes in height. The chest becomes deformed. There is angular curvature in the dorsocervical region. The lower extremities are usually bent, and the pelvis, as a general thing, is broadened. Paget says: "The most characteristic features are the loss in height, indicated by the low position of the hands, the stooping with round shoulder, the head held forward with the chin raised and the chest sunken toward the pelvis, the abdomen pendulous, the curved lower limbs held apart and usually with one advanced in front of the other and both with knees slightly bent, the ankles overhung by the legs, and the toes turned out. The enlarged cranium, square looking and bossed, may add distinctness to these characteristics, and they are completed in the slow and awkward gait of the patients." In some of the cases there is a tendency to tumor formation. In the 67 cases collected by Packard and Steele, 3 suffered from cancer and 5 from sarcoma. In the 158 cases collected by Higbee and Ellis ("Jour. Med. Research," vol. xxiv, No. 1) there were

14 instances of tumor growth. In some the tumors were in diseased bone, in some they were in normal bone. In Paget's disease there is no particular tendency to fracture.

In a case reported by Gruner, Scrimger, and Foster ("Archives of Internal Medicine," June, 1912) sarcoma appeared in the radius, head of the humerus, and other places. Some cases are associated with goiter. It has been suggested that there is a bacterial cause for Paget's disease. An Italian investigator claimed to have discovered a bacterium and made a serum for use in treatment. In 2 cases I exposed areas of new bone, removed portions, and took cultures. One set of cultures remained sterile. A tube of the other was found contaminated by the skin staphylococcus. In 2 of my cases metabolism studies were made (DaCosta, Funk, Bergeim, and Hawk, Ibid.). Much more calcium and less sulphur were retained than is the case in normal individuals. This is opposite to what is seen in osteomalacia, in which condition the body loses calcium and gains sulphur.

Treatment is practically useless except to the extent of removing surgically some large bony mass. Abbe did this in a man who suffered from a large mass growing from the hard palate. No known remedy diminishes the size of the bones, although iodid of potassium is said occasionally to mitigate pain. Abbe points out that excellent repair takes place after operating upon a bone affected with Paget's disease ("Jour. Amer. Med. Assoc.," Feb. 9, 1918).

Osteo-arthropathie Hypertrophiante Pneumique (*Marie's Disease*).—(See page 606.)

Multiple Myeloma.—By this term we mean a new growth in the cancellous tissue of bone which occurs particularly in the ribs, sternum, and vertebræ. It may occur also in the diploë of bones of the cranium, in the clavicles, in the bones of the hands and feet, and in the ends of the long bones. The multiplicity is not due to metastasis, but the growths start as separate foci. The nature of the cells in the growths is uncertain. They almost certainly spring from marrow cells. Some consider them myelocytes, some bone-marrow plasma cells. Some of these tumors seem to be truly malignant. Multiple myelomata are related to leukemia, chloromata, etc. (Vance, "Amer. Jour. Med. Sciences," 1916, clii). The effect of the growth is to thin the bones and make them very brittle. This condition was first described by Rustitzky in 1873. About 60 cases have been reported.

The condition begins insidiously, in either sex, during middle age, sometimes in advanced life. It begins usually with attacks of aching in the limbs and weakness. Such attacks may come and go over a considerable period of time. Eventually the back, chest, and ribs become the seats of pain and tenderness. Finally, the pain becomes constant and the patient is confined to bed. In many cases a sternal tumor can be palpated. Spontaneous fractures are apt to occur. In 80 per cent. of cases of myelomata Bence-Jones's protein is found in the urine (W. Walters in "Jour. Amer. Med. Assoc.," March 5, 1921). The finding of this protein is not proof of the diagnosis, as it is sometimes found in other bone disorders. Nitric acid does not precipitate the Bence-Jones protein except on standing and such a precipitate is redissolved by adding acetic acid and boiling. Death is due usually to exhaustion. Treatment is futile. (See article by Meyer and Swain in "Amer. Jour. Med. Sciences," Sept., 1918.)

Fractures

(In the revision of this section I had the valuable aid of Dr. Thomas A. Shallow, Chief Assistant of the Surgical Out-patient Department of the Jefferson College Hospital.)

Definition.—A fracture is a solution, by sudden force, of the continuity of a bone or of a cartilage. Clinically, under this head are placed epiphyseal separations and the tearing apart of ribs and their cartilages. Blake insists on the difference between a fracture and a wound of a bone. He says: "A bone may be perforated or a portion of it broken off or removed by a missile, and its continuity still remain intact. Such a condition is more often observed in an epiphysis than in a diaphysis. It frequently occurs that a missile penetrates or even perforates an epiphysis without causing a true fracture; but usually, when a diaphysis is perforated, any slight indirect violence is sufficient to break the remaining line" ("Gunshot Fractures of the Extremities," by Lt.-Col. Joseph A. Blake, U. S. A.).

Varieties of Fractures.—The varieties of fractures are as follows:

Simple fracture is a subcutaneous fracture, or one in which there is no wound ex-

tending from the surface to the seat of bone injury. This corresponds to a contusion of the soft parts.

Compound fracture (Figs. 294 and 307) is an open fracture, or one in which an open wound extends from the surface to the seat of bone injury or in which a wound opens up a passage from the fracture to the surface. This corresponds to a contused or lacerated wound of the soft parts. The opening may be through the skin; through a mucous membrane, as in some fractures of the base of the skull and pelvis; through the drum of the ear, as in some fractures of the middle fossa of the base of the skull; through the lung, as when a broken rib penetrates that organ; or through the bowel or bladder, as in some fractures of the pelvis.

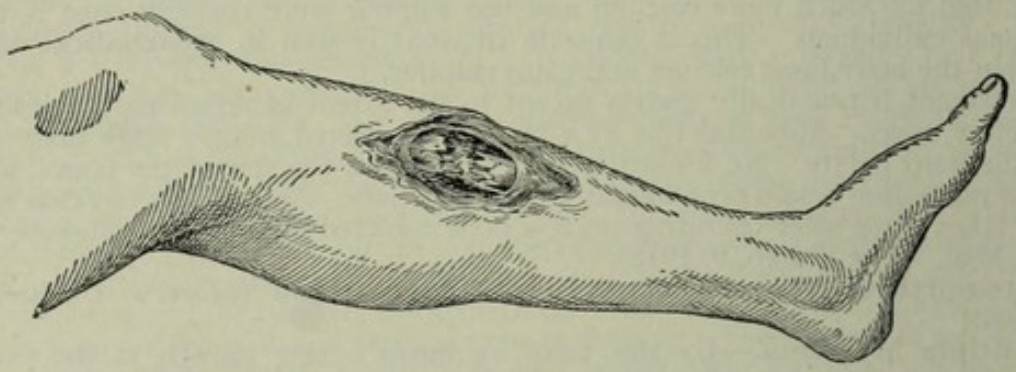


FIG. 294.—Compound comminuted fracture of the tibia.

A *primary compound fracture* is one in which the breach in the soft parts is produced at the time of the accident, either by the direct violence of the injury or by the forcing of a bone or bones through the tissues.

A *secondary compound fracture* is one in which the breach in the soft parts occurs after the accident, either from sloughing of damaged tissues, from ulceration because of the pressure of ill-adjusted fragments, or from the forcing of a bone or bones through the soft parts because of rough handling, neglect, or the tossing of delirium.

Complicated fracture is a fracture plus the complication of a joint injury, arterial or venous damage, or injury to the nerves or soft parts. When a fractured rib injures the lung or when a broken vertebra damages the cord a complicated fracture exists.

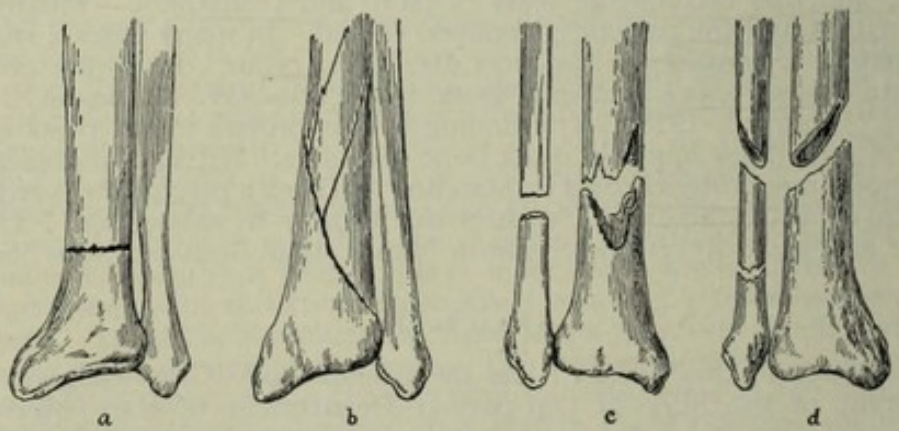


FIG. 295.—Complete fractures: *a*, Transverse; *b*, spiral; *c*, dentated; *d*, oblique.

The term is unfortunate, as it conveys no definite meaning, and its use is no more justifiable than it would be to speak of "complicated pneumonia" or "complicated typhoid," for the complication should be named in any case. It must be remembered that damage to the soft parts not sufficiently severe to produce a wound reaching from the surface to the seat of fracture does not make the case a compound fracture, but rather complicates a simple fracture. Remember also that even superficial areas of tissue destruction must be treated antiseptically, otherwise absorption of pyogenic bacteria and their deposition at the seat of injury may cause diffuse osteomyelitis.

Complete fracture is that which extends through the whole thickness of a bone or entirely across it (Fig. 295).

A *linear*, *hair*, *capillary*, or *fissured fracture*, or a *fissure*, is a crack in a bone with very little separation of the edges. This is an incomplete fracture, but may be associated with a complete break (Fig. 295, *b*).

A *greenstick*, *hickory-stick*, *willow*, or *bent fracture* is a true incomplete break (Figs. 296, 297, 298). The bones most frequently so broken are the radius, ulna, clavicle, and ribs. It arises from indirect force, and it is very rare after the age of sixteen. In rickets greenstick fractures are very common. It is called "greenstick" because the bone breaks like a green stick when forced across the knee, first bending and then breaking on its convex surface. The bone, being compressed between two forces, bends, and the fibers on the outer side of the curve are pulled apart, while those on the concavity are not broken, but are compressed. In correcting the deformity such fractures are often made complete. The permanent bending of a bone without a break may possibly occur in youth. In children a portion of a bone of the skull may be bent inward, causing depression. In some cases such a depression is permanent; in others it is temporary, the bone returning to its proper level.

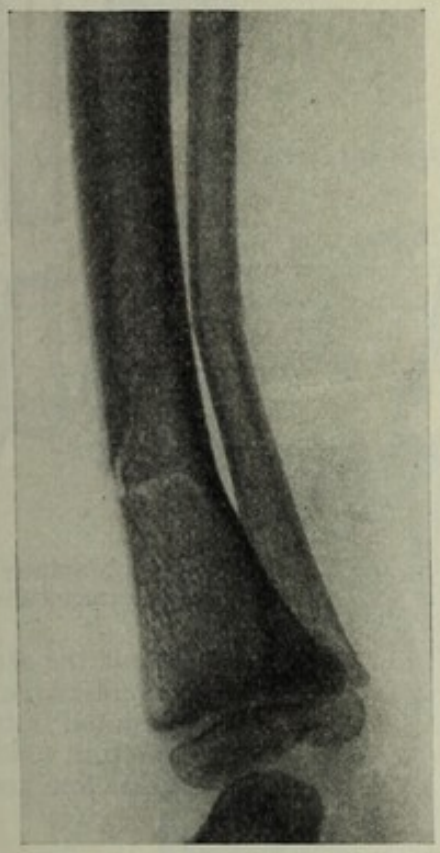


FIG. 296.—Dr. J. W. Lytle's case of greenstick fracture of the radius and ulna (St. Joseph's Hospital case; *x*-ray by Dr. Sender).

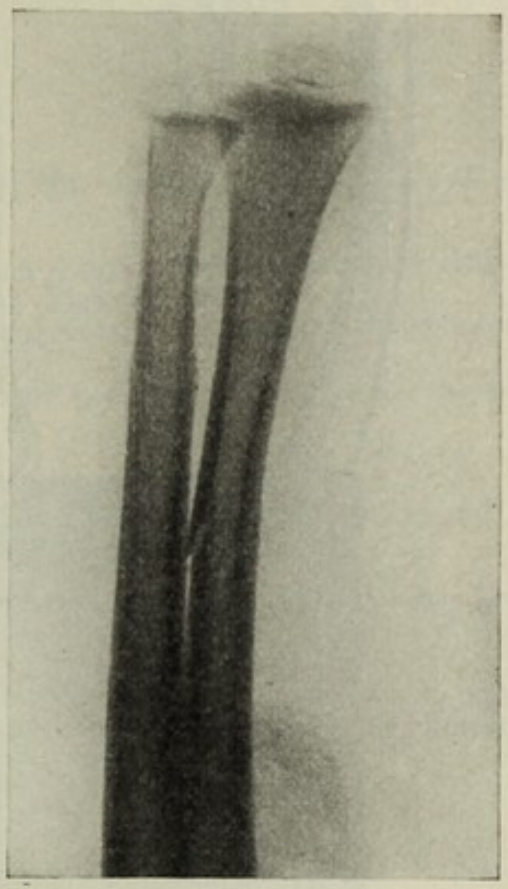


FIG. 297.—Lateral view of greenstick fracture of radius (subperiosteal) (Dr. Ellis's case in St. Joseph's Hospital; *x*-ray by Dr. Sender).

Depression fracture occurs when a portion of the thickness of a bone is driven in by crushing. Fracture by depression is a result of the bending in of a bone (as the parietal), a fragment breaking off from the side toward which the bone is bending. A *depressed fracture* is complete, not incomplete, and by this term is meant an injury in which a fragment of the entire thickness of the bone is driven below the level of the surrounding surface.

Splinter- and Strain-fracture.—The breaking off of a splinter of bone (splinter-fracture) or of an apophysis constitutes a form of incomplete fracture. A strain upon a ligament or a tendon may tear off a shell of bone, and this injury is the "strain-fracture" or "*sprain-fracture*" of Callender.

Longitudinal fracture is a fracture whose line is for a considerable distance parallel, or nearly so, with the long axis of the bone. Such fractures are common in gunshot injuries (Fig. 299).

Oblique fracture is a fracture the direction of which is positively oblique to the long axis of the bone. Most fractures from indirect force are oblique (Figs. 295, *d*, and 299).

Transverse fracture is a fracture the direction of which is nearly transverse to the long axis of the bone (no fracture is mathematically transverse) (Fig. 295, *a*). The *fracture en rave* (radish-fracture, so called because the bone breaks as does a radish) is transverse at the surface, but not within.

Serrated, toothed, or *dentated fracture* is a form of fracture in which the end of each fragment is irregularly serrated and the fragments are commonly locked together; hence it is difficult to correct the deformity (Figs. 295, *c*, and 300). Most simple fractures from direct force are serrated.

Wedge-shaped, V*-shaped, cuneated,* or *cuneiform fracture* ("fracture oblique spiroide," "fracture en V" of Gosselin, "fracture en coin") is one, the lines of which take the



FIG. 298.—Greenstick fracture.

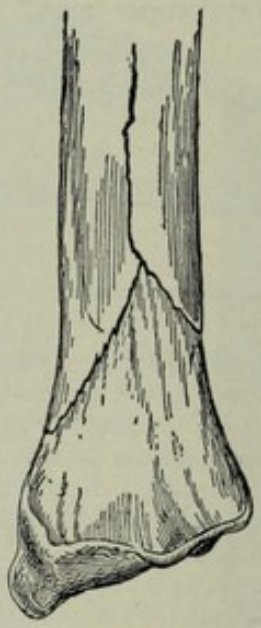


FIG. 299.—Longitudina and oblique fracture.

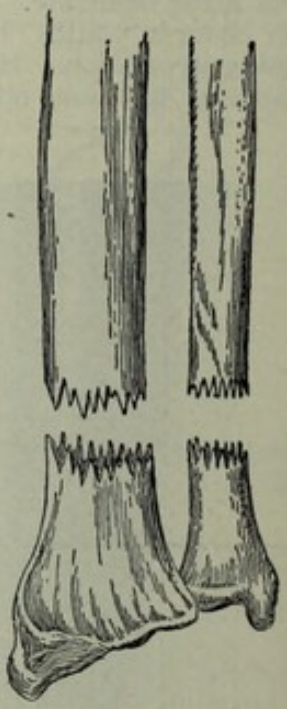


FIG. 300.—Appearances of the ends of fragments.

shape of a V, which may be entire or may lack the point. It occurs at the articular extremity of a long bone, and a fissure usually arises from its point and enters the joint. If complete, it is a "comminuted fracture."

T*-shaped fracture* is a fracture which presents a transverse or oblique line and also

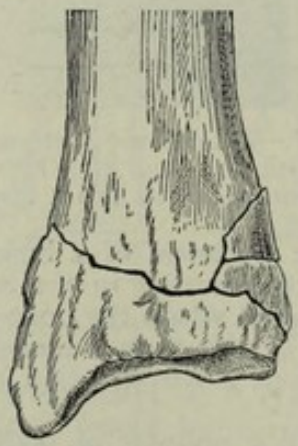


FIG. 301.—Comminuted fracture of the lower extremity of radius.

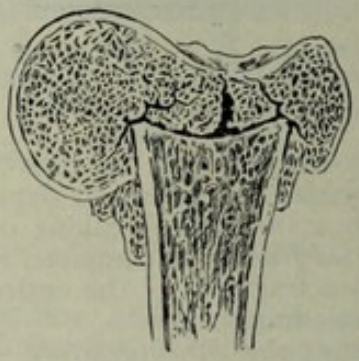


FIG. 302.—Comminuted fracture of the upper part of femur.

a longitudinal or vertical line. It occurs at the lower end of either the humerus or femur, the transverse line being above, and the vertical line (intercondyloid) between, the condyles. If complete, it is, in reality, a form of comminuted fracture.

Multiple or *composite fracture* is a condition in which a bone is broken into more than two pieces, the lines of fracture not intercommunicating, or a condition in which

two or more bones are broken. Multiple fractures of one bone are divided into double, treble, quadruple, etc. Multiple fractures involving more than one bone are seldom seen, and represent less than 2 per cent. of fracture cases. The reason of their rarity in hospitals is that they result from severe force and many of the victims die before they can be brought to an institution. The mortality in cases which reach the hospital is large, over 27 per cent. (Astley P. C. Ashhurst in "Annals of Surgery," August, 1907).

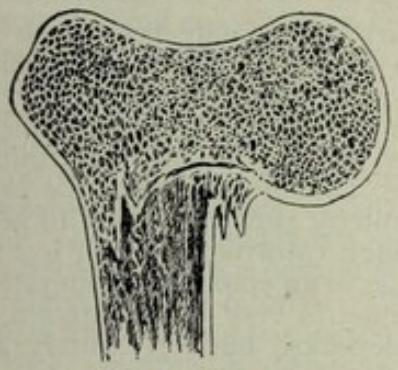


FIG. 303.—Impacted fracture of the neck of the femur.

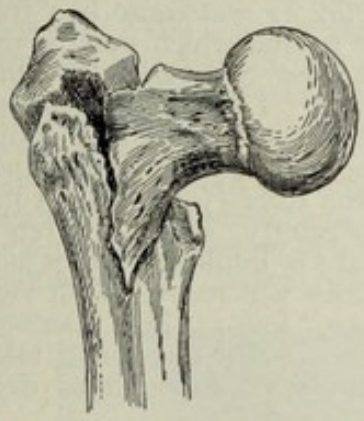


FIG. 304.—Impacted fracture of the neck of the femur.

Comminuted fracture is a condition in which a bone is broken into more than two pieces, the lines of fracture intercommunicating (Figs. 301, 302).

The bone may be broken into many small fragments, there may be much splintering, or the osseus matter may actually be ground up.

Impacted fracture is one in which one fragment is driven into the other and solidly wedged (Figs. 303–305).



FIG. 305.—Impacted fracture of neck of femur (Conner).

Fracture with crushing or *penetration* is a fracture in which one fragment is driven into the other, the encasing bone being so splintered that the impacting bone is not firmly held.

Pathologic, *spontaneous*, or *secondary fracture* is one occurring from a very insignificant force acting on a bone rendered brittle by disease.

Ununited fracture is a fracture in which bony union is absent long after the passage of the period normally necessary for its occurrence.

Direct fracture is one occurring at the point at which the force was primarily applied.

Indirect fracture is one occurring at a point distant from the area of primary application of force.

Stellate, or *starred, fracture* (fracture par irradiation) is one in which several fissures radiate from a center. If the fracture be complete, the condition is, in reality, a form of comminuted fracture.

Helicoid, spiral, or *torsion fracture* is a fracture in a long bone the result of twisting (Fig. 295, *b*).

Fracture by contrecoup is a fracture of the skull which is on the opposite side of the head to that which was the recipient of the force.

Epiphyseal Separation, or Diastasis.—This injury occurs only before the age of twenty-five. The age of greatest liability is from twelve to fourteen. In order of frequency, the bones chiefly subject to epiphyseal separation are: the upper end of the humerus, the lower end of the radius, the lower end of the femur, and the lower end of the tibia (John Poland in the "Practitioner," Sept., 1901). This injury induces deformity, which is often difficult to reduce, and by damaging the cartilage may retard or inhibit a further lengthening of the limb by growth. About 10 per cent. of the cases will recover with very decided shortening (Morris K. Smith in "Annals of Surgery," Feb., 1924). Occasionally after damage to an epiphysis suppuration will occur; sometimes thickening takes place. Non-union is very rare. After a sprain of an epiphysis tuberculous disease sometimes develops, but very rarely after a separation.

Intra-uterine fractures are usually due to injuries of the mother's abdomen sustained toward the end of pregnancy. Some hold that they can arise as a consequence of the force of violent uterine contractions. Many so-called "intra-uterine" fractures are wrongly named, as they result from injury during delivery. In sporadic cretinism the bones are fragile and ill-ossified, and many fractures may occur *in utero*. In the fetal type of fragilitas ossium fractures may occur before, during, or soon after birth.

Designation According to Seat of Fracture.—A fracture may be designated according to its anatomic seat; for instance, fracture of the upper third of the shaft of the femur, fracture of the olecranon process of the ulna, fracture of the middle third of the clavicle, and fracture of the body of the lower jaw. *Intra-articular* fracture is one within or extending into a joint; *intracapsular* fracture is one within the capsule of either the shoulder- or hip-joint; and *extracapsular* fracture is one just without the capsule of either the shoulder- or hip-joint.

Causes of Fracture.—The causes of fracture are: (1) exciting, immediate or direct, and (2) predisposing or indirect.

Exciting causes are: (*a*) external violence and (*b*) muscular action.

External violence is the most usual exciting cause. Two forms are noted: (1) direct violence and (2) indirect force.

Fractures from direct violence occur at the point struck, as when the nasal bones are broken with the fist. In such fractures the soft parts are injured; they may be destroyed at once in part, they may be damaged so severely that a portion sloughs, or they may be damaged so slightly that they do not lose vitality; hence fractures by direct violence may be compound from the start, may become so, or may remain simple. In fractures by direct force discoloration, due to effused blood, usually appears soon after the accident at the point struck. In compound fractures by direct violence the soft-part injury is so great that primary tissue union cannot occur.

Fractures from indirect force do not occur at the point of application of the force, but at a distance from it, the force being transmitted through a bone or a chain of bones, as when the clavicle is broken by a fall upon the extended hand. Such fractures tend to occur in regions of special predilection. If they are not compound, there is no injury of the surface over the fracture. If they become compound by projection of fragments, primary union may still occur. Discoloration over the seat of fracture is usually not present soon after the accident, but may occur later. Discoloration rapidly appears in soft parts at the point where the force was first applied.

Muscular action is rather an unusual cause except in the patella. Fractures thus produced result from sudden or violent muscular contraction. Bones so broken are usually diseased. Violent coughing may fracture the ribs; attempting to kick may fracture the femur; saving one's self from falling backward may fracture the patella; throwing a stone may fracture the humerus; and sudden extension of the forearm may fracture the olecranon process of the ulna.

Predisposing Causes.—There are two classes of predisposing causes, namely: (1) physiologic, natural or normal, and (2) pathologic or abnormal.

Natural Predisposing Causes.—Under this head is considered the liability to fracture possessed by individual bones because of their shape, structure, function, or position. Those predispositions occasioned by special ages are also considered. In youth epiphyseal separation is commoner than fracture and a fracture is apt to be incomplete. Fractures are commonest between the ages of twenty-five and sixty. From two to four years of age a child is more liable to fracture than later, because it is then learning to walk (Malgaigne). The bones of the old are easily broken, but the normal lack of activity of the aged saves them from more frequent injury. Thus, the predispositions of age are in part due to habits and in part to bony structure. The bones of the young, being elastic, bend considerably before they break; the bones of the old, being brittle and inelastic, break easily, but do not bend. In old age the bones become lighter and more porous, though they do not diminish in size. Absorption takes place from the interior of a bone, particularly at its articular head, the medullary canal increases in size, the cancellous spaces become notably larger, and portions of the remaining bone of the interior show a fatty change. There is no increase in the amount of mineral salts present, as was long taught. These alterations occur earlier in women than in men.[1] The change of age is a diminution in the amount of bone present, and sometimes a fatty change in a portion of what remains. If the atrophy of bone is other than that normal to senility, it constitutes a pathologic predisposing cause of fracture. Normal predisposing causes include the person's weight (which determines the force of a fall), muscular development, habits, sex, occupation, and the season of the year.

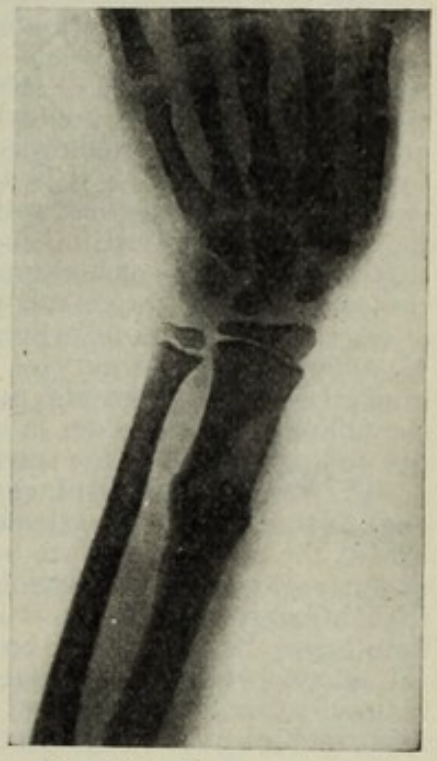


FIG. 306.—Cyst of the radius with pathologic fracture (Dr. N. Ginsburg).

Pathologic Predisposing Causes.—Hereditary fragility, a form of *fragilitas ossium*, is a condition commonest among women, often existing in generation after generation, and in this condition fractures occur from a very slight force. There exists in these cases bony rarefaction—in fact, a premature senility. *Fragilitas ossium* (*osteopsathyrosis* or *osteogenesis imperfecta*) may be congenital, may be infantile, or may come on later in life (page 449). Brittleness may result from senility, wasting diseases, scurvy, scarlatina, bone-cyst, (Fig. 306), malignant disease of the bone, certain nervous disorders, rickets, osteomalacia, or atrophy due to disuse. Workers in phosphorus are particularly liable to spontaneous fracture of the long bones.

Nervous Diseases.—Bony nutrition is dependent on the spinal cord, and the trophic influence is probably exerted through the posterior nerve-roots. In diseases of the anterior cornua bony growth is much interfered with; in diseases of the posterior columns, as in locomotor ataxia, a true bony atrophy indicates trophic disorder. Syringomyelia causes brittleness of the osseous structures, and in paralysis agitans bones are thought to break easily. Trophic changes may occur in the bones of the insane, most commonly when insanity is linked with organic disease. About one-quarter of paretic dements show undue brittleness or unnatural softness of bones.[2] The bones of maniacs are frequently fragile. Fractures among the insane are not necessarily an indication of abuse.

Rickets predisposes to fracture because of altered bone structure and the great liability to falls.

Osteomalacia predisposes to fracture of the long bones, sternum, and ribs.

Atrophy of Bone.—This condition, as has been stated (see above), is normal in senility. It may arise from want of use, as is observed in the bedfast, in the wasted femur of hip-joint disease, and in the bones of a stump. It may arise from pressure, as when an aneurysm compresses the ribs, sternum, or vertebræ. Among other of the pathologic predisposing causes are to be mentioned cancer, sarcoma, hydatid and solitary cysts of bone (Fig. 306), caries, necrosis, gout, scrofula, syphilis, mollities ossium, and scurvy.

[1] Humphrey on "Old Age."
[2] "Manual of Insanity," by Spitzka.

Symptoms of Fractures.—*History of an Injury.*—In spontaneous fracture there may be no record of violence; for instance, a bone may break while an individual is turning in bed. In investigating the history, not only seek for a record or for evidences of violence, but try to determine exactly how the accident happened.

A *sound of cracking* is occasionally audible to a bystander at the time of the injury. The patient may have heard it, but very rarely does. A rupture of a tendon or a ligament produces a similar sound.

Pain is usually, but not invariably, present (absent often in rickets). In some fractures the pain is slight, in some there is no pain, in others pain is torturing, and in most it is severe for a time after the injury, but gradually abates unless reinduced by movement. Pain developed at the time of the accident is far less important as a symptom than that which can subsequently be produced by movement. In indirect fracture there is an area of pain at the point of application of the force, and another at the seat of fracture. Pain at the seat of fracture can be greatly aggravated by pressure or movement and is rather narrowly localized.

Deformity or *alteration in length or outline* is due in part to swelling and in part to a change in the mutual relation of the fragments (displacement). The deformity due to swelling is no aid to diagnosis, as the same condition occurs in contusion, and often hides some positive symptomatic distortion in fracture. The swelling is due first to blood and next to inflammatory products and pressure-edema, and is very great in joint fractures. Swelling due to bleeding is early and rapid. Swelling due to inflammatory exudation is later and gradual. Swelling due to pressure-edema may be rapid. The greater part of the swelling is due to hemorrhage and exudation from the damaged soft parts, a portion of it is due to hemorrhage and exudation from the bone. The swelling is usually in direct ratio to the mobility, the greater the mobility, the greater the swelling. "The swelling in fractures of the skull is inconsiderable, notwithstanding that the total area of bone surface involved is commonly more than in fractures of the leg or arm, and the vascularity greater. The reason for this is the natural immobility of fractures of the skull" (James P. Warbasse in "Jour. Amer. Med. Assoc.," March 13, 1909). The deformity of displacement may be produced by the violence of the injury (as in the depression in a skull fracture), by the weight of an extremity (as in the falling of the shoulder in a fracture of the clavicle), or by muscular action (as in the pulling upward of the fragment of a fractured olecranon process).

The **varieties of displacement** are: (1) *Transverse* or *lateral*, where one fragment goes to the side, front, or back, but does not overlap the other; (2) *angular*, the bony axis at the point of fracture being altered and the fragments forming with each other an angle; (3) *rotary*, one fragment rotating in the bony circumference, the other remaining stationary. As a rule, it is the lower fragment which turns on its long axis, the limb below the level of the break rotating with it; (4) *overlapping* or *overriding*, when the upper level of one fragment is above the lower level of the other fragment. It is usually the lower fragment which is drawn by the muscles above the upper, but in a fracture of the lower extremity the body weight and sliding down in bed may push the upper below the lower fragment. In overriding, the ends are near together and the bones are usually in contact at their periphery. It is obvious that overlapping is associated with transverse displacement, as one fragment must go front, back, or to the side; (5) *penetration* or *impaction* when one fragment is driven into the other, thus producing shortening; (6) *separation of the two fragments* occurs in fracture of the patella, olecranon, os calcis, certain articulations, and in some breaks of the humerus when the arm is not supported.

It is important to remember that a dislocation as well as a fracture may produce displacement, but these two conditions may be differentiated by the observation that the displacement of fracture tends to reappear even after complete reduction, while the displacement of dislocation does not reappear after correction. A displacement is difficult of detection in a flat bone and when one of two parallel bones is broken.

Loss of function may be shown by inability to move the limb because of the break, but it is not always markedly present, though some degree invariably exists. It is slightest in "greenstick" and impacted fractures (unless the loss of power arises from pain or nerve injury). A person can walk when the fibula alone is broken, and likewise in some cases of intracapsular fracture of the femur, and can often put the hand on the head in fractured clavicle (Malgaigne). The pain of an injury or the loss of power from nerve traumatism may cause loss of movement in the limb. This symptom is of slight diagnostic value in most fractures.

Extravasation of Blood.—A contusion of the surface accompanied by skin abrasion

indicates merely the point of application of direct external violence. If contusion is extensive over a superficial bone, as the tibia or parietal, after a few hours it often simulates fracture by presenting a soft, compressible center soon surrounded by a ring of hard, condensed tissues and coagulated blood. Direct external violence may merely occasion ecchymosis, and in fracture from indirect force ecchymosis may occur throughout a considerable area. In regard to this symptom, note that even great external violence may occasion no evident contusion or ecchymosis, and in any fracture this symptom may be present or absent. In old people, anemic subjects, fat individuals, alcoholics, and opium-eaters extravasation of blood is frequently marked and persistent. By suggillation is meant an extravasation of blood which slowly invades wide areas of tissue and which appears at the surface after some time only, and then usually as a yellowish discoloration, red hemoglobin having been changed to yellow hematoidin. Linear ecchymosis has been esteemed by some as a sign of fissure, and it is often noted after fracture of the fibula. Linear ecchymosis over the line of the posterior auricular artery was shown by Battle to be a valuable sign of fracture of the posterior fossa of the base of the cranium.

Preternatural mobility is a most important symptom, which is pathognomonic when surely found. The unbroken bone is nowhere mobile in continuity. By preternatural mobility is meant that a bone is mobile in continuity or that there is abnormality in the direction or extent of joint mobility. In some fractures this symptom does not exist (impacted, greenstick, and locked serrated fractures); in others it cannot be found (fractures of tarsus, carpus, vertebral bodies); in others it is difficult to obtain, but at times can be developed (fractures near or into many joints). To develop this symptom try, when the case admits, to grasp the fragments and to move them in opposite directions. In a fracture of the shaft of the femur or humerus fix the upper fragment and carry the knee or elbow in various directions to develop bending at the point of fracture. In fracture of the clavicle push the shoulder downward and inward. In fractures of either bone of the forearm grasp the parallel bone with four fingers of each hand and make pressure on the suspected bone alternately with either thumb, and the same procedure can be used in fractures of the leg. In fracture of the neck of the femur the altered rotation-arc of the great trochanter demonstrates preternatural mobility (Desault). In fracture of the lower end of the radius bend the hand back, and in a break of the lower end of the fibula evert the foot (Maisonneuve). In seeking preternatural mobility remember that the elastic ribs when forced in give a sense of bending, and that the fibula at its middle is "normally flexible" (Dupuytren). Some rachitic bones may be made to bend.

Crepitus or *crepitation* is both a sensation and a sound, which indicates the grating together of the two rough surfaces of a broken bone. This symptom is of great value, but it is not always present. It is absent in locked serrated fractures, in impacted fractures, in cases where the ends of the fragments cannot be approximated (as in overlapping), is rare when a fractured surface is against the side, and not the broken face, of the other fragment, and is unusual in incomplete fractures. Crepitus is often absent in epiphyseal separation, in softened bones, and in fractures in or near joints, and it may be prevented from occurring by blood-clot, fascia, synovial membrane, periosteum, or muscle between the broken surfaces. The grating found in tenosynovitis must not be mistaken for the crepitus of fracture; the former is diffuse, large, soft, and moist; the latter is limited, small, harsh, and dry. The clicking of an inflamed or eroded joint and the crackling of emphysema must also be separated from bony crepitus. Crepitus of fracture may be present at one moment, but absent the next. It is often not detected during the time swelling is marked, and cannot be discovered after organization of the callus begins. In but a few fractures is it needful to try to hear crepitus with the unaided ear or with a stethoscope upon the part, but in doubtful cases of fractures of ribs and joints this evidence should be sought for.

The above-named symptoms are known as "direct." There are other symptoms known as "circumstantial," such as the flow of blood and cerebrospinal fluid from the ear after some fractures of the middle fossa of the base of the skull; emphysema of the face and epistaxis after fracture of the nasal bones; hemoptysis and emphysema after crushes of the chest; discoloration following the line of the posterior auricular artery after fracture of the posterior fossa of the skull, and subconjunctival ecchymosis after fracture of the anterior fossa of the base of the skull.

Diagnosis.—Examine as soon as practicable after the injury—before the onset of swelling, if possible. Expose the part completely, taking off the clothing, if necessary, by clipping it along the seams. Note if the pulse is present below the seat of injury.

Attentively scrutinize the part and compare it with the corresponding part on the opposite side. If any deformity be present, it must be ascertained that it did not exist before the accident. If the nature of the injury be uncertain, if the patient be very nervous, or if the part be acutely painful, it is better to give ether to diagnosticate, set, and dress. In injuries of the elbow-joint anesthetize before examination, unless an *x*-ray apparatus is accessible to settle the diagnosis, and even then it is usually well to anesthetize in order to facilitate reduction and dressing. In every case of suspected fracture get an *x*-ray picture if possible. A correct diagnosis is of the first importance and on a correct diagnosis proper treatment primarily depends.

A fracture is distinguished from a dislocation by its preternatural mobility, its easily reduced but recurring displacement, and its crepitus, as contrasted with a dislocation's preternatural rigidity, deformity, absence of crepitus, and early strenuous resistance to reduction, with a final tendency to remain in place when once reduced. Further, in dislocation the bone, when rotated, moves as one piece, whereas in fracture it does not so move; in dislocation the bony processes are felt occupying their proper relations to the rest of the same bone, while in fracture some of them present altered relations. In dislocation the head of the bone is found out of its socket, but in fracture it is felt in place. It is important to remember, moreover, that a fracture and a dislocation may occur together, and that the rubbing of a dislocated bone against an articular edge, when the joint has been roughened by inflammation, simulates crepitus.

Great contusion, by inducing extreme tumefaction, may mask characteristic deformity and obscure crepitus. When only a contusion exists, pain is apt to be widespread; but if a fracture has occurred, the pain is accentuated at some narrow spot. In many cases, before he can give a certain opinion, the surgeon must wait some days until the swelling has largely subsided. In such a case it is best to assume in our treatment that a fracture exists until the contrary is known. Combat swelling by rest, the use of evaporating lotions, and moderate compression.

In impaction the diagnosis is difficult. The moderate deformity is concealed by swelling; crepitus and preternatural mobility do not exist unless the fragments are pulled apart, and there is not necessarily much loss of function. A conclusion is reached largely by considering the nature, direction, and extent of the violence, the seat of the pain, and by a careful study of the most minute deformity. It is difficult to recognize fissures. They rarely present any evidence of their existence except a localized pain, and possibly a linear ecchymosis appearing after a few days.

In greenstick fractures the age, the deformity, and possibly crepitus during reduction help in the diagnosis, although in many cases no crepitus is obtained. Epiphyseal separations are diagnosticated by the age, the preternatural mobility, the pain, the swelling, the ecchymosis, the deformity, the situation of the injury, and the absence of crepitus or the presence only of a soft crepitus. It is important, however, to remember that an epiphyseal separation is sometimes incomplete, and even when it is complete there may be no displacement. In cases without displacement the *x*-rays will not enable us to make a diagnosis. In many cases of complete separation soft crepitus is obtainable, but in not a few cases it is not to be found. In incomplete separation crepitus is absent. If absent in complete separation, probably some tissue is caught in the opened area between the fragments. Fractures are often difficult to recognize when occurring in a group of bones (which are firmly joined by dense ligaments) like those of the carpus and tarsus, or in one of two parallel bones. There is not always a certainty that a fracture exists (see below), and when, after a careful examination, there is still uncertainty, do not prolong the efforts or use great force, but treat the case as a fracture until a cure ensues or the diagnosis becomes apparent.

In a child the diagnosis of fracture is sometimes difficult. Pain may be trivial. Children are liable to a form of fracture in which the periosteum is but slightly torn or is not torn at all, the disability and pain are often slight, and the fracture may be easily overlooked (Cotton and Vose). If after a fall, blow, or twist, a child refuses to use the limb for a considerable time the surgeon should always suspect the existence of a fracture.

In 1895 a method of incalculable value in diagnosticating fracture was given to the surgeon, that is, the use of the force known as the *x*-ray or the Roentgen ray. We can look through a part with a fluoroscope and see the bones as shadows, or we can take a negative of the shadows and print skiagraphs from it. This method is applicable even when the parts are swollen, and even when a limb is clothed or wrapped in dressings. It is possible to obtain a picture of a fractured skull; fractured ribs and vertebræ can be detected; and the process is of the greatest use in detecting fractures

of the limbs. It is not infallible. An epiphyseal separation may not be detected, and a slight angling of the plate may give a deceptive appearance of distortion. An *x*-ray picture, to be useful, must be taken by an expert and should be interpreted by a surgeon in association with the *x*-ray expert. It is imperative to employ this method in doubtful cases if an *x*-ray apparatus is accessible. It is advisable to use it in all recognized cases and in all suspected cases.

Complications and Consequences.—Some of the consequences and complications of fractures are: sloughing of the soft parts, thus making the fracture compound; extravasation of blood, causing swelling or even gangrene; rupture of the main artery or vein of the limb; dislocation; edema from pressure of extravasated blood, from inflammatory exudation, from tight bandaging, from thrombosis, or, later, from the pressure of callus; stiffness of joints from synovitis with adhesion, from displaced fragments, or from intra-articular callus; stiffness of tendons from adhesive thecitis or from the pressure of callus; paralysis from traumatic neuritis, the pressure of callus upon nerve-trunks, or from division of a nerve; muscular spasm; painful callus; exuberant callus; embolism; fat-embolism; pulmonary congestion; pulmonary embolism; gangrene; shock; septicemia; pyemia; tetanus; delirium tremens; urinary retention; extensive laceration of the soft parts; rupture of large nerves, and involvement of joints. A fracture may fail to unite, fibrous union or cartilaginous union only being obtained. An epiphyseal separation may arrest the future growth of the limb.

Repair of Fractures.—Simple Fracture.—In a simple fracture the bone is broken, the medullary contents are lacerated, the periosteum is torn, and the overlying soft parts are damaged to a considerable degree. The periosteum is stripped more or less from each fragment, but it is rarely completely torn across, an untorn portion known as the *periosteal bridge* remaining. The amount of blood effused is usually considerable, and it forms a decided prominence at the seat of fracture; it gradually gathers because of oozing, and soon clots. This clot lies in the medullary canal, between the fragments, under the periosteum at the ends of the fragments, and in the tissues outside of the periosteum. Very rapidly after the accident the damaged parts inflame (bone, endosteum, periosteum, and the torn periosseous structures). The inflammatory exudate enters into the blood-clot and the leukocytes eat up and destroy the clot. The clot is simply dead material and in no way contributes to repair. The cells of the damaged tissue proliferate and the young proliferating cells (fibroblasts) enter into the spaces in the clot which were eaten out by the leukocytes. Finally, the entire clot is replaced by fibroblasts and much of this cellular mass quickly becomes vascularized (granulation tissue).

The osteoblasts which exist in the deeper layers of the periosteum and, in the tissue of the medulla itself, begin to proliferate actively soon after the fracture has taken place. The fibroblasts have been formed by the proliferation of the ordinary connective-tissue cells, and the proliferating osteoblasts soon enter into and become widely distributed through this mass of fibroblasts. Some observers maintain that the fibroblasts themselves are directly transformed into bone; others deny this, and think that all bone formation comes from the osteoblasts. Osteoblasts may form bone directly, or may form cartilage first and then bone. When a fracture takes place, a bridge of periosteum is usually left untorn, and this bridge holds the fragments in contact at some point, just as a strap nailed to a trunk and also to its lid holds these two objects in contact at some point. The new tissue about the periosteal bridge always becomes cartilaginous for a time, but the rest of the callus rarely shows the development of cartilage, and passes directly into bone. If, however, osteoblasts fail to proliferate with sufficient activity, the mass of granulation tissue becomes fibrous tissue; bone is not formed at all, or is very scantily formed, and fibrous union occurs. If the osteoblasts lack activity, but are more active than in the case just cited, they form cartilage extensively—but cartilage only; consequently, cartilaginous union occurs. During the process of the repair of a fracture the ends of the bony fragments are always softened and some of the bone is absorbed by the osteoclasts. The osteoclasts are really large osteoblasts that have lost the power of producing bone and that furnish a secretion which absorbs bone (the elder Senn). After bony union has been accomplished the osteoclasts absorb the superfluous callus. The mass of new tissue around and between the bone-ends is called *callus*. It will be observed that the name is applied successively to fibroblastic tissue, granulation tissue, fibrous tissue, and bone. Warren tells us that callus has no well-defined outline, and "involves not only the bone and periosteum but also the connective tissue and some of the surrounding muscular tissue." Within a few days after the injury the inflammatory mass is much firmer than that which

follows inflammation involving other structures, and the bone ends have become deeply embedded in a dense mass.

During the second week the callus is greatly strengthened by the formation of dense fibrous tissue in and below the periosteum, of less dense fibrous tissue outside the periosteum, and of cartilage from the periosteal bridge. The newly formed tissue contracts decidedly. During the third week ossification begins at the points farthest from the fracture, and in the course of a short time (from three to six weeks) is complete. The mass of ossified callus, or new bone, is spindle shaped and spongy.

The terms *intermediate*, *definitive*, or *permanent* callus are used to describe the material which forms between the ends of the broken bone. The names *provisional* or *temporary* callus are given to the material within the canal (central callus) and external to the bone (ensheathing callus). The amount of provisional callus depends directly on the extent of separation and the amount of motion between the fragments. It is Nature's splint, and when the break is not well immobilized a large amount is formed. The greater the amount of motion, short of a degree sufficient to cause non-union, the larger the amount of provisional callus.

The ensheathing callus is after a time largely absorbed, and the central callus in the course of a long time may also be absorbed, with the restoration of the medullary canal, although this latter result is rare. An excessive amount of provisional callus may ossify nearby tendons, may unite parallel bones (radius to ulna, tibia to fibula, a rib to its neighbors), may block a joint just as a stone in the crack of the door will block a door, or may absolutely abolish a joint. Fragments, even if entirely detached, often unite, but they may be surrounded by provisional callus; sometimes they do not

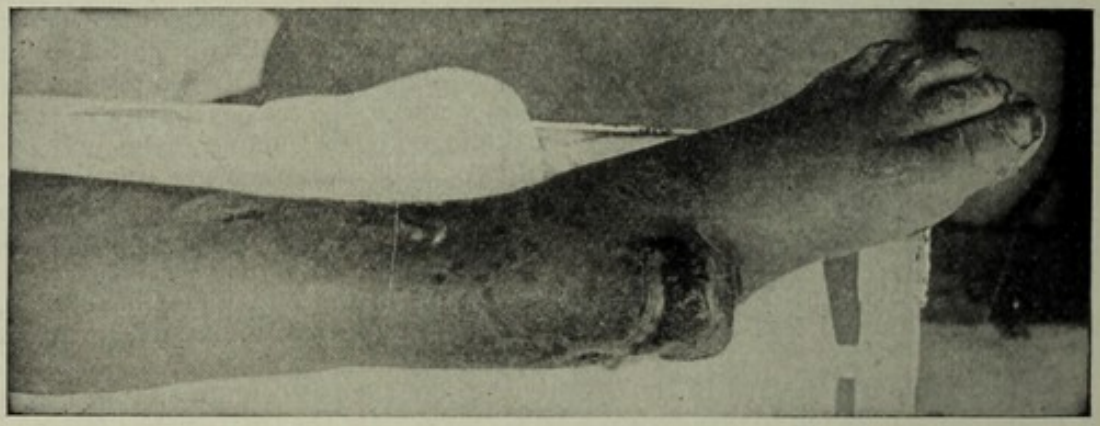


FIG. 307.—Compound fracture.

cause trouble, but sometimes suppuration takes place. It takes about one year for Nature to remove the temporary callus. The definitive or permanent callus after a time ceases to be porous and becomes very dense bone. We know that the blood of infants and children during the growth of bone contains decidedly more inorganic phosphorus than does the blood of healthy adults.

It has been observed recently that following major fractures in adults there is a rise in the inorganic phosphorus content, in many instances to the level found in children (Tindall and Harris in "Jour. Amer. Med. Assoc.," 1922, pp. 884–887).

There appears to be a similar change in the calcium. The rise may be noted several days to two or four weeks after the fracture. After union has taken place the phosphorus content gradually falls. As a general proposition cases with non-union do not show this reaction in the blood phosphorus following fracture.

Compound fractures (Fig. 307) due to indirect force, the bones having been stuck through the tissues and destruction or bruising of soft parts being slight, if treated antiseptically, soon become simple fractures and unite as such (page 472). If septic inflammation occurs, pus forms, and union by granulation is the best that can be obtained. Compound fractures by direct violence will not heal by first intention because of the loss of vitality of a large area of the soft parts unless débridement is performed (page 472).

Delayed union is usually due to imperfect approximation or unstable fixation of the fragments. Imperfect approximation may result from failure to reduce the fracture (muscle, ligament, or synovial membrane being caught between the bone fragments); extensive destruction of bone; stripping of large surface of periosteum;

the use of unsuitable splints; too tight application of bandages; pregnancy; and general causes of ill health, for instance, anemia, scurvy, Bright's disease, rickets, or syphilis; disobedience of the patient or delirium tremens. In delayed union there is pain on passive motion; in non-union there seldom is. In delayed union there is loss of voluntary motion; in non-union there is power of voluntary motion (A. H. Tubby in "Brit. Med. Jour.," Dec. 7, 1901). In delayed union there is apt to be tenderness on pressure and often a quantity of callus can be palpated. Delayed union is not non-union, but may eventuate in non-union. The exact time requisite for the solidification of a particular fracture cannot be predicted. The average, taken from a large majority of patients, is not true in a minority. For no apparent reason consolidation may require two or three weeks more than the average, but be accomplished at last. Sir Robert Jones, of Liverpool, well says that ununited fracture is often the result of "surgical impatience," the surgeon frequently examining a part in which union is slow, and that "non-union would rarely occur if delayed union obtained proper attention" ("Brit. Med. Jour.," Dec. 7, 1912).

Bending of Callus.—Sometimes apparently sound callus will bend. This is particularly apt to occur in the leg if the bones are not in correct alignment. Failure of correct alignment means great deflection of the weight of the body. I have seen shortening of the femur increase during the third month after a fracture. Sir Robert Jones (Ibid.) points out that the surgeon can refracture bones by manipulation up to four months after the break. It is obvious that fractures are not soundly united as early as we used to believe, and that a patient must not be allowed to walk too early.

Vicious union, malunion, or **faulty union** is union with great deformity (Fig. 309). This condition may be due to imperfect reduction of deformity, inadequate splinting, or insufficient extension. It may arise because the splints or the extension was removed at too early a period, the callus yielding because of weight bearing or muscle strain. In many cases of vicious union the deformity is slight and produces little or no pain or impairment of usefulness. In other cases it is pronounced and produces functional impairment or disastrous pressure on nerves or vessels. Vicious union near a joint always impairs function. If there is pronounced vicious union the bone should be rebroken and set as a fresh fracture. In some recent cases the bone is broken by manual force, and for a number of weeks after a fracture this can be easily accomplished. In older cases osteotomy should be performed.

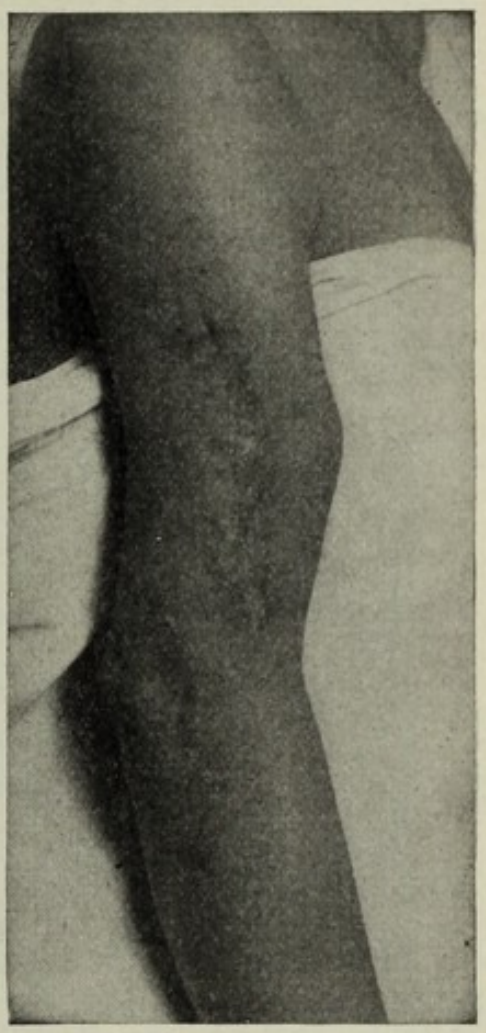


FIG. 308.—Ununited fracture of humerus; unsuccessful wiring.

Comminution may lead to vicious union and union in deformity is not uncommon about joints. Deformity may consist in overlapping, angulation or rotation, and rotation may be linked with angulation or overlapping.. An excess of callus in or about a joint constitutes malunion. We see angular deformity most commonly in fractures of the upper third of the femur. Malunion in angulation is seen in cases in which Colles's fracture was imperfectly reduced and in coxa vara following incompletely reduced fractures of the neck of the femur. Overlapping is common after fractures of the femur. Rotation is common in the femur and is particularly common in fractures of the radius above the pronator radii teres muscle.

Non-union of Fractures.—An ununited fracture is a fracture in which union is not effected at all or in which it is not brought about by bone (Figs. 308, 310). Non-union is especially common in fractures of the upper third of the femur and of the middle third of the humerus. The causes are local and constitutional. The *local causes* are: (1) Want of approximation of fragments; a frequent cause of want of

approximation is interposition of soft tissues—viz., muscle, fascia, or periosteum; this is a common cause of non-union, a cause responsible for a decided majority of the cases; if soft tissues are interposed between bone fragments non-union is almost inevitable; (2) want of rest. As pointed out above, delayed union may result in non-union because of frequent meddlesome examinations. As Sir Robert Jones says, if there is no union at the end of the fifth week do not examine daily, but leave the parts alone for a fortnight at least; (3) want of blood-supply (as seen in the heads of the humerus and femur, or when a nutrient artery is torn, or when a thrombus forms in a vein near the fracture); (4) defective innervation; (5) bone disease; (6) the use of unsuitable splints; (7) tight bandaging. The *constitutional causes* are debility, scurvy, Bright's disease, syphilis, etc. Sometimes union fails without appreciable reason. In an ununited fracture the broken ends of the bone round off and the medullary canal of each fragment becomes closed by bone. The fragments may not be held together by any material, or they may be held by very thin and much-stretched fibrous

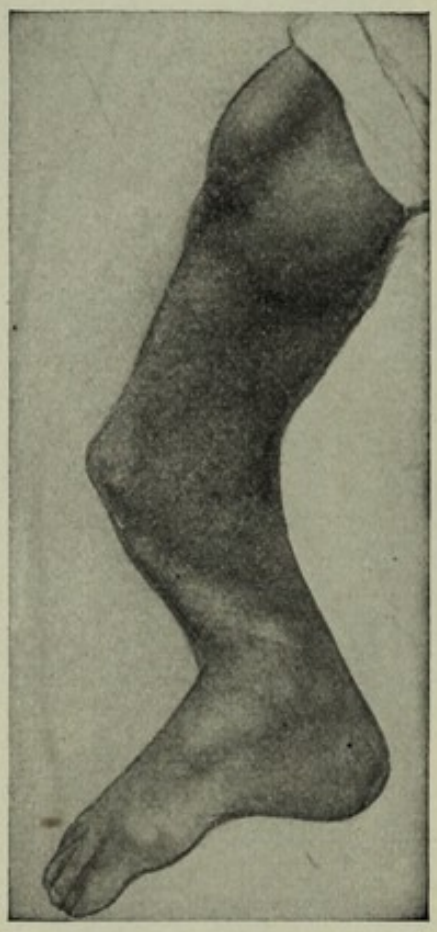


FIG. 309.—Vicious union of fractured bones of the leg. View from inner side of limb.

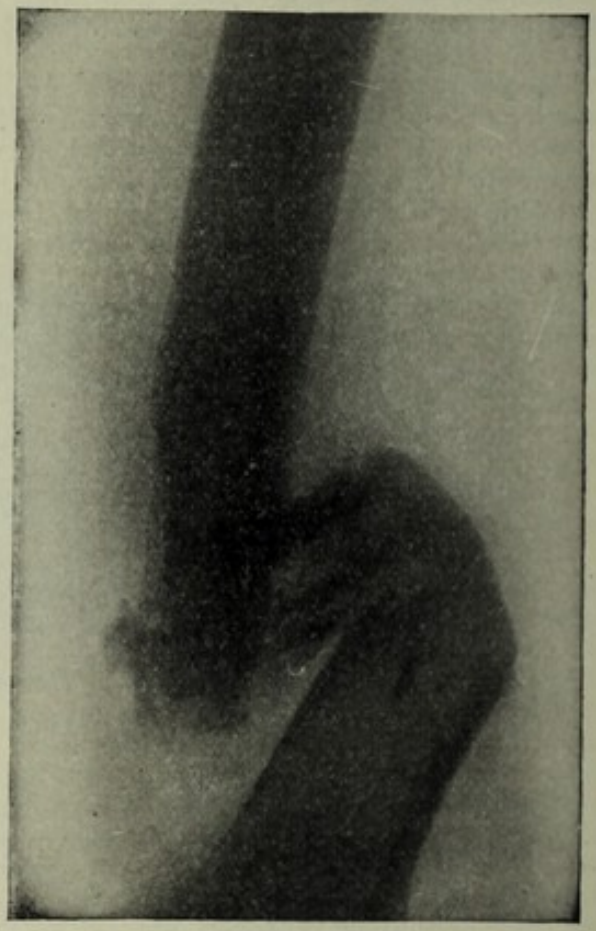


FIG. 310.—Ununited fracture of the femur.

tissue (*membranous* union), or by strong, thick, fibrous tissue (*ligamentous* or *fibrous* union). When the ends of the bones come together, are held by a fibrous capsule, and move on each other, there exists a *false joint* or *pseudo-arthrosis*. Such a joint may after a time secrete serous fluid for lubrication. In very rare cases a fracture once apparently soundly united may at a later period be obviously ununited, callus having been absorbed or broken. Pain on active motion in the region of a fracture a number of weeks old suggests absence of solid union. If there is also tenderness it is highly probable that the bones have not as yet solidly united. If, with pain and tenderness, there is marked thickening, non-union is certain ("Brit. Med. Jour.," Dec. 7, 1912).

Treatment of Fractures.—The treatment comprises first aid, reduction, and retention. If a man is found in the street with a fracture, further injury must be prevented by applying, after cutting off the clothing over the fracture, some temporary support. If an ambulance or patrol-wagon cannot be obtained, move the patient by hand. If the lower extremity be involved, an improvised stretcher (a board or

a shutter) is placed on the ground beside the patient, who is laid on the stretcher, the surgeon lifting the injured limb, and the patient is then carried to the hospital and carefully transferred to a fracture-bed, or, if taken home, to a small ordinary bed, several boards being placed transversely beneath a rather hard but even mattress. The temporary appliances are now removed and a diagnosis is made by the methods before given. Whenever possible have *x*-ray pictures taken (see page 480). After determining the nature of the injury the fragments must be adjusted. This should, if possible, be done at once, because a fracture remaining unreduced may become compound, the fragments may injure important structures, and they are apt to cause intense pain. Reduction is easily effected during shock, as the muscles are then in a state of relaxation. Early reduction and fixation largely prevent swelling. If there is very great swelling, reduction may be impossible, and the part must then be supported, moderate cold, sorbefacients, and gentle pressure being used, ice and tight bandaging, which predispose to gangrene, not being employed. In most cases we can reduce displacement in spite of swelling and cure swelling by the reduction. Set the fracture at the first possible moment. Velpeau's axiom was to reduce fractures at once, regardless of pain, spasm, or inflammation, as reduction is their cure. The longer we wait to reduce a fracture, the greater the amount of force necessary to accomplish it because of progressive infiltration of the soft parts with inflammatory exudate and blood, a process which lessens and finally destroys tissue elasticity. In reduction try to get broken ends in even apposition. In this we may fail, but we must at least strive to obtain a correct alignment. In order to obtain apposition or alignment it may be necessary to make traction by pulleys, and if this is done the patient must be anesthetized (Sir Robert Jones, "Brit. Med. Jour.," Dec. 7, 1912). Jones says that "end-to-end apposition with an angle of deflection is less satisfactory than slight overlapping in the presence of correct alignment" (Ibid.).

If the patient is very nervous, if the pain is severe, or if rigid muscles antagonize the efforts of the surgeon, reduce the fracture under anesthesia. In some fractures (as those of the clavicle) adjustment is effected by altering the position, and in others (as those of the femur) by extension and counterextension, aided perhaps by pulleys; in some by tenotomy, and in some by kneading, bending, and coaptation. When extension is employed always endeavor to get a point of counterextension. The extension is to be made on the broken bone (if possible, in the axis of the bone), is to be steady, and neither jerky nor violent. In some cases complete reduction is impossible. This may be due to spasm, to swelling, to the catching of soft parts between the fragments, to the existence of a loose fragment, to locking, or to impaction. An impaction by rotation can generally be released, but it is sometimes undesirable to unlock it. If the fragments cannot be adjusted without violence, retain them in the best attainable position, combat the antagonistic cause, and set them properly as soon as possible, or else operate.

After adjusting the fragments maintain them in position by some apparatus. Do not use set splints for each variety of injury. The splints we describe as commonly used are suited to many cases, but in each case a surgeon uses the plan of treatment which in his opinion is suitable to that case. In a given case the routine plan may prove unsuitable. The treatment is to be adjusted to the individual case. The case is never to be forced to an unsuitable routine treatment. All sorts of materials, are used for splints; among them may be mentioned wood, felt, pasteboard, plaster of Paris, silicate of sodium, tin (Levis), and aluminum (Elsberg). Avoid pressure over joints or bony prominences and particularly guard against tight or improper bandaging. In fracture of a bone of a limb the circulation in the fingers or toes must be observed as an index of circulation in the limb; hence leave those digits exposed. A retentive apparatus should prevent the redevelopment of deformity, and not be itself productive of pain or harm. For the first few days of treatment of a simple fracture the dressing (if not plaster or silicate) is to be removed every day, to make sure that deformity has not recurred, and if it does recur the fragments must at once be reset. The splints should be padded thoroughly, especially when over joints or bony prominences, and they should, if possible, fix the joints immediately above and below the break. A primary roller should not be used unless plaster of Paris is to be employed. By a primary roller is meant a bandage applied to the extremity before splints are placed upon it.

Some years ago Steinmann proposed to obtain extension in fractures by what is called *nail extension*. A steel wire nail is driven through the end of the lower fragment. This nail is used as a fixed body on which to set an apparatus for extension.

It can also be used to antagonize rotation. The nail is removed in from eighteen to twenty-one days. If it is retained longer it may produce pressure necrosis (Dyas in "Surgery, Gynecology, and Obstetrics," 1916, xxiii).

J. C. A. Gerster leaves it in from twenty-eight to thirty-five days ("Jour. Amer. Med. Assoc.," 1916, lxvii). Ransohoff devised tongs, the points of which catch in the femoral condyles, and Codavilla uses a pin for the same purpose.

There is no doubt that by this method powerful traction can be brought to bear exactly where it is needed. It is said to be safer than treatment by operation. I have never used the method. It seemed to me to possess some of the objections long ago filed against Malgaigne's hooks used for fracture of the patella. Blake, however, tells us that it is the most perfect of methods by which traction can be made upon the femur "because it permits the placing of the limb in an absolutely correct position and acts directly upon the fragment without fixing or injuring the knee. With it a weight of 6 kilos produces as much effect as 15 kilos attached by the ordinary adhesive bands. The objection to it is the fear of infection at the site of the pin or tongs, but present experience seems to prove that the tongs at least may be employed with impunity" (Lt.-Col. Blake, Ibid.).

Some surgeons at once apply an immovable dressing. This proceeding is safe in simple fractures without much displacement or soft-part injury. This dressing

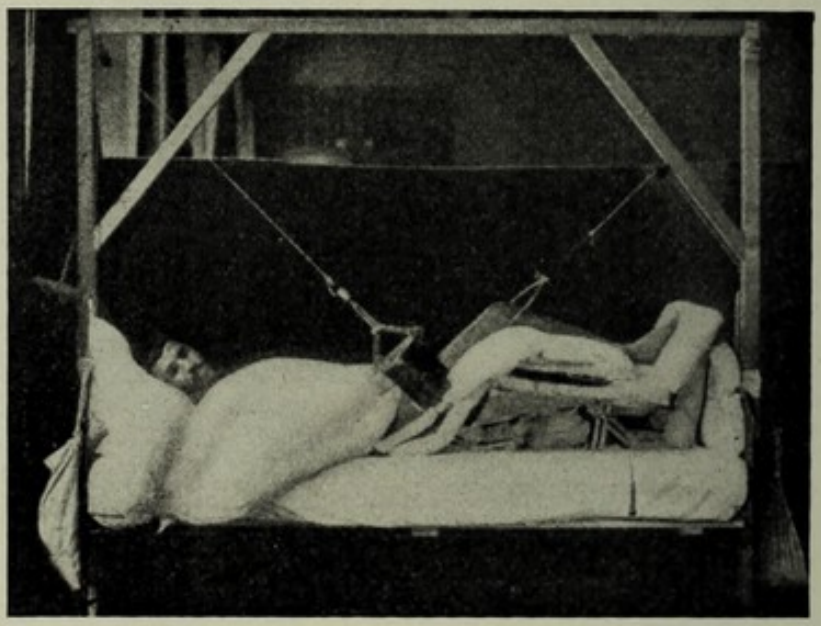


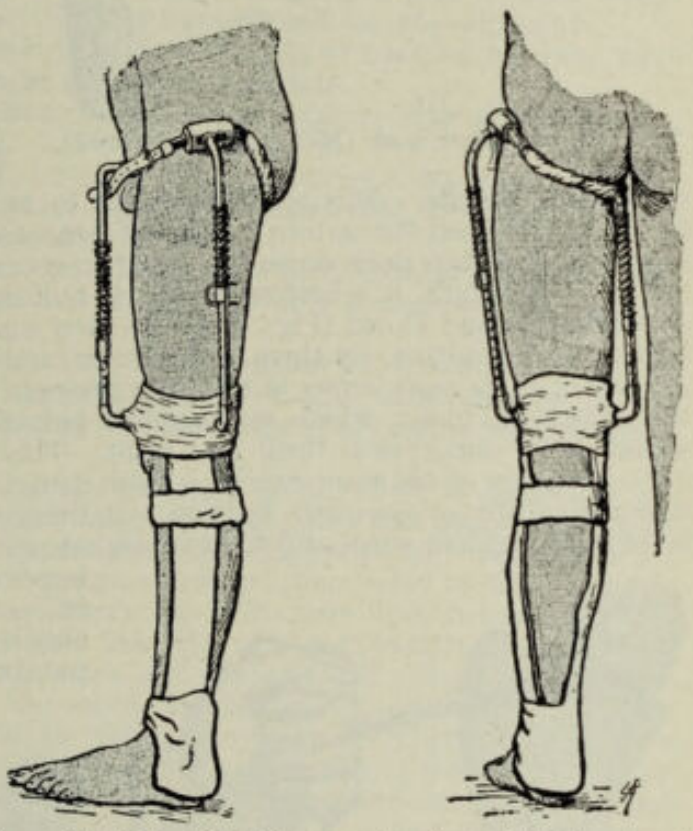
FIG. 311.—Showing the use of Steinmann pins in the treatment of multiple simple fracture of the middle third of femur (Fauntleroy).

is valuable in military practice, for the old and feeble whom we fear to put to bed, for the young who are very restless, and for the insane or the delirious. If, however, there is great deformity, much soft-part injury, or marked swelling, immovable dressings may induce sloughing, edema, gangrene, or faulty union. In the above-named cases use ordinary splints for the first few days; then, if it is desirable, the immovable dressing can be applied. Plaster-of-Paris bandages are used with great care in very young children, as gangrene might result from careless application. It is dangerous to keep old or feeble persons long in bed, as they are prone to develop bed-sores and hypostatic pulmonary congestion. The period for the artificial retention of the fracture varies with the seat of the fracture and the age and condition of the patient. Passive motion is to be made in most fractures in from two to three weeks, though it is sometimes made earlier to prevent ankylosis, and sometimes later because of risk of non-union. Landerer strongly advocates massage, believing that it hastens union and prevents wasting. He applies it as soon as there is no danger of the callus bending (in from eight to fourteen days). Massage should not be used when great edema points to the possibility of venous thrombosis. The movements might break up a clot and cause fatal embolism.[1] Very early massage may cause fat-embolism. In fracture of the patella wiring is frequently performed, and wiring or plating is frequently practised in fracture of the clavicle, fracture of the tibia, fracture of the upper third of the femur,

[1] Cerne's case in "Normandie med."; "Bull. med.," 1895, No. 44.

and other regions. If fragments cannot be approximated or retained by ordinary methods, an incision should be made, approximation effected, and the fragments retained by wire, a clamp, a plate, or a bone ferrule.

The plan known as the **ambulatory treatment** of fractures of the lower extremities has had warm advocates. The ambulatory splint is an apparatus which enables a man to walk about a few days after receiving a fracture of the leg or thigh. It was devised by Hessing, a carpenter dwelling in a village near Augsburg. Its aim is not only to get the patient about on crutches but also to cause him to use the limb. It is held that this plan of treatment greatly lessens the patient's sufferings and actually favors union by the stimulation of walking. Bardeleben, in his report to the German Surgical Congress, gave the records of 111 fractures of the lower extremity thus treated (77 simple and 12 compound fractures of the leg, 17 simple and 5 compound fractures of the thigh). The patients were gotten about a few days after the accident, were able to attend to business, had excellent appetites, digested their food perfectly, slept well, and were saved from muscular atrophy. Pilcher has warmly advocated the method. It can be used in fractures as high up as the middle of the femur. The apparatus which we should employ in the ambulatory treatment reaches below the sole of the foot, and is supported firmly above the seat of fracture, the weight of the body being transferred from above the fracture to the firm pad below the sole of the foot on which the patient walks. This appliance in a fractured thigh is put on about one week after the infliction of the injury. While the patient sits on the ischial tuberosities extension is made upon the leg. The seat of fracture is encircled by a thin plaster cast. The sole of the other foot is raised by a cork sole. Albers, when treating a fractured thigh, uses plaster of Paris strengthened by bits of wood, running from *below* the sole of the foot to the iliac crest. Krause says in fracture of the ankle carry the dressing to the head of the tibia; in fracture of the leg carry it to the middle of the thigh; in fracture of the lower end of the femur carry it to the pelvis.[1] Bradford warmly advocates the use of Thomas's splint often combined with plaster of Paris. During the last few years surgeons have come to recognize that ambulatory treatment must not be used for all fractures of the lower extremity and is only suited to selected cases. The ambulatory treatment is warmly commended by some military surgeons on the ground that it secures full return of function and also favors union of the bone and healing of the wound (Captain C. Max Page, R. A. M. C.). In fracture of the femur Delbet uses the apparatus shown in Figs. 312. 313. He gets his patients up and has them walking about a few days after the injury,



FIGS. 312, 313.—Delbet's apparatus for ambulatory treatment of fractures of the femur (Leriche).

Prevention and Treatment of Complications.—In every case of fracture of an extremity feel for the pulse between the periphery and the seat of injury in order to be sure the artery is not ruptured. If the soft parts are badly contused, try to prevent sloughing by employing rest and relaxation and by applying heat. If superficial sloughing occurs, treat antiseptically, remembering that even a superficial excoriation can admit bacteria which, carried by the blood or lymph, may infect the bones. If a slough leads down to the fracture, treat the case as a compound fracture. If there be great blood extravasation the danger is gangrene, and after fracture of the lower ex-

[1] "Centralbl. f. Chir.," vol. xxii, 1895.

tremity the foot of the bed may be elevated, or, better, after fracture of the upper or lower limb the extremity, to which splints and bandages are to be loosely applied, is to be raised and surrounded with hot bottles. If a bleb forms, it is to be opened with a clean needle and dressed antiseptically. If gangrene occurs, treat by the usual rules. Frequently after fracture of a bone blebs containing reddish serum form on the skin. The appearance of *blebs* when the circulation is good does not mean gangrene, and is not of any particular consequence. If blebs are distinct symptoms of circulatory impairment, gangrene impends or already exists.

Edema may be due to tight bandaging. If it is due to phlebitis, there is danger of pulmonary or cerebral embolism. In phlebitis elevate the limb slightly, remove all constriction, and employ locally ichthyol ointment; do not use massage, and give stimulants by the mouth. In edema due to weak circulation or venous relaxation use daily frictions and firm bandaging. If the fracture involves a joint, carefully adjust the fragments, make passive motion early, and inform the patient that he is in danger of a permanently stiff joint.

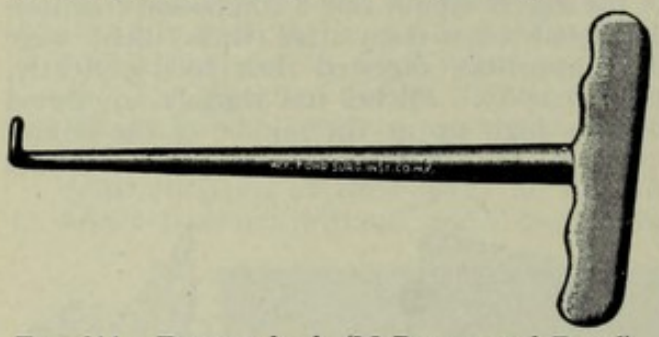


FIG. 314.—Fracture hook (McBurney and Dowd).

A *dislocation occurring with a fracture* is reduced at once if possible. To do this, splint the limb and give ether, and try to reduce while the limb is manipulated, using the splint as a handle. Allis was often able to reduce a dislocation accompanied by a fracture. He used the untorn portion of periosteum as a hinge, pulled upon the lower fragment, and thus drew down the upper fragment and pushed it in place by manipulation. If this fails, it is best to incise and pull the separated end in place by the hook of McBurney and Dowd (Figs. 314–316); but some surgeons say, get the bones in the best possible position, set them, await union, and then treat the unreduced dislocation. A *rupture of the main artery* of the limb presents the symptoms of absent pulse below the rupture, a tumor which may exhibit pulsation and possibly furnish a whirring sound or an aneurysmal thrill and bruit. This condition demands operation (page 377). *Rupture of the main vein* of a limb causes intense edema and calls for sutures, lateral ligature, or complete ligation. If these measures fail after injury of vein or artery, it is seldom successful to ligate higher up. Such a course might succeed in the upper extremity. It would almost certainly fail in the lower. Amputation will probably be necessary. If gangrene appears, amputate at once above the seat of the fracture.

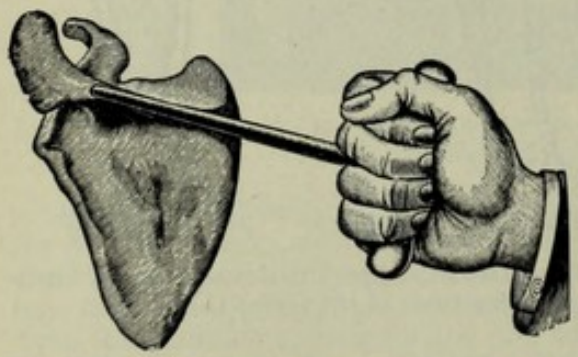


FIG. 315.—Fracture hook applied at base of acromion process (McBurney and Dowd).

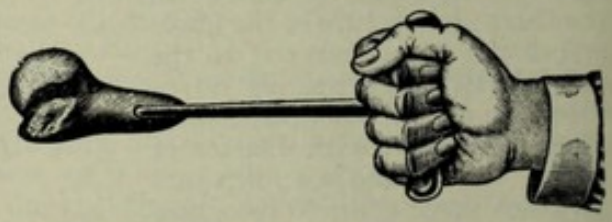


FIG. 316.—Fracture hook inserted in displaced fragment (McBurney and Dowd).

Inflammation is to be treated by compression, rest, moderate cold, and later by 50 per cent. ichthyol ointment. *Muscular spasm* requires morphin internally, firm bandaging, or even tenotomy. Fat-embolism is treated by stimulants and inhalation of oxygen, and possibly by artificial respiration. Shock, delirium tremens, urinary retention, etc., are treated according to the ordinary rules of surgery.

Functional Result of Non-operative Treatment.—Union with a good anatomic result means a good functional result in over 90 per cent. of the cases. We used to suppose that a good functional result is usual even with a poor anatomic result, but Sir Robert Jones ("Brit. Med. Jour.," Dec. 7, 1912) shows that we get it in less than 30 per cent. of cases in which the anatomic result is bad.

Treatment of Compound Fractures.—In a compound fracture of a limb the first-aid treatment consists in arresting hemorrhage temporarily by the elastic band, paint-

ing the wound and the skin about it with iodin, packing the wound and covering it with sterile gauze, applying a temporary splint for transportation, and adopting means for combating shock. During transport it may be necessary to administer morphin because of pain. If the bone projects do not restore it until the patient is on the operating table. As soon as possible give a prophylactic dose of antitetanic serum. The *x*-rays are of great value in determining the condition of bones in a crushed part. Thorough examination and satisfactory disinfection require the giving of ether, then the surgeon can determine whether or not amputation is necessary. The question is sometimes determined by the age and general health of the patient. When in doubt and the patient is a healthy young person, give the limb the benefit of the doubt and wait. It is needless to say that amputation is demanded when the limb is completely crushed or pulpified through its entire thickness. If the artery alone is ruptured, cut down upon it and tie both ends. If the vein alone is torn, suture it, apply a lateral ligature, or, if necessary, tie both ends. If the nerve is severed, suture it. If a joint is opened, drain and asepticize. W. L. Estes ("Jour. Amer. Med. Assoc.," 1914, lxii) from an experience of 800 cases reaches the following important and specific conclusions as to the indications for amputation:

1. If the skin has been so crushed or torn that it is obvious that at least three-fourths of the skin of the periphery and over the fracture will slough—amputate.
2. If the entire periphery of the limb at or near the site of fracture has been subjected to a destructive circular or annular pressure—amputate.
3. If there is much annular laceration of the skin and the muscles are also badly crushed or torn—amputate.
4. If the limb has been subjected to immense pressure (as by a car wheel) and the skin though intact is so completely cut off from nourishment that its doom is sealed, the muscles torn and the bone comminuted—amputate.
5. A nerve trunk can usually be sutured. If the chief blood-vessels are torn across in the usual jagged way either anastomosis or transplant will be useless, and the surgeon should amputate.
6. If the comminution is so extensive that the fragments are free and stripped of periosteum and the condition would demand the sacrifice of 3 inches or more of the shaft, and if (as is almost sure to be the case) there are extensive lacerations of muscles and skin—amputate.

If an attempt is made to save the limb, be ready at any time to amputate for gangrene, secondary hemorrhage (if religation at original point and compression high up fail), extensive cellulitis, and profuse and prolonged suppuration.[1] When it is determined to try to save the limb, the part must be cleansed thoroughly by the antiseptic method (in no injuries is this more important). In a fracture from indirect force, if a small portion of bone protrudes, cleanse the skin of the extremity and the protruding bone, push the spicule out a little more, and cut it off. If a large piece of bone is protruded it must not be cut away, but should be thoroughly disinfected, and after the skin wound has been enlarged should be returned into place. Hemorrhage requires a free incision to permit of ligation of bleeding points. In comminuted fractures loose splinters should be removed. Attached splinters covered by periosteum should not be removed. To remove them favors non-union. Drainage is not required unless the soft parts have been badly damaged. In a compound fracture from a crush the wound is grossly infected and débridement is necessary (page 229). After small and complete débridement drainage is unnecessary. After extensive or incomplete débridement use Carrel's tubes and Dakin's fluid and when the wound is sterile suture it. Personally I do not use bone plates in recent compound fractures unless the ends cannot be fixed without them. All hopelessly lacerated tissue is cut away, the wound is left wide open or is partially sutured, and Dakin's fluid is used (page 229). In some cases a counteropening must be made and the Dakin fluid used, as shown in Figs. 115–117. If circumstances do not admit of using the Carrel-Dakin treatment make a counteropening and pass a drainage-tube through the limb (Fig. 317).

An antiseptic dressing is applied, and the extremity is either subjected to extension or dressed with plaster. The plaster can be applied over a narrow strip of wood, trap-doors or fenestra being cut in the plaster before it sets (the *fenestrated splint*). The wound is then covered with gauze and a bandage.

The bracketed splint is a better dressing than the one just described. After the wound has been dressed with gauze, plaster is at once applied over the ends of brackets (Fig. 318). For fractures of the femur or the bones of the leg we may use a Thomas

[1] See Howard Marsh, on "Fractures," in Heath's "Dictionary of Practical Surgery."

traction splint or the Balkan frame, sling, and weights (Fig. 326). For the leg a Hodgen splint is satisfactory, the knee being slightly bent (Fig. 325). In some fractures of the humerus use suspension and traction. In others use a Thomas splint (Figs. 356 and 358). Some fractures of the forearm are treated by the Thomas splint, others by suspension, traction, and counterextension. The above methods not only immobilize the fractured bones, but keep the parts aseptic and afford easy access to the wound. If drainage-tubes are used they are usually removed, if suppuration does not occur, in from forty-eight to seventy-two hours. The wound is treated as any other wound. In some compound fractures it is found difficult or impossible to retain the fragments

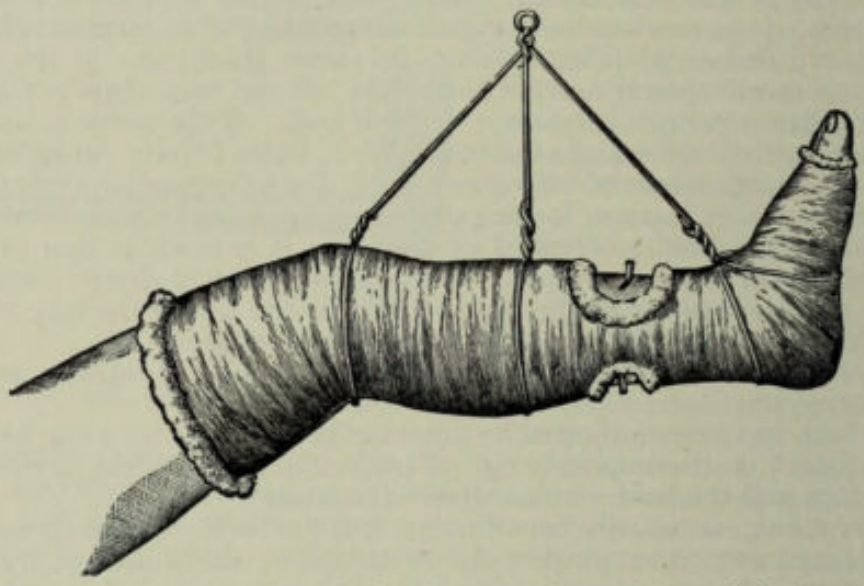


FIG. 317.—Fenestrated plaster-of-Paris dressing. Drainage-tube pulled through limb. This is only done when there is extensive damage or was incomplete débridement. If Dakin's fluid is used through-and-through drainage is seldom employed.

in apposition by splints or extension (lower end of femur, upper third of femur). In such cases the ends of the bone should be resected and the bones should be fastened together as in a case of ununited fracture, with silver wire, aluminum wire, chromicized catgut, kangaroo-tendon, or the bones should be plated. In a *compound fracture of the patella*, after free incision and disinfection, investigate to determine the gravity of the injury. In an ordinary case in which there are two or three fragments, open the joint, irrigate with saline fluid, drill the fragments, and fasten them with silver wire. Very small fragments should be removed. The wound is partially sutured, Carrel's tubes are inserted, dressings are applied, the limb is immobilized in extension, and Dakin's fluid is used. In a case of severe compound comminuted fracture of the patella, after disinfection, any completely loose piece should be removed and "the remaining portions made smooth with bone forceps and the sharp spoon."[1] The wound is only partially sutured, Carrel's tubes are inserted, dressings are applied, the limb is placed on a straight posterior splint, and Dakin's fluid is used. If a fracture of a rib is compound internally, resect the rib; if it is compound externally, dress antiseptically.

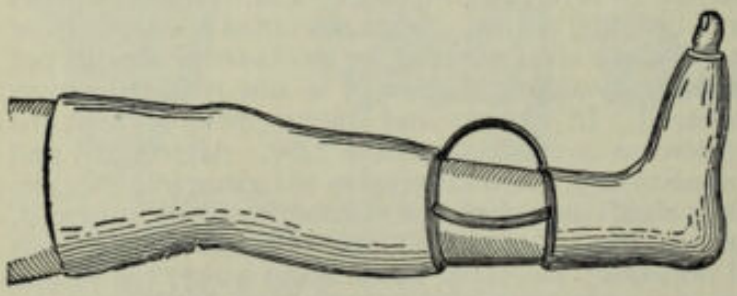


FIG. 318.—Bracketed plaster-of-Paris dressing.

Compound fractures may be followed by tetanus, gangrene, sloughing, periostitis, erysipelas, septicemia, pyemia, osteomyelitis, necrosis, etc. If cellulitis arises after a compound fracture, open freely, remove sloughs, and employ Dakin's fluid until suppuration is controlled. Many surgeons have opposed suturing after the abolition of infection of a compound fracture. Some do it. Morison, Good, and others, when suppuration has been controlled, proceed as follows: Cleanse the skin about the wound

[1] Lilienthal's "Imperative Surgery."

and also the wound. Dry the wound. Cover the wound and fill all pockets and bone cavities with "Bipp Paste" (bismuth, subnitrate, iodoform, and paraffin). Wring out gauze in liquid paraffin, put a quantity of "Bipp" in its center, and bring the gauze in contact with the entire wound surface. Dressings need changing only in from five to fifteen days. The infection soon becomes entirely local. Then the skin surfaces are brought toward each other by heavy mattress button sutures of silk, coated with "Bipp." In six or seven days much will be gained, and then new sutures are introduced and the skin edges curve nearer together. At each séance "Bipp" is introduced into the wound. The skin will require undercutting to prevent inversion. From time to time any loose bone fragments should be removed. (The above is taken from the "International Abstract of Surgery," Nov., 1918, which took it from F. B. Gurd's article in the "Lancet," 1918, cxciv.) Gurd treats sinuses by passive hyperemia. If that fails, he excises the scar, cuts away dead bone, introduces "Bipp," and inserts mattress-sutures.

Operative Treatment of Recent Simple Fractures.—Before the World War many surgeons were very radical, operating upon very many recent fractures. Since the war the teachings of Sir Robert Jones and the employment of the Thomas splint with extension have come to be valued properly. I think all of us have become more conservative. We now operate only on carefully selected cases. Very thorough *x*-ray studies are imperatively demanded. We have learned what surgeons of a former day knew, that is, that even great displacement or extreme overlapping can usually be corrected by manipulation and extension. In children and in old age conservatism is the rule. Excessive comminution is a contraindication to operation. Some cases are now operated upon immediately (within ten days of the injury). Others are operated upon at a later period than ten days after injury because non-operative methods have failed to obtain or to maintain good position (delayed operation). In some fractures reduction and fixation are only possible by operation.

Skiagraphs have demonstrated that the ordinary non-operative treatment is often followed by permanent displacement. In many cases this does not seriously impair function, in not a few it does. There is much impairment of function after fracture of the patella with wide gaping of the fragments, and after fracture of the femur with repair in a position of marked angulation or decided overlapping.

The most perfect results are obtained by an operation, which exposes the fracture and enables the surgeon to correct the deformity and fix solidly the fragments. Practically all surgeons agree that for fracture of the patella, fracture of the olecranon, and fracture of a long bone with incomplete reduction, or in which deformity recurs in spite of splinting, operation gives the best chance for a good functional result. In most fractures of long bones treated conservatively perfect apposition of the fragments is not obtained, although we may think it has been. Bloodgood points out that in fractures near joints there is great difficulty in reduction and little evidence of deformity.

The Special Committee of Inquiry of the British Medical Association in a recent report warmly advocates operation in many cases. Sir Robert Jones, of Liverpool, although believing as a general rule in non-operative treatment, says that if in any case there is sound reason to doubt the successful outcome of non-operative treatment, operation should be performed. He opposes waiting to see what happens because the delay may lose the chance of obtaining a good functional result ("Brit. Med. Jour.," Dec. 7, 1912).

Personally, I follow Sir Robert Jones's rule and operate when I fear that conservative treatment may fail. I operate primarily for:

Fractures that cannot be well reduced or which cannot be kept reduced. Many fractures about joints are of this character.

Fractures in which crepitus cannot be obtained because soft parts are caught between the fragments.

Transverse fracture of the patella.

Some fractures of both bones of the leg in the middle third.

Most fractures of the os calcis.

Some cases of Pott's fracture.

Most cases of fracture of the upper third of the femur.

Some fractures of the neck of the femur in the young and middle aged.

Some fractures of the surgical neck of the humerus.

Fractures of the olecranon, especially those in which the upper fragment has rotated.

Some fractures of the elbow-joint.

Some fractures of both bones of the forearm (in order to preserve pronation and supination).

Some fractures of the metacarpus.

Fractures of the zygoma.

Some few fractures of the mandible.

Fractures of the clavicle when complete reduction is impossible or when sharp-pointed fragments threaten to pierce the skin or damage important structures.

In compound fractures operation is necessary. If in any case of fracture an important nerve or blood-vessel has been divided an operation is necessary to arrest hemorrhage, to treat traumatic aneurysm, or to perform nerve suture.

Most children are manageable by conservative methods and do not do as well as adults after operation. Hence in children I am more conservative than in adults.

Again, do not forget that operation may not give a good functional result. It may fail to do so. If this is not well understood both the surgeon and patient may be disappointed after operation. There is, of course, some risk in the treatment by incision, and it is only justifiable in competent hands and amid proper surroundings, The occasional operator should look to it with less confidence than the daily operator. Infection is very rare when the operator is a well-trained surgeon, but if infection occurs it will be a catastrophe. The least it can do is to lead to non-union; it may cause osteomyelitis, necrosis, septicemia, or pyemia; it may make amputation necessary and may cause death, hence perfect asepsis is required imperatively. To fix the ends together loosely favors infection. To fix them together very firmly will lead to the formation of but a trivial amount of callus and hence favors non-union. Operation for recent fractures can never be routine treatment and will never be extensively employed outside of a hospital.

If operation is determined upon, the best period to select, unless some grave complication calls for haste, is from seven to ten days after the accident. This period is selected because the tissues are more resistant to infection than they are earlier. Great swelling calls for further delay, perhaps for three or four weeks. An incision is made, the bone is inspected, tissue intervening between the fragments is removed, and the deformity is reduced completely, largely by manipulation, partly by extension. Everything is done by means of instruments and the fingers are to be kept out of the wound. If there is no tendency to displacement after reduction, it is not necessary to fix the fragments with a plate. The bleeding is arrested thoroughly, the soft parts are sutured, dressings are applied, and the extremity is encased in plaster or suitable splints are used.

If the ends tend to displacement after coaptation, they must be fixed. Various plans have been employed. Those to be considered are wiring, band fixation, intramedullary pegs of bone or ivory, and plating. (See William Pearson in "Lancet," Jan. 19, 1924.) Metal bands are used for those rare cases of very "long oblique and spiral fractures for which operation is necessary" (Pearson, Ibid.). In transverse fracture with a strong tendency to lateral displacement a peg of bone may be used, one end being placed in the medullary canal of one fragment and the other end in the medullary canal of the other fragment. Such a peg is eventually absorbed. As a rule for fixation I prefer a plate.

Plates and screws are used by many. Wire used for fracture of a long bone acts as a hinge, and in a wired fracture the alignment is apt to be disturbed. Wire was first used for this purpose in 1775 by Lapeyode and Sicre, of Toulouse (George W. Guthrie, "Amer. Med.," March 7, 1903). It is now seldom used except for the patella, the olecranon, the clavicle, the zygoma, a condyle of the humerus, and the anatomic neck of the humerus. I prefer the steel plates of Arbuthnot Lane (Fig. 319) or the silver plates of Halsted. These plates are perforated for screws. The plate is not removed unless it loosens or gives trouble. Manipulations should be conducted with instruments, the fingers being kept out of the wound. After fixation hemorrhage must be arrested completely. The soft parts are then closed without drainage. If there is very great overlapping it is wise to employ extension for two or three days before operating. It is not proper to expose a fracture and reduce it by main force. (See directions given by Mr. Pearson in "Lancet," Jan. 19, 1924.) After operation the extremity must be carefully fixed by splints or plaster of Paris; the circulation must be watched, guarded, and maintained; massage should be used and passive motion be employed as in a case treated by the non-operative method. If rigid fixation of the fragments is obtained and maintained repair will usually occur with very little callus formation. Too firm approximation may be followed by so little callus formation

that there union is delayed or the fracture fails entirely to unite. In some cases the screws cause bone absorption and the plate loosens. Occasionally necrosis occurs. I agree with J. B. Lowmann ("Penn. Med. Jour.," 1915, xix) that in some cases plating prevents union. Months after operation the plate may be found to be loose and bent and the break entirely ununited.

In one of my cases of fractured femur the plate broke. Bone-grafting is seldom used in recent fractures. A graft is not firm enough to resist much force and will break if there is a strong tendency on the part of the fragments to bend, rotate, or override. We need fixation, not a method which has as its chief purpose the stimulation of bone production. Gallie uses a plate of boiled bone and screws of bone ("Canadian Jour. of Med. and Surg.," 1916, xxxix). It is seldom that a metal plate requires removal from the humerus or femur. It not unusually requires removal when applied to more superficial bones.

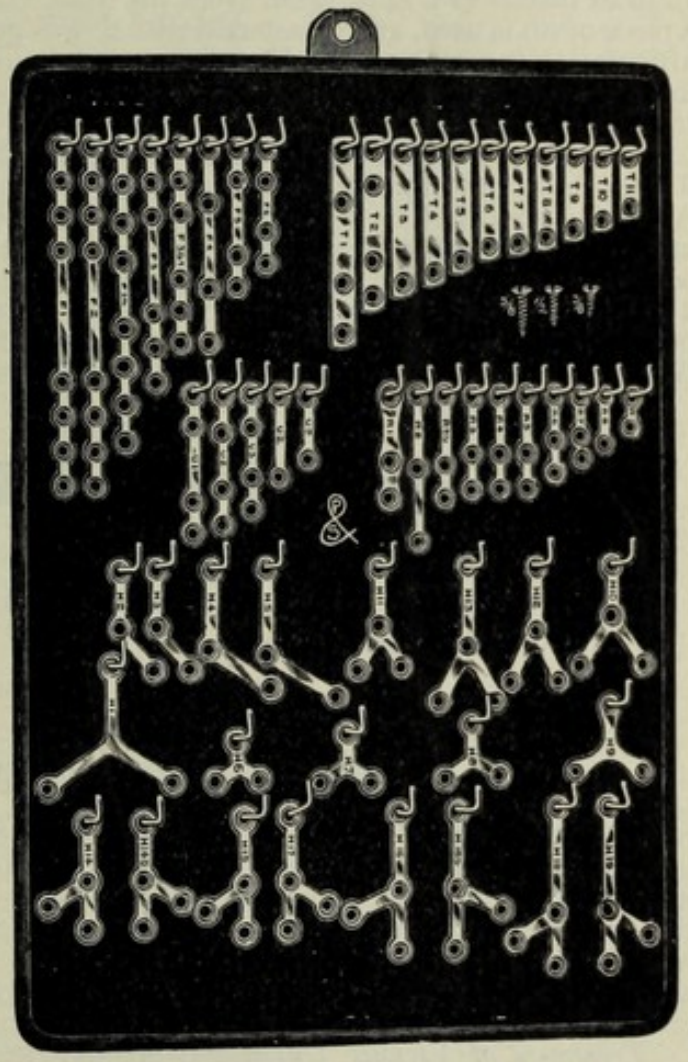


FIG. 319.—Lane's vanadium steel plates.

Treatment of Delayed Union and Ununited Fracture.—When delayed union exists, seek for a cause and remove it, treating constitutionally if required, and thoroughly immobilizing the parts by plaster. Orthopedic splints may be of value. Use of the limb while splinted, percussion over the fracture with a rubber hammer, and rubbing the fragments together, thus in each case producing irritation, have all been recommended. Blistering the skin with iodin or firing it has been employed. Buechner advocates the induction of hyperemia by a constricting band, just as Bier induces congestive hyperemia in treating tuberculous areas. At first the constriction is permitted to remain but a short time, the period is lengthened every day, until in a few days it remains almost continuously day and night. It is to cause a pinkish-blue flush of the skin, but not pain. The limb must be warm to the touch. During the two or three hours daily that the band is off raise the limb to relieve edema. Ten days of this treatment will inaugurate union in some cases. Helferich, of Greifswald, devised this method in 1887. In several cases I have thought that it did good. I also administered thyroid extract to these patients. Lannelongue and Menard inject a few drops of 1 : 10 solution of zinc chlorid between the fragments. I have had several successes with this plan. Leaving acupuncture needles in for days is approved by some, and electropuncture is advocated by others. Lisowskaja takes a piece of periosteum from the tibia, cuts it into small bits, puts them into normal salt solution, and injects the mixture between the fragments. Kauffer makes a mixture of pulverized bone and sterile petrolatum and injects it between the fragments. If the union be very long delayed, forcibly separate the fragments and put up the limb in plaster as we would a fresh break. If these means fail, irritate by subcutaneous drilling or scraping, or, better, by laying open the parts and then drilling and scraping at many places. Cases of ununited fracture must be treated by operation. We need stimulation of bone production. The fragments can be fastened together by Lane's plates, by screws and silver plates, by pins, by periosteal sutures, by wire (iron, silver, or aluminum bronze), by clamps, by bone-pegs, by bone-rings, or by bone-ferrules, but not one of these methods

stimulates bone formation. Delorme makes an incision, removes bone-splinters and fibrous tissue, smoothes off one end, forces this into the bored-out medullary canal of the other fragment, and sutures the periosteum, an unsatisfactory procedure. Gussenbauer's clamp and other bone clamps are no longer used.

The indication is to stimulate bone formation and the best operation is *bone-grafting*. We owe a debt of gratitude to Albee for what he has done to popularize and to improve the methods (Fred. H. Albee in "Annals of Surgery," vol. ii., 1921). Even when there is a considerable space between the fragments, as in many gunshot fractures, bone-grafting saves the limb from shortening. A bone-graft may be partially separated from one of the fragments and interposed between the freshened ends. A piece of bone may be taken from the sound tibia and be applied as a lateral graft (Albee's method). In most instances a graft is cut from the tibia. In some ununited fractures of the jaw a piece of rib is used, and is fastened with screws or nails. When the fracture is near the articulation it may be advisable to drive in a bone-peg. This will hold the fragments in apposition, although it has small osteogenetic value. It is always desirable to take the bone-graft from the individual. Such a graft is much more powerfully stimulating to bone growth than a graft from another individual or from one of the lower animals. Transplantation from the lower animals has, however, been successfully practised. Albee believes that in a recent fracture Lane's plates fulfil the indications, but in an ununited fracture they do not, because in the latter there is lessened osteogenetic activity. The bone-graft fixes the fragments, stimulates osteogenetic activity, furnishes a scaffold for bone growth, and also grows bone itself. A graft should contain periosteum to help vascularize the parts and to protect osteoblasts, compact bone to aid in fixation (it adds little to osteogenesis), and endosteum which

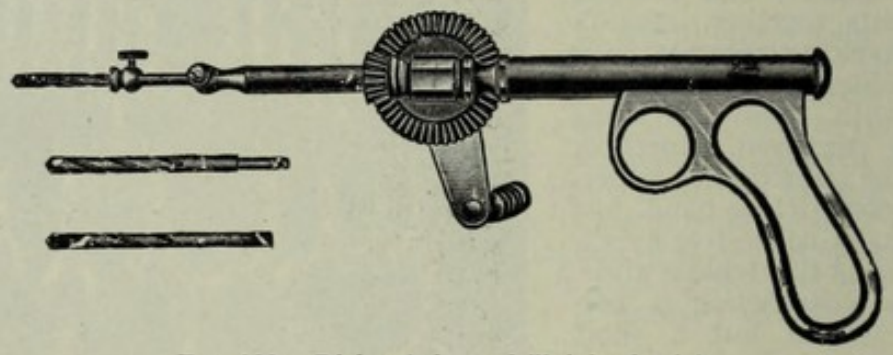


FIG. 320.—Richter's bone-drill (pistol grip).

contributes powerfully to osteogenesis (Pearson in "Lancet," Jan. 19, 1924). A large, lateral graft is usually the best for operation. As Pearson states (Ibid.), a graft may withstand a mild infection and success depends to a great degree on "accurate coaptation, wide contact, and firm fixation between graft and recipient bone." For further remarks on operation see Operation on Bones. For an ununited fracture near an articulation it may be desirable to use a bone-peg to forcibly impact the bones, or even to do a resection.

Treatment of Vicious Union.—If angular deformity results from faulty union, it can be corrected by molding the part into shape while the callus is soft. If the callus has become hard, the bone can be refractured. If faulty union occurs with marked overriding, angulation, or rotation, an osteotomy can be performed (see page 650).

Gunshot Fractures.—Of course, simple fractures occur in war, but they present nothing peculiar. Compound fractures are extremely common and are frequently fatal. We have already set forth the difference between a bone wound and a gunshot fracture (page 471).

Leriche points out that a missile may fracture a bone (impact), may fracture it and lodge (penetration), may fracture it and pass through (perforation). Gunshot fractures are regarded as certainly infected except some fractures due to rifle or shrapnel bullets, infection being brought about by a contaminated projectile or by a bit of clothing or other foreign body which was carried in. Bits of clothing are particularly apt to be carried in by shell fragments. All sorts of breaks may occur. Comminution is the rule except in fractures by impact. A rifle bullet striking point ahead is apt to split a bone, but it may only cause comminution. A rifle bullet striking side on causes comminution like a shell fragment. In fractures due to shell fragments the bone is comminuted extensively and the soft parts are badly damaged, and, as Blake

and others point out, the tissues for some distance wide of the lacerations are in a state of lowered vitality because of tissue shock. Military surgeons dwell on the frequency with which bone fragments are driven widely before the missile, causing pulpification of muscle and perhaps a huge wound of exit.

Blake ("Gunshot Fractures of Extremities") says that in many thigh fractures in which the wounds of entrance and of exit are small, incision makes evident a great area of pulpy muscle, strewn with bone fragments. In shell wounds the bones and soft parts are damaged more gravely than is commonly seen in the compound fractures of civil life. A great deal of tissue is not quite dead, but is on the verge of death. Such tissue serves as a luxurious breeding-place for bacteria. Captain Basil Hughes, R. A. M. C., calls attention to the facts that amputation performed through such tissue does not cause pain, and that the use of a rubber tourniquet or the application of a powerful antiseptic causes the death of such decadent tissue ("Brit. Med. Jour.," March 3, 1917).

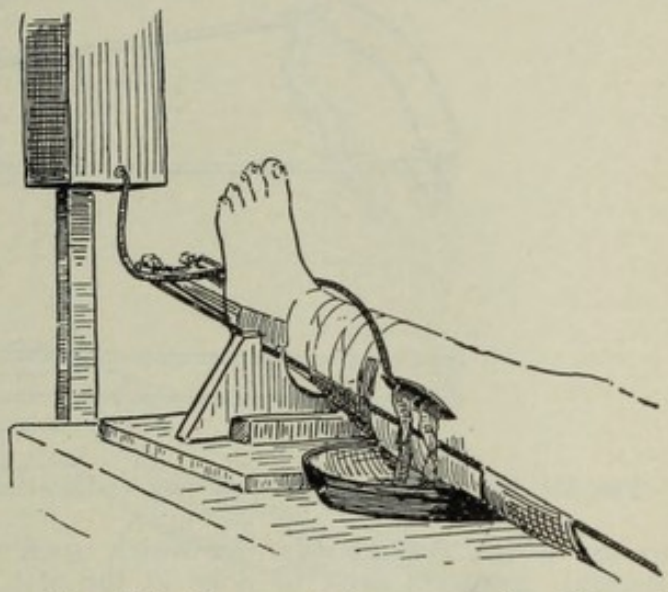


FIG. 321.—Compound fracture of the tibia and fibula. The Thomas splint is supported by a bracket in order to suspend the leg. Continuous irrigation apparatus and bandage drains are in use (Hull).

The wounded man is gravely shocked and is predisposed to infection because of this damaged tissue and his fatigue and exposure. Transportation is a great strain and radical treatment may be long deferred.

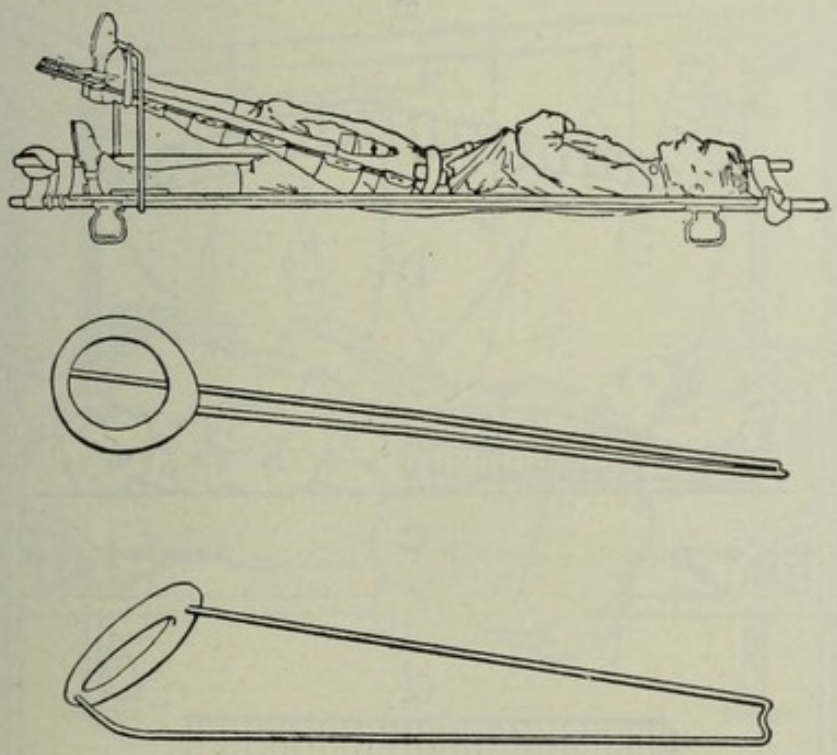


FIG. 322.—Thomas traction leg splint (Osgood).

Usually at the first-aid station iodin is painted on the parts, an antiseptic dressing is applied, the limb is fixed in an emergency splint, and antitetanic serum is given. A large T is written on the forehead with iodin or an anilin pencil to show that antitetanic serum has been given. A tourniquet is seldom applied in a case of gun-

shot fracture. Few persons will bleed to death for want of it. Many will develop gangrene if it is used. The patient is then transported to the rear. Attempts at immediate sterilization were not successful in the World War, a notable contrast

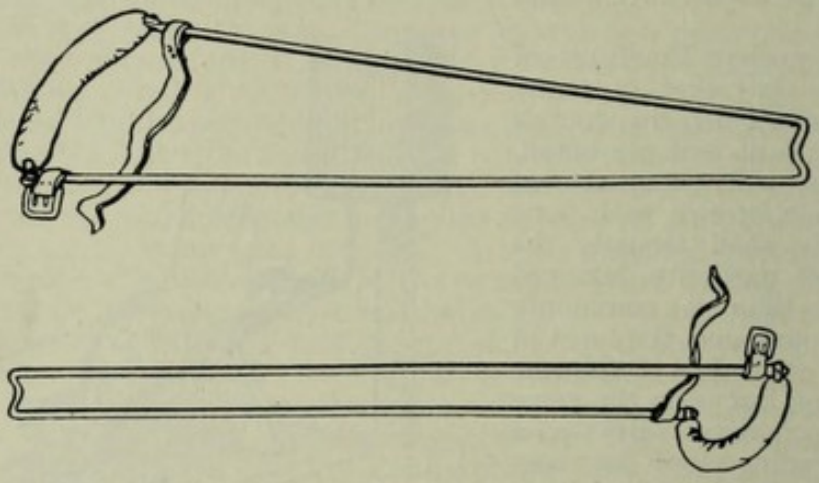


FIG. 323.—Blake-Keller hinged half-ring modification of Thomas traction leg splint (Osgood).

to the South African War, in which such treatment proved very serviceable. Radical operation must be done at the first possible moment. In trench warfare it may be possible to apply it at a first dressing station. It may be done at the field hospital, at the evacuation hospital, or, in some unfortunates, at the base

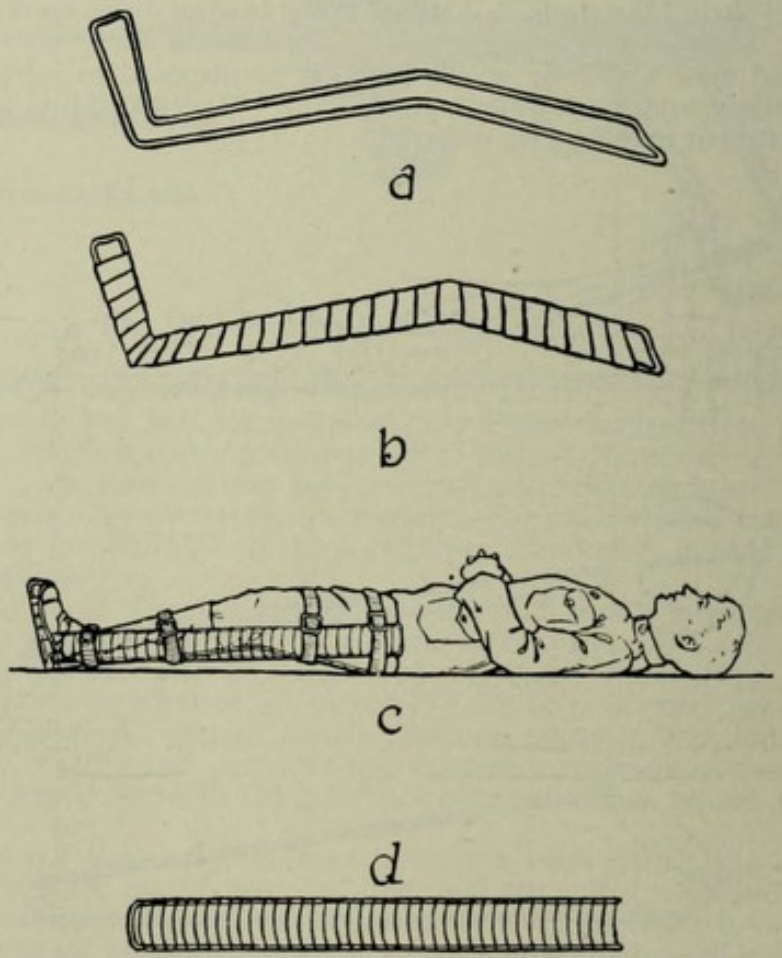


FIG. 324.—Cabot posterior wire splint (*a*) in skeleton, (*b*) bandaged, (*c*) applied with side splints of ladder material; (*d*) ladder splint material (Osgood). This is very useful for transport.

hospital. The rule should be to do it at the earliest possible minute. The danger of gas gangrene, tetanus, and sepsis is intensified by every minute of delay. During transportation pulmonary embolism may arise, there may be hemorrhage.

shock may be aggravated, insecurity of fixation may lead to tearing of the tissue by the bone ends and to the dissemination of infection (Hughes, Ibid.). Some cases require immediate amputation. Most cases in which tourniquets were in use for a considerable time require amputation (Hughes, Ibid.). The treatment for

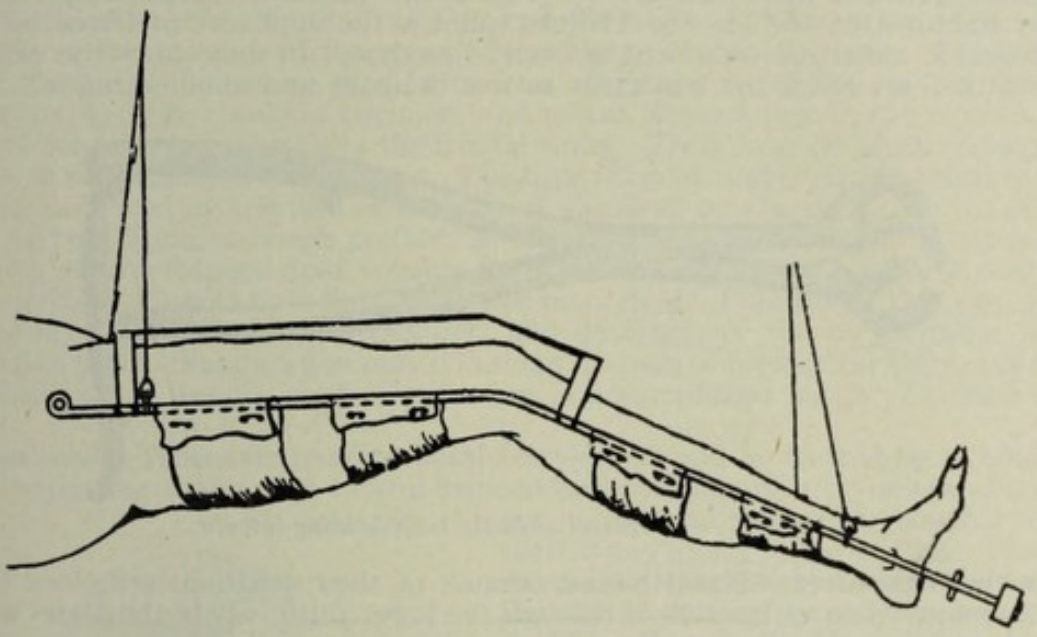


FIG. 325.—Modified Hodgen's splint.

the average case which does react from shock is: give an anesthetic, shave the skin, clean the parts with gasoline, and paint with iodin. Make a free incision, remove foreign bodies, remove bone fragments which are entirely loose or which are stripped

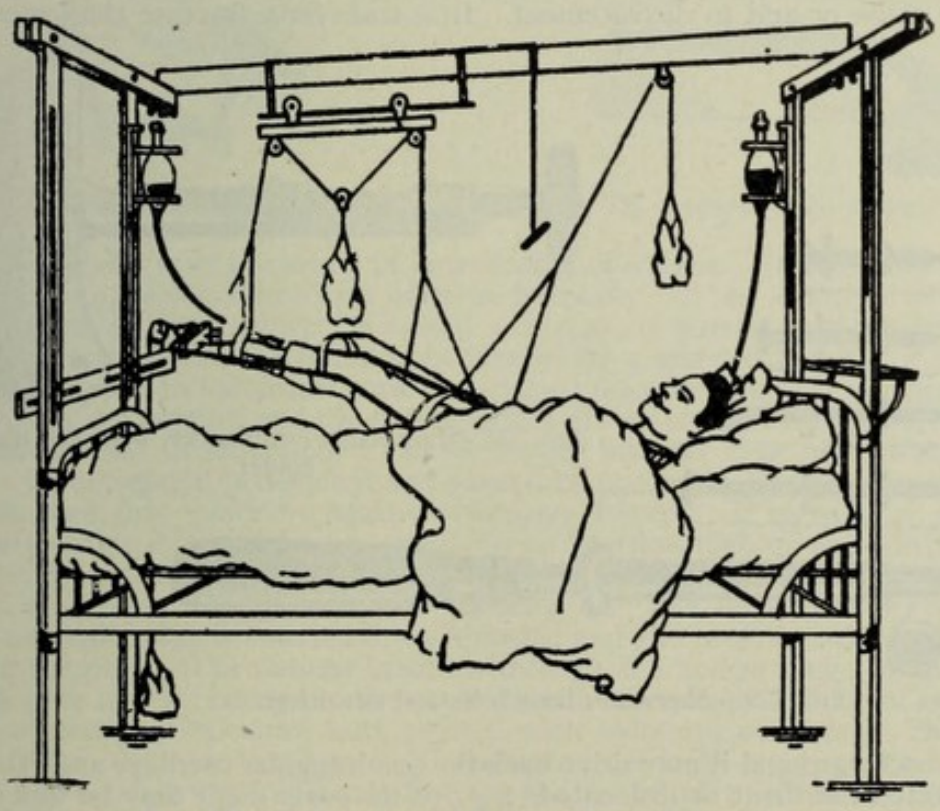


FIG. 326.—Balkan frame for suspension and extension.

of periosteum, and excise freely damaged tissue. The wound is left open. It is not the custom to close compound fractures without drainage. Tubes are inserted, Dakin's fluid is introduced, dressings are applied, and the limb is immobilized in the form of splint obtainable and best suited to the case. Suspension with extension (Fig. 326)

is praised by many surgeons. Some prefer plaster. The special splints are legion. A treatise is necessary to discuss gunshot fractures, and that treatise must be written by a military surgeon. Figures 321–325 and 356–361 show some of the many apparatus employed. In fractures through or near the hip-joint the abduction frame of Sir Robert Jones is most satisfactory (Fig. 424). In other fractures of the femur and in fractures of the leg the Thomas splint is the appliance preferred by many. The desirable antiseptic treatment is Carrel's method. In some cases the exigencies of the situation restrict the treatment to free drainage and immobilization.

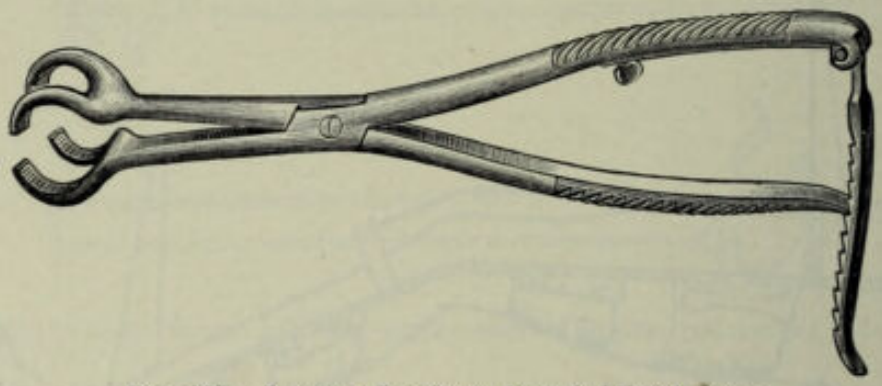


FIG. 327.—Lowman-Lambotte bone-holding forceps.

Special Fractures.—Nasal bones, because of their situation, are often broken. The commonest seat of fracture is through the lower third, where the bones are thin and lack support. The fracture is usually compound externally or through the mucous membrane internally. There may be a transverse fracture or a comminuted fracture. The *cause* is direct violence. Displacement may not occur at all, but when present at once after injury it arises directly from force, and never from muscular action, no muscle being attached to these bones. If the force is from the front, the nose is flattened; if from the side, it is deflected. Manipulation, blowing the nose, or sneezing, may cause or add to displacement. In a transverse fracture the lower fragment



FIG. 328.—Lowman's combination bone and plate holder.

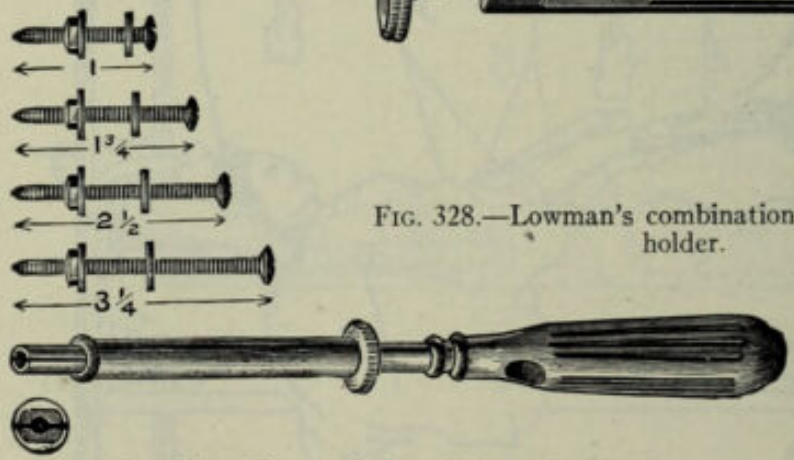


FIG. 329.—Sherman's bone bolts and nut-driver.

is driven backward and it may drive back the quadrangular cartilage and "the cartilage may be fractured, bent or dislocated, . . . or its lower angle may be torn loose from the membranous portion of the septum, or from its connection with the maxillary bones at the anterior end of the vomer" ("Fractures" by Roberts and Kelly). Side blows may luxate one or both nasal bones. A blow from in front may luxate one or both bones from the frontal bone. Displacement is soon masked by swelling. Crepitus can sometimes be elicited by lightly grasping the upper part of the nose with the fingers of one hand and moving that feature gently below from side to side with the

fingers of the other hand. Preternatural mobility is valueless as a sign because of the natural mobility of the cartilages. Nose breathing is difficult because of blocking of the nostrils by blood-clot. When deformity is absent, diagnosis, except by the *x*-rays, may be almost impossible.

The complications that may be noted are cerebral concussion, brain symptoms from implication of the frontal bone or cribriform plate of the ethmoid bone, and extension of the fracture to the superior maxillary or lacrimal bones. The vomer or the nasal spine of the frontal may be broken. Emphysema of the root of the nose, the eyelids, and the cheeks is common, and means either a rent in the mucous membrane of Schneider or a crack in the frontal sinus. There may be much discoloration because of subcutaneous hemorrhage. Epistaxis is usual, and is distinguished from the epistaxis produced by fracture of the base of the skull by the facts that the bleeding in the first condition, although profuse, is, as a rule, soon checked, and is not followed by oozing or cerebrospinal fluid, whereas in the second condition it is profuse, continued, and is perhaps followed by a flow of cerebrospinal fluid. Fracture of the bony septum occasionally complicates nasal fractures, and deviation of the cartilaginous septum often takes place. Suppuration may occur and necrosis of bone or cartilage may follow. The prognosis is usually good if reduction is accomplished early. Fixation occurs soon.

Treatment.—Whenever possible nasal fractures should be treated by a rhinologist. After cocainizing the nares a careful inspection should be made by means of a mirror and a light to determine whether or not there is any injury of the septum. This point must be determined in order that the deformity of the septum may be corrected at the same time as the deformity of the nasal bones. When there is no displacement, or when a displacement does not tend to be reproduced after reduction, employ no retentive apparatus of any kind. Order the patient not to blow his nose for ten days



FIG. 330.—Mason's pin.

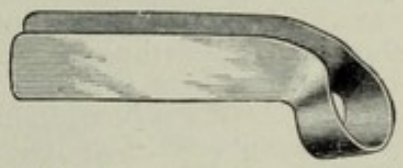


FIG. 331.—Jones's nasal septum splint.

and syringe it daily with a solution of bicarbonate of sodium. If deformity be noted, correct it at once, as the bones soon unite in deformity. If the attempts at reduction are very painful, or if the subject be a child, a woman, or a nervous man, give ether to obtain primary anesthesia. Reduction is effected by a grooved director or steel knitting-needle wrapped in iodoform gauze and passed into the nostril; the fragments are lifted with this instrument, and the fingers externally mold them into place. A rubber dilator can be used in reduction. This is pushed into the nose and inflated by air or water. If the septum is deviated and cannot be pushed in place by a metal sound, it must be bent into place by means of septum forceps. If bleeding is moderate, check it with cold; if severe, by plugging. "For fractures high up with displacement, gauze packing carried well up will be required to retain the elevated bones. For lower deviations the Asch tube will be needed" (Scudder on "The Treatment of Fractures"). A hollow vulcanite plug is inserted in each nostril and the nose is molded into correct shape over the plug. The patient breathes through the hollow plug. A thread runs from each plug and is fastened to the cheek by adhesive plaster. Once or twice a day the plugs are removed, cleaned, and greased with iodoform ointment. The nose is cleared and the plugs are reinserted. If flattening tends to recur, pass a Mason pin (Fig. 330) just beneath the fragments, through the line of fracture and out the opposite side. Steady the fragments by a piece of rubber externally caught on each end of the pin, or with figure-of-8 turns around the ends with silk. Leave the pin in place for five days. The instrument of Mason is a sharp, strong, nickel-plated pin, with a triangular point.

If lateral deformity tends to recur, hold a compress over the fracture or fix a molded-rubber splint over the nose by a piece of rubber plaster 1½ inches broad and long enough

to reach well across the face, and use compression for ten days. In neither of the above cases is the nose to be blown, and in both cases it is to be syringed once or twice a day. In fractures rendered compound by tears in the mucous membrane, irrigate with normal salt solution or boric acid solution, holding the head so that the solution will not run into the mouth; plug with iodoform gauze around a small rubber catheter, which instrument permits nose breathing; carefully remove the gauze daily and syringe. In fractures compound externally cleanse externally, antisepticize with iodin, and dress with a film of cotton soaked in iodoform collodion or compound tincture of benzoin, or apply sterile gauze. Fractures of the bony septum, if showing a tendency to reproduction of deformity, require packing as above explained, or the use of a special splint within the nostrils (Fig. 331), or the application of vulcanite plugs, so made that the patient can breathe through them and threads can be attached to them. Fractures of the nasal cartilages are to be pinned in place. Fractures of the nose are entirely united in from ten to twelve days. If an unreduced fracture unites in deformity osteotomy and refracture is the only resource. If bone and cartilage are involved in a lateral deformity the septum is usually deviated. In such a case a septal deviation should be amended by submucous resection and the cartilage deviation be corrected by intranasal surgery.

Fractures of the Lachrymal Bone.—The lachrymal bone may be broken when the nose, a superior maxillary bone, or the lateral plate of the ethmoid is fractured. Union is solid in from three to four weeks. The question of how much deformity is to be expected is always uncertain, and in not a few cases obstruction of the nose follows fracture because of damage to the septum.

Treatment.—Treat the chief injury, which is the fracture of the other bone or bones. Maintain the patency of the lachrymal duct by frequently passing a clean probe.

Fractures of the Superior Maxillary Bone.—Although a fragile bone, the superior maxillary is rarely broken except through the alveolar border. It may be broken by transmitted force from blows on the chin, or on the head when the chin is fixed; but direct violence is the usual cause. The walls of the antrum may be crushed in, the palatine process or the nasal process may be broken, transverse fracture may occur, there may be intermaxillary separation, or separation of the alveolar process. Comminution may exist. Fracture of the orbital surface is a not uncommon result of a gunshot wound. If the causal force has been very violent, the line of fracture may extend into the base of the skull. Comminution is the rule, and the injury is often compound. These fractures induce great swelling, pain, asymmetry, and inability to chew. Mobility and crepitus may be detected. Deformity is due to the breaking force and not to the action of any muscle. When a portion of the alveolar arch is fractured, as may occur in pulling teeth, the small fragment is depressed backward, and there exist irregularity of the teeth (some of which may be loosened) and inability to chew food. Fracture of the nasal process is apt to injure or cause pressure upon the lachrymal duct. When the antrum is broken in there are great sinking over the fracture, depression of the malar bone, and if the mucous membrane has been torn, emphysema. Transverse fracture of the upper part of the body of the bone may cause no deformity. The force required to break the superior maxillary bone is so great that fractures of other bones almost certainly occur, and concussion of the brain not infrequently exists. Injury of the infra-orbital nerve is not unusual, causing pain, numbness, or an area of anesthesia involving one-half of the upper lip, the ala of the nose, and a triangle whose base is one-half of the upper lip and whose apex is the infra-orbital foramen. There is also loss of sensation in the gums and upper teeth of the injured side. Orbital fracture causes subconjunctival ecchymosis. Fractures of the superior maxillary bone occasionally induce fierce hemorrhage from branches of the internal maxillary artery; and if this has happened, be on the watch for secondary hemorrhage (these vessels being in firm canals).

Treatment.—If the fracture does not implicate the alveolus, or if no deformity exists, apply no apparatus, but feed the patient on liquids for four weeks. Reduce deformity, if it exists, by inserting a finger in the mouth. If the antrum is broken in, put the thumb in the mouth and push the malar bone up and back. In certain cases of deformity make an incision at the anterior border of the masseter muscle, insert a tenaculum or aneurysm needle, and pull the bone into place (Hamilton). If the malar bone or malar process is driven into the antrum, Weir tells us to incise the mucous membrane above and external to the canine tooth of the upper jaw, break into the antrum with a bone-gouge, insert a steel sound, lift out the malar bone, and

pack the antrum with gauze. Loose teeth are not to be removed, but are to be pushed back into place and held by wiring them to their firmer neighbors. Hemorrhage is arrested by cold and pressure. If hemorrhage is dangerously profuse or prolonged, tie the external carotid artery.

If the line of the teeth, notwithstanding the wiring, is not regular, mold on an interdental splint. The usual splint for the upper jaw is the lower jaw held firmly against it by the Gibson, the Barton, or the four-tailed bandage, but this is to be regarded as a purely temporary dressing, if the line of the teeth is uneven. There is a great amount of dribbling of saliva during the treatment, and a dressing must be used to catch this fluid. Every day remove the bandage and dressing, and wash the face with soap and water. The patient, who is ordered not to talk, is to live on liquid food administered by a nasal tube or by pouring it into the mouth back of the last molar tooth by means of a tube or a feeding-cup. Never pull a tooth to obtain a feeding space; but if a tooth is lost, utilize the vacant space for this purpose. After every meal wash out the mouth with peroxid of hydrogen, followed by chlorate of potassium, boric acid, or normal salt solution, and thus prevent foulness and the digestive disorders it may induce. Dispense with the dressings in four or five weeks, and let the patient gradually return to ordinary diet.

In fractures compound externally do not remove fragments, antisepticize by dichloramin-T, arrest bleeding as far as possible by ligature, by pressure, or by plugging, wire the fragments if feasible, dress with gauze, and wash the mouth with great frequency. Fractures compound internally are treated as simple fractures, except that the mouth is washed more frequently.

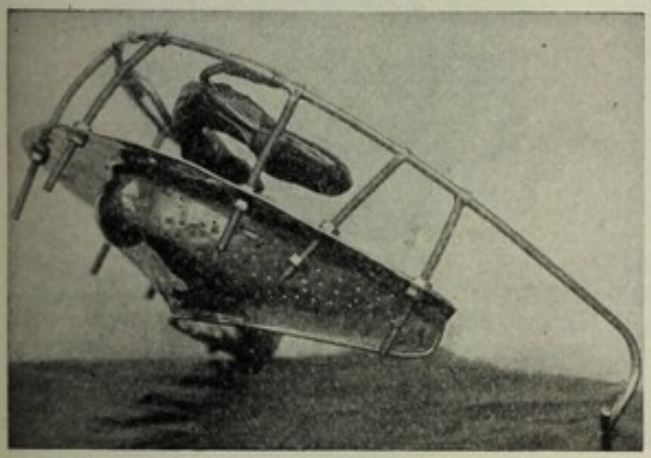


FIG. 332.—Hard-rubber splint; wire arms and chin-piece held together by metal rods and nuts.

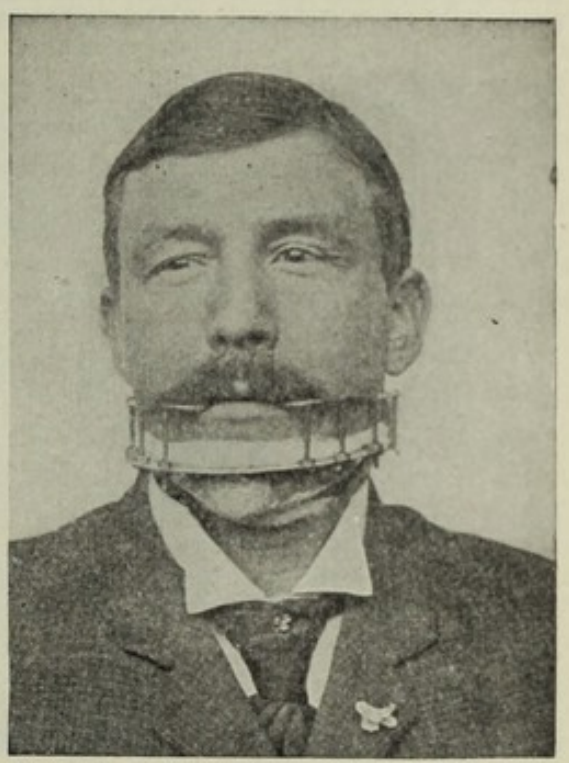


FIG. 333.—Front view of splint (Fig. 332), with mouth closed (Moriarty)

The **malar bone** is rarely broken alone. Hamilton says no uncomplicated case is on record. The malar is a strong bone resting on a fragile support, and hence it may become a wedge to break other bones and yet itself be unfractured. The *cause* of fracture is violent direct force. A fracture of the orbital surface of this bone causes subconjunctival hemorrhage like that encountered in fracture at the base of the skull, and may produce irritation of the infra-orbital nerve. Protrusion of the eye may result either from hemorrhage or from crushing in of the malar bone. There is a hollow below and to the outer side of the orbit. Occasionally the line of fracture is detectable, but mobility and crepitus are very rarely discoverable. Chewing is apt to cause pain, and often the motions of the lower jaw are limited, the coronoid process being pressed upon by a depressed malar bone, an associated fracture of the zygoma, a blood-clot, or swollen tissue (see Scudder on "Treatment of Fractures").

Treatment.—If no deformity exists, there is practically nothing to be done. If deformity exists, try to correct it as in fractures of the superior maxillary bone. If correction is impossible by ordinary methods and the movements of the lower jaw are impeded by the displaced bone, make a small incision and through this insert an instrument and endeavor to lift the bone into place. As these cases are almost invariably

complicated by fracture of the upper jaw, they are treated in the same manner as the latter injury. The union is complete in three weeks.

Fractures of the zygomatic arch are very rare. The *causes* are: (1) direct violence; (2) indirect force (from depression of the malar), and (3) forcing foreign bodies through the mouth. Direct violence is the usual cause. Direct violence causes inward displacement, and indirect force may cause outward displacement. The usual seat of fracture is at the smallest portion of the process—that is, on the temporal side of the temporomalar suture (Matas). The symptoms are pain, ecchymosis, swelling, displacement, and difficulty in moving the jaw (because of injury to the masseter muscle).

Treatment.—In simple fracture give ether and try to push the arch into place. Many surgeons do not make an incision, as depression will do no harm and the functions of the jaw will be restored. Simply dress with a compress, adhesive strips, and the crossed bandage of the angle of the jaw. Union will take place in three weeks. Matas[1] advises operation. An anesthetic is administered and the parts are antisepticized. A long semicircular Hagedorn needle threaded with silk, is entered 1 inch above the middle of the displaced fragment, is passed well into the temporal fossa, and is made to emerge ½ inch below the arch. The silk is used to pull a silver wire around the fracture, and this wire is employed to pull the bone into position. A firm pad is applied externally and the wire is twisted over the pad. Antiseptic dressings are applied and on the ninth or tenth day the wire, splint, and dressings are removed permanently. I have employed this plan in 2 cases, with perfect satisfaction.



FIG. 334.—Hard-rubber splint in position, upper teeth resting upon it (Moriarty).

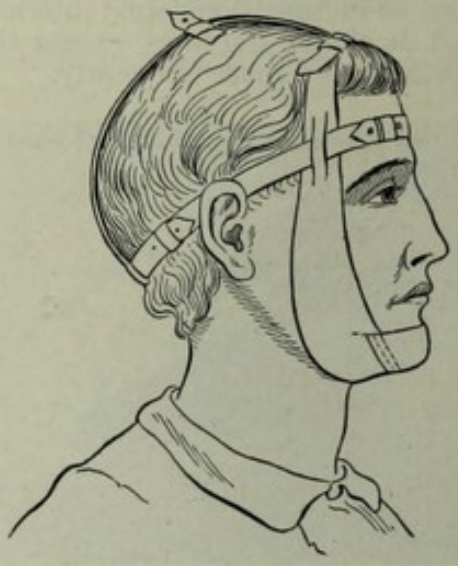


FIG. 335.—Hamilton's bandage.

Fractures of the inferior maxillary bone (the *mandible*) may, and usually do, involve the body, although they occasionally occur in the ramus. Fractures of the coronoid process and condyle are very rare. Any part of the body may be fractured, the most usual seat being near the canine tooth or a little external to the symphysis (Pick). A portion of alveolus may be broken off. In fractures of the ramus either the angle, the condyloid neck, or the coronoid process may be broken. In fractures of the body the posterior fragment generally overrides the anterior. Fractures of the lower jaw are often multiple and those of the horizontal portion are almost always compound through the mouth, because the oral mucous membrane and alveolar periosteum are torn. They are sometimes compound by way of a skin wound. Fractures of the ramus, of the condyle, and of the coronoid are seldom compound. A portion of the alveolus may be broken during the extraction of teeth. The *cause* is usually direct violence, as a blow, a kick, a fall, or a gunshot wound. Indirect violence (lateral pressure) may fracture the body at or near the symphysis. Fractures near the angle are always due to direct violence. Indirect violence may fracture the neck of the condyle (falls on the chin), and so may direct violence. Fractures of the coronoid process

[1] "New Orleans Med. and Surg. Jour.," Sept., 1896.

are very rare, and they arise from great direct violence (usually a gunshot wound or some other penetrating force) or by muscular action (violent contraction of the temporal muscle). Comminuted fractures are rare. Multiple fractures are by no means unusual.

Symptoms.—In fracture of the body pain, preternatural mobility, and crepitus generally exist. The gum over the fracture swells rapidly and decidedly. There is bleeding because of laceration of the gum; the gum swells, the face swells, swallowing becomes painful, saliva dribbles constantly; the patient supports the jaw with the hand; great pain exists (possibly from injury of the nerve), and deformity is present, shown by inequality of the teeth if the fracture is anterior to the masseter, the anterior fragment going downward and backward and the posterior fragment going upward and forward. The downward displacement is due to muscular action (action of the digastric, geniohyoid, and geniohyoglossus). The backward displacement is due to the violence. The temporal, internal pterygoid, and masseter muscles draw the posterior fragment upward and to the front. In a fracture of the lower jaw at any point below the orifice of the dental canal the nerve will be more or less injured and examination will discover areas of anesthesia on the skin of the chin, on the side of the cheek, on the inner surface of the lower lip, and on the buccal surface of the gum. These areas represent the trajectory of the mental branch of the inferior dental division of the inferior maxillary nerve (Imbert and Gauthier in "Paris Médicale," Jan. 20, 1917). Two or three days after fracturing the jaw the submaxillary and cervical lymph-glands enlarge. When a fracture of the lower jaw is compound internally, suppuration usually takes place and the odor of decomposed pus and food fragments becomes marked. In fracture of the neck of the condyle the jaw is drawn toward the injured side, and the condyle is pulled inward and forward by the action of the external pterygoid muscle. In fracture of the coronoid process the temporal muscle pulls the small fragment upward.

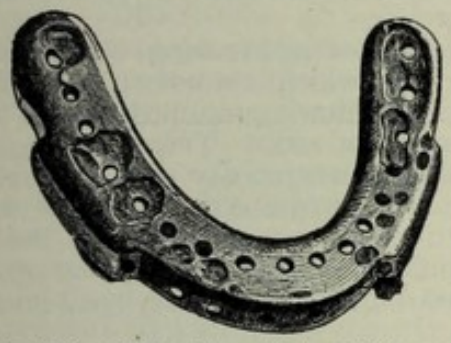


FIG. 336.—Vulcanite splint with boxes vulcanized on each side. If the jaw is fractured in the region of the molars, considerable pressure is required to get the parts in position; therefore it is best to vulcanize on to the sides of the vulcanite splint boxes into which wire arms can be inserted (Pilcher).

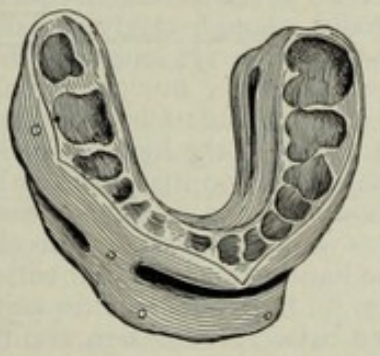


FIG. 337.—Interdental splint.

The *complications* are: digestive disorders and diarrhea from swallowing foul discharges; loosening of the teeth; lodgment of loosened teeth between the fragments; bleeding (usually only oozing from the gum, but there may be hemorrhage from the inferior dental artery), and suppuration. Necrosis may follow these fractures, an abscess of the neck may develop, or a sinus may form.

Treatment.—The advice and aid of a dental surgeon are invaluable. Correct deformity with great care and be sure to bring the teeth into normal alignment. In fracture of the body, as a rule, push loose teeth into place and put back detached ones; but occasionally a tooth obstinately prevents perfect approximation, and if it does it must be removed. Remove a tooth if it lies between the fragments, but replace it in its socket after reducing the fracture. Wash the mouth with hot water to clean it and to check bleeding. If bleeding is very severe, compress the carotid artery for a time. The fracture can be dressed temporarily with a pad of lint over the chin and Hamilton's four-tailed bandage (Fig. 335). A common plan is to make a jaw-cup of pasteboard (Fig. 348, 3, 4), pad it lightly with cotton, mold it to the part, and hold it in place with a Barton or a Gibson bandage. Apposition of the fragments cannot be maintained by either of the above methods. It is necessary to fasten the teeth together with wire, wire the fragments together, or have a dentist apply an interdental splint (Figs. 336, 337). Fracture of the lower jaw can often be satisfactorily treated by Angle's bands. These bands are of great value in complicated cases in which two

or more fractures exist. Each band consists of thin metal and a screw and a nut to fit the screw. The band is adjusted around a firm tooth and a nut is applied so as to hold the band tightly. Several bands are placed upon teeth in both jaws. Silver wire or silk is thrown around the pins of the bands so as to catch, and the jaws are thus held firmly together. In some cases holes are drilled in the bones and the fragments are held together by means of silver wire. In some few cases plates and screws are used. In fracture near the angle or anywhere in the vertical ramus the teeth of the lower jaw should be fixed to the teeth of the upper by Angle's jaw bands, when forward pressure of a crossed bandage of the angle of the jaw will hold the fragments together. In fracture of the coronoid bandage fixation is sufficient. In fracture of the neck of the condyle fix the teeth of the lower jaw to the teeth of the upper jaw to correct the deviation of the jaw to the injured side, and hold by bandages. The patient is to be fed on liquid food (see Fracture of the Upper Jaw), the mouth is to be washed frequently with peroxid of hydrogen, followed by boric acid solution or normal salt solution, and if bandages are used they should be changed every second day. The union should be complete in five weeks. The best plan of treatment in all cases not operated upon is to send the patient to a skilful dentist and have him apply an interdental splint and direct the treatment. A specialist may succeed in obtaining such fixation that union in good alignment follows when a general surgeon might only secure union in poor alignment. Though these fractures are often compound, they very seldom endanger life.

Fractures of the Hyoid Bone.—These fractures are uncommon injuries, and are caused by hanging, by throttling, by blows, and by falls in which the neck strikes some obstacle. If the bone breaks by throttling, it is its body which fractures (indirect force). Fractures by muscular action are most unusual. The thyroid cartilage, the cricoid cartilage, or the trachea may also be broken.

Symptoms.—The symptoms are: A sensation of something breaking; bleeding from the mouth if the mucous membrane be lacerated; pain, which is worse on opening the jaws or on moving the head or tongue; difficulty in swallowing; muffled, hoarse voice or aphonia; swelling, and frequently ecchymosis of the neck. There are observed occasionally, though rarely, harsh cough and dyspnea, irregularity of bony contour, and crepitus. Always look into the mouth and see if there can be detected ecchymosis or laceration of the mucous membrane or projection of a bony fragment. The displacement is produced by contraction of the middle constrictor of the pharynx. A simple fracture of the hyoid bone is seldom dangerous, but if there is laryngeal involvement that condition may destroy life.

Treatment.—For dyspnea be ready to perform intubation or tracheotomy at a moment's notice. Edema of the glottis is a great danger. Try to restore the fragments with one hand externally and with a finger in the mouth. Put the patient to bed and have him lie back upon a firm rest so that his shoulders are elevated. His head is to be placed between extension and flexion, a pasteboard splint or collar is molded on the neck, and a bandage is applied around the forehead, neck, and shoulders to keep the head immobile. The patient must not utter a word for a week; he must be fed at first by nutritive enemata, and then for some time on liquid diet, which is given through a stomach-tube early in the case. Endeavor to control the cough by opiates. A fractured hyoid bone requires about four weeks to unite.

Fractures of the tracheal and laryngeal cartilages are caused by direct violence, as hanging, throttling, blows, or kicks. Very seldom is muscular action responsible. The thyroid or cricoid may be broken alone or together. The hyoid bone may be broken with them both or with the thyroid alone. The tracheal cartilages may suffer alone or with the laryngeal cartilages. The arytenoid may break. These injuries are greatly more common among men than women. They are rare in young persons, and are commonest when the cartilages have begun to ossify. They are very grave injuries. The mortality is between 30 and 40 per cent. Death may be caused by edema of the glottis, hemorrhage beneath the mucous membrane or hemorrhage into the air passage causing obstruction to the entrance of air.

The *symptoms*, which are severe, are pain, aggravated by attempts at swallowing or speaking; swelling, ecchymosis it may be, emphysema of the neck; cough; aphonia; intense dyspnea; and bloody expectoration if the mucous membrane is ruptured. There can be detected inequality of outline (flattening or projection) and perhaps moist crepitus. The usual seat of injury is the thyroid cartilage.

Treatment.—Cases without dyspnea require quiet, avoidance of all talking, feeding with a stomach-tube, the application of compresses and adhesive strips over the fracture,

and the use of remedies to quiet cough. The surgeon must be ready to operate at any moment. In most cases dyspnea exists due to projection of the fragments or submucous extravasation. When there is dyspnea, emphysema, or spitting of blood, at once practice intubation, or, if unable to do this, open the trachea below the seat of fracture. If laryngotomy or tracheotomy is performed, try to restore displaced fragments to proper position. If the fragments of a tracheal cartilage will not remain reduced, introduce a Trendelenburg cannula or a tracheotomy tube, and pack gauze around it. Take out the packing in four days, and remove the tube as soon as the patient breathes well, when the opening may be allowed to close. In these cases feed with a stomach-tube and keep the patient absolutely quiet. Union takes place in four weeks.

Fractures of the Ribs.—The ribs, owing to their shape, elasticity, and mode of attachment, readily bend and as readily recover shape, and thus withstand considerable force without breaking. Notwithstanding these facts, the situation of the ribs so exposes them that in 16 per cent. of all cases of fractures noted by Gurlt these bones were involved. In children fracture of a rib seldom occurs and is usually incomplete; it is common in adults and the aged, and in them is generally complete. It is more frequent among men than among women. The ribs commonly broken are from the fifth to the ninth, the seventh being the one that most frequently suffers. Fracture of the first rib alone is an excessively rare accident. The eleventh and twelfth ribs are seldom broken. A rib may be broken in several places, and several ribs are often broken at the same time. Fracture of a single rib is not nearly so common as fracture of several ribs. These fractures may be compound, either through the skin or through the pleura. Damage of the lung will result in pneumothorax. Fractures compound by a wound of the skin surface are very rare, except from gunshot wounds.

Causes.—Direct force, as buffer accidents, kicks, blows with heavy instruments, or being jumped on while recumbent, may produce these injuries. A fracture from direct violence occurs at the point struck, and the ends, projecting inward, may damage a viscus. *Indirect* force, as great pressure or blows which exaggerate the natural bony curves, tends to produce fractures near the middle of the ribs or in front of their angles and to force the ends outward. A number of ribs are apt to be broken. Muscular action, as in coughing, sneezing, lifting, or parturition, occasionally, but very rarely, is a cause.

Symptoms.—In connection with the history of the accident the symptoms are: acute localized pain (a stitch) on breathing, increased by pressure over the seat of pain, pressure backward over the sternum, cough, and forcible inspiration or expiration. Respiration is largely diaphragmatic, the patient endeavoring to immobilize the injured side; cough is frequent and is suppressed because of pain. Crepitus is often, but not invariably, found. The surgeon seeks for it, first by resting the palm of his hand over the seat of pain while the patient takes long breaths; second, by placing a thumb before and one behind the seat of pain and making alternate pressure; third, by auscultation. It should be remembered that incomplete fractures are the rule in children; hence, in them do not expect crepitus. Deformity is usually trivial unless several ribs are broken, because shortening cannot occur and intercostal attachments prevent vertical displacement. Preternatural mobility may occasionally be elicited, when the region is not deeply covered with muscle, by pressing on one side of the supposed break and observing that a part of, and not the entire, rib moves. If air gathers in the subcutaneous tissue and there is no wound of the surface, it is proof of rib fracture with lung damage. In such a case the lung has been penetrated by a fragment, and air has been forced out into the tissues. This condition is recognized by great and growing swelling, which crackles when touched. Such a collection of air is known as *cellular emphysema.* Bloody expectoration suggests lung injury; bloody expectoration and cellular emphysema, without an external wound, prove injury of the lung. A simple, uncomplicated case of fracture of a rib or ribs in a young person gives a good prognosis.

The *complications* are: additional injury, making the fracture externally or internally compound; laceration of the pleura, pericardium, heart, lung, diaphragm, liver, spleen, or colon; rupture of an intercostal artery; hemothorax; cellular emphysema; pulmonary emphysema; pneumothorax; pyothorax; traumatic pleurisy; pneumonia; bronchitis; congestion or edema of the lungs.

Treatment.—In an uncomplicated case the patient is not kept in bed, as breathing is easier when erect than when recumbent. When in bed he is to be nearly erect upon a bed-rest. Angular displacement outward is corrected by direct pressure. Displacement inward is soon corrected as a rule, by the expansion of ordinary

respiratory action; but if it is not thus corrected, etherize, the deep breathing of the anesthetic state almost always succeeding. If ether fails, and dangerous symptoms ensue, incise under strict antiseptic precautions, elevate, or sometimes resect a portion of the rib.

After correcting any existing deformity immobilize the injured side. If the patient is a man, shave the chest. Direct the patient to raise his arms above his head, to empty his chest of air by forced expiration, and to keep it empty until a piece of rubber plaster (2 inches wide) is forcibly applied a number of inches below the fracture and from the spine to the sternum. The patient is now allowed to take a breath and is then directed to empty the chest again, another piece of plaster being applied, covering the upper two-thirds of the width of the first strip. This process is continued until the side is strapped well above and well below the fracture (Fig. 348, 13). Over the plaster light turns of a spiral bandage of muslin are carried, or a figure-of-8 bandage of the chest is applied, the turns crossing over the seat of injury. About once a week the plaster is removed and fresh pieces applied after rubbing the chest with soap liniment, drying, and anointing excoriations with an ointment of oxid of zinc. The dressing is worn for three or four weeks. The patient avoids cold, damp, and drafts. The diet must be nutritious but non-stimulating, and any cough should be treated by opiates and expectorants. A person with this injury who has reached the age of sixty must take stimulant expectorants (ammonii carb., 10 gr., in infus. senegæ, ½ oz., *t. i. d.*) or employ a steam-tent several times a day. The old method of treatment, in which the chest was included in a forcibly applied broad rib-roller, is not to be used except as a temporary expedient; it compresses the entire chest, causes pain and dyspnea, and tends to loosen and slip.

Fracture of the ribs complicated by visceral injury is highly dangerous, and requires confinement to bed. The treatment is that of the visceral injury. If there be bloody expectoration, apply adhesive strips as above indicated, put the patient to bed nearly erect on a bed-rest, keep him quiet, subdue the circulation, and employ opium, diaphoretics, and expectorants (a good mixture consists of squill, ipecac, ammonium acetate, and chloroform; opium is given separately). Inflammations of the lung or the pleura, fortunately, are apt to be localized, and are treated as ordinary inflammations of these parts. In laceration of an intercostal artery incise and try to ligate; if unable to ligate, resect a rib and apply a ligature. If the signs point to internal bleeding, resect a rib, search for the bleeding point, ligate, close, and aspirate air from the pleura. Emphysema usually soon disappears; but if it does not, make many small incisions in the cellular tissue, dress antiseptically, and employ pressure. Pneumothorax, if increasing dangerously, demands tapping with a trocar, and if this fails, the introduction of a drainage-tube. When there arises a sudden attack of dyspnea, which is prone to happen in these cases, and in which the face becomes blue, the heart labors, and suffocation seems imminent, bleed the patient almost to syncope. Empyema calls for operation.

Fractures of the costal cartilages are not common, even in the aged. Such fractures occur either through the cartilages or through their points of junction with the ribs. These injuries generally arise from direct violence, the cartilage of the eighth rib being most prone to suffer. Bennett, of Dublin, has seen over 25 specimens of fracture of the first costal cartilage. Indirect force (such as a blow upon the shoulder) is occasionally the cause, but when it is the cause some other injury besides the fracture of the cartilages is apt to be noticed. Muscular action is a possible cause.

Symptoms.—Displacement is often absent; but if present, it is forward or backward of either fragment, and is due chiefly to the force of the injury, but partly, it may be, to muscular action. When displacement is absent, crepitus will not often be found; in fact, crepitus is usually absent in these injuries. Localized pain, swelling, and ecchymosis are noted. Preternatural mobility may or may not be detected. Union by bone is to be expected.

Treatment.—If displacement exists, try to reduce it. If the fragment is displaced backward, reduce by deep inspirations; if the fragment is displaced forward, reduce by pulling back the shoulders. In this attempt failure is the rule, and the surgeon may then adopt Malgaigne's expedient of applying a truss over the projection for a day or two. Dress and treat the case as if a rib were broken, dispensing with dressings in four weeks.

Fractures of the Sternum.—The sternum may be broken, along with the ribs and spine, from great violence. Fractures of the sternum alone are infrequent, because the bone rests on a spring-bed of ribs. Fractures of the sternum may be simple or compound, complete or incomplete, single or multiple. The most usual injury is a simple

transverse fracture at or near the gladiomanubrial junction, at which point dislocation may also occur. Both fracture and separation of the ensiform cartilage are very rare. The sternum may be broken along with the ribs or clavicle.

Causes.—These are: *direct* force, as by a fall of an embankment or of a wall, by a car crush, or by the passing of a cart wheel over the body; *indirect* force, as by a fall upon the head, thus driving the chin against the chest; by a fall upon the feet, the buttocks, or the shoulder; by forced flexion or extension of the body over an edge or angle (as may occur during labor-pains).

Symptoms.—In fracture of the sternum displacement is not always present, but when it does occur the lower fragment is apt to pass forward; displacement may, however, be transverse or angular, or there may be overriding. The posterior periosteum, which rarely tears, limits displacement, but some deformity can, as a rule, be detected. The history of the nature of the accident has a valuable bearing upon the question of diagnosis. The position assumed by the patient is with the head and body bent forward, as attempts to straighten up cause much suffering. There is fixed and localized pain, increased by deep respiratory action, by body movements, or by cough. Crepitus is sought for by auscultation and by placing the hand over the injury and directing the patient to make quick respirations. Mobility may become manifest on external pressure, during respiration, or while attempts are being made to bring the body erect. Respiration in these cases is usually much interfered with. It is not important to separate diagnostically diastasis from fracture.

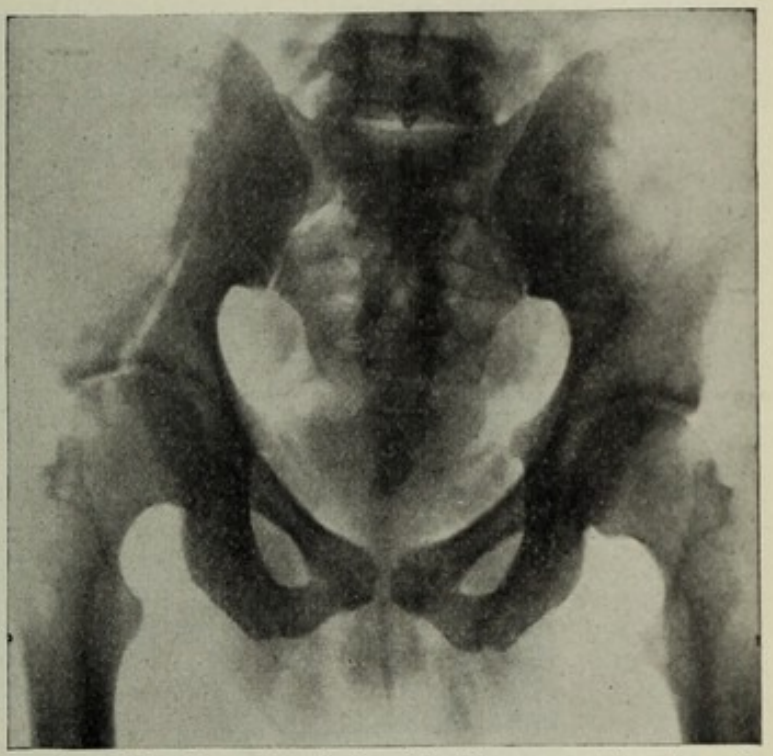


FIG. 338.—Fracture of the right ilium extending through the acetabulum to the articulation with the sacrum (U. S. Naval Hospital, League Island, Pa.; skiagraphed by Lieutenant George U. Pillmore, Medical Corps, U. S. Navy).

Complications.—Other fractures generally complicate fracture of the sternum, and laceration of the pleura or pericardium and hemorrhage into the anterior mediastinum may exist. Abscess of the mediastinum and necrosis of the sternum may appear as late consequences. The *prognosis* is good in uncomplicated cases.

Treatment.—The deformity attending fracture of the sternum is to be corrected, if possible, by external pressure. If overriding is found, effect reduction by bending the body back over a firm pillow and ordering the patient to respire deeply; if this method fails, give ether and then bend the body backward. The deformity, after reduction, tends to recur, but the bones unite well even in deformity, and no great harm results. The fragments need not be cut down on or be hooked up unless there be internal injury. After reducing the deformity, cover the front of the chest with adhesive strips extending laterally from one axillary line to the other, and covering a region from above the fracture down to the ensiform cartilage. Place over this covering an anterior figure-of-8 bandage of the chest. In some cases, where deformity recurs after reduction, a circular bandage of the chest is applied and the shoulders are pulled strongly back with a posterior figure-of-8 bandage. The plaster is to be reapplied once a week. Some surgeons treat these cases by means of a large compress held by adhesive plaster and a broad, tight roller.

The patient goes promptly to bed, and reposes, erect or semi-erect, on a bed-rest. This position favors easy respiration and antagonizes the tendency to displacement. The diet should be light, nutritious, and non-stimulating. Convalescence is established in four weeks, and the plaster should be permanently removed in five

weeks. When the ensiform cartilage is so bent in as to cause intense pain or to injure the stomach, it should be exposed by incision and resected. Edema of the skin and fever, if they appear, indicate pus, in which case an incision should be made at the edge of the sternum and the pus cavity should be irrigated and drained.

Fractures of the Pelvis.—In some of the fractures serious injury of the pelvic contents is apt to be found.

Fractures of the False Pelvis.—Fractures of this region are seldom dangerous unless comminuted. There may be fracture of the iliac crest or of the anterior superior spine, or the line of fracture may traverse the entire length of the flanged-out ilium, or the bone may be comminuted with the association of grave visceral damage. The anterior superior and posterior superior spines may be broken off.

Causes.—The cause of fracture of the false pelvis is generally violent *direct* force, as the passage of a wagon wheel, the fall of a wall, the kick of a horse or mule, or the force of car crushes. Violent contraction of the rectus femoris muscle may tear off the anterior inferior spine of the ilium.

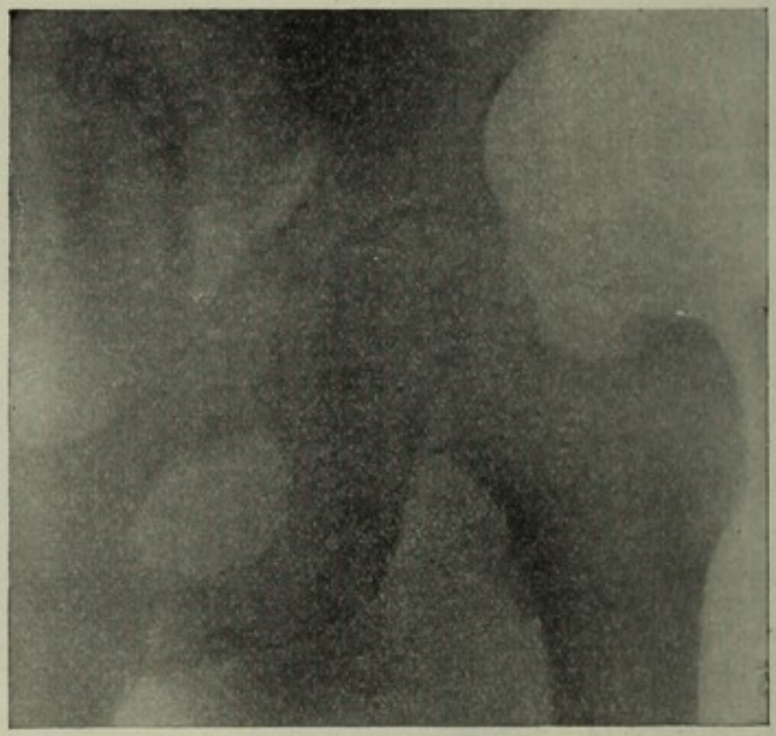


FIG 339.—Dr. C. F. Nassau's case of fracture of ascending and descending rami pubic bone (picture by Sender).

Symptoms.—In fracture of the false pelvis the history of violent force is noted. The patient leans toward the injured side. Pain exists, which is aggravated by movements (particularly by bending forward), by coughing, or by straining to empty the bowels or the bladder. Ecchymosis and swelling are manifest. Crepitus and preternatural mobility are detected by moving the iliac crest. Deformity is very rarely present. A person with fracture of the crest alone or of a spine alone can stand and walk. Cases uncomplicated by visceral injury make good recoveries.

Complications.—The fracture may be, but rarely is, compound, as the parts are well protected by muscles. The colon may be injured when comminution has taken place.

Treatment.—If there are symptoms of injury to the colon, perform laparotomy, search for the injured region, and suture it. In treating an ordinary fracture of the false pelvis the Bradford frame is probably the best apparatus, but many surgeons simply put the patient on a fracture-bed, raise the shoulders, and apply a canvas binder about the pelvis, or encase the pelvis in broad pieces of rubber plaster, or employ the belt or girdle. The pressure of the binder, girdle, or plaster must not be so great as to force the fragment of ilium inward. The knees should be bent over two pillows so as to semiflex the legs and thighs, and the knees should be tied together. To restrain thigh movements it may be necessary to encase a restless patient in splints or bind him to sand-bags. If the pelvic binder displaces the fragments or causes pain, abandon

it and trust to position. If the fragment cannot be retained in place, wire it. The dressings can be removed in six weeks, and the patient is allowed to get up in eight weeks. In simple, uncomplicated fracture of the false pelvis the prognosis is good. In compound fractures of the false pelvis asepticize, drain and dress, put on a binder, and direct the same position to be maintained as for simple fractures.

Fractures of the True Pelvis.—The most usual seat of these fractures is through the obturator foramen, the ascending ischial and the horizontal pubic rami being broken. A fracture may occur near the symphysis pubis, the symphysis may be separated, a line of fracture may run near to or into the sacro-iliac joint; the same may involve each side of the body of the pubis, and there may be multiple fractures. Fractures of the acetabulum and of the tuberosity of the ischium may occur. Before the seventeenth year the innominate bone may be broken into its three anatomic segments. Fractures of the true pelvis are highly dangerous because of the damage which is apt to be inflicted on the pelvic contents. There may be laceration of the bladder or membranous urethra, injury of the vagina, the rectum, the uterus, or the small gut. The *cause* of pelvic fracture is violent force, direct or indirect. Front force tends to produce direct, and side force indirect, fracture. The acetabulum may be broken by falls upon the feet.



FIG. 340.—Fracture of pelvis. Man caught between wharf and boat.

Symptoms.—In pelvic fracture there is a history of violent force. There are great shock, swelling, and intense pain increased by attempts at motion, coughing, and straining. There is also inability to sit or to stand. Mobility becomes obvious on grasping an ilium in each hand and moving the hands. Crepitus may be noticed by this maneuver or by moving an ilium with one hand, a finger of the other hand being inserted in the rectum or vagina. In making movements for diagnostic purposes be very gentle, as rough manipulation may cause injury by sharp fragments. There may be doubt as to whether crepitus is to be referred to pelvic fracture or to fracture of the neck of the femur; in this case follow the rule of John Wood: "The surgeon grasps the femur with one hand and places the other firmly upon the anterior superior iliac spine or crest or upon the pubes; then, on moving the femur and abducting it freely, if a crepitus be detected, it will be felt the more distinctly by that hand which rests on or grasps the fractured bone." In from one to three days ecchymosis usually appears in the perineum and scrotum of the male and in the perineum and labia of the female. This sign is similar in origin to Battle's sign of fracture of the posterior fossa of the base of the skull (Coopernail in "Medical Record," March 4, 1916). In a fracture of the pubes without much tearing of the soft parts there may be simply a linear discoloration.

Rupture of the bladder is made manifest by pain in the hypogastric region, intense desire to micturate, inability to pass urine in quantity, although a few drops of bloody urine may be voided, great shock, sometimes dulness on percussion in the loins, and evidences of extravasation in the prevesical space. Always catheterize at the first examination of a patient with a pelvic fracture. Vesical rupture is proved to exist by practising the maneuvers suggested under Rupture of Bladder. The symptoms of ruptured urethra are set forth later. Bleeding from vagina or rectum points to laceration of the part by a fragment. The vagina may be badly lacerated and the bowels may emerge from the laceration (Maurice H. Richardson's case). Intestinal injury is apt to induce septic peritonitis. Fracture of the acetabulum may occur. Fracture of the brim of the acetabulum permits dorsal dislocation of the femur which will not remain reduced, and causes shortening, which at once recurs when extension is abandoned; also inversion and adduction, although the power of eversion and abduction is preserved (Stokes). There is crepitus, and the head of the bone goes with the fragment upward and backward (Stokes). If the head of the femur be driven through the acetabulum into the pelvis, the injury is very grave; there are then found shortening, adduction, and semiflexion of the thigh, absence of the prominence of the



FIG. 341.—Rugh's case of fracture of the acetabulum with internal dislocation of femur.

great trochanter, and more capacity for movement than is noted in dislocation. This injury is called *internal dislocation* of the femur (Fig. 341). Fracture of the ischium rarely occurs alone.

Treatment.—Examine carefully to determine if the bowel, the bladder, the urethra, or the vagina is injured. If such an injury exists, radical operation is, of course, demanded. Always use a catheter to see if the urine is bloody. Bloody urine suggests, but does not prove, the existence of a torn bladder. It may be due to simple contusion of the bladder or to contustion of the kidney. In some cases the bladder is sutured. In others it is drained suprapubically without suturing. In treating a pelvic fracture endeavor to restore the parts to a normal position, employing external manipulation and inserting a finger into the rectum or in the vagina. If reduction is difficult, administer ether. The pelvis should be encircled by a canvas binder and the patient should be placed upon a Bradford frame. If this is done, he can be cleaned readily and the bed-pan can be easily used. If movements of the thighs distort the pelvic bones, each thigh should be bound to the frame. In fracture with separation of the pubic bones the bones should be wired in place. If urinary extravasation from urethral rupture occurs, perform perineal section. If there are signs of bowel injury

or intraperitoneal rupture of the bladder, perform laparotomy; and if the bladder is found to be torn, apply sutures and drain suprapubically. All visceral injuries are treated by general rules. Remove the dressings in six weeks and allow the patient to get about in twelve weeks. In fracture of the acetabulum, if the limb is shortened, give ether and reduce by extension and counterextension. Treat these fractures in the same way as intracapsular fractures of the femur. Fractures of the ischium are best treated by the application of a pad and adhesive plaster and rest in bed.

E. P. Quain ("Surgery, Gynecology, and Obstetrics," July, 1916) collected 126 cases of rupture of the bladder associated with fracture of the pelvis. To these he adds one of his own. In most of the cases a spicule of bone tore the bladder. Most of the lacerations were extraperitoneal and in severe cases they were multiple. Only 34 of the cases recovered, a mortality of 74 per cent. Forty-four of the cases were reported since 1890, and of these 23 recovered, a mortality of 48 per cent. Out of 21 cases reported since 1905 only 8 died, a mortality of 38 per cent. Quain maintains that suturing or wiring of fragments is unsatisfactory when there is extravasation of urine. He practised indirect fixation of the pelvic bone fragments by "percutaneous screws and external clamps at points distant from the fracture and extravasated urine" (Ibid.). A fracture may seem to be safe and firm and yet the *x*-rays may fail to demonstrate callus to the amount and in the state of solidity we assume necessary for solidity.

Fractures of the Sacrum.—This bone may be broken by direct force, such as a kick, but the injury is rare. The sacral plexus is usually injured, and if it is, paralysis is observed in the territory of its branches.

The *symptoms* of fracture of the sacrum are pain, frequently incontinence of feces and retention of urine, irregularity of the sacral spines, ecchymosis, and crepitus. Crepitus may be sought for with one hand externally and a finger of the other hand in the rectum. The lower fragment passes forward and may obstruct or may tear the rectum. Paralysis may be found in the area of distribution of the sacral plexus. A rectal examination is always necessary.

Treatment.—In any case of fracture of the sacrum, if there are evidences of pressure upon nerves by displaced bone, expose and elevate the depressed bone. If the rectum is lacerated, sutures must be inserted. In many cases of fracture of the sacrum the older conservative treatment is sufficient. The conservative treatment is as follows: Press the fragments into place with a hand externally and a finger in the rectum. Do not plug the rectum. Put a pad over the upper fragment, hold it by a plaster or a binder, place the patient recumbent on a fracture-bed, and insert a large cushion underneath the pad. Some surgeons give opium to induce constipation, and allow a fecal support to accumulate in the rectum. Use a clean catheter regularly, and guard against bed-sores. Union occurs in about four weeks, when the dressing can be removed. The patient can get about again in six weeks. If urinary retention persists, or if intractable bed-sores form after eight or ten weeks, cut down on the seat of injury and elevate or remove the portion of bone causing pressure.

Fractures of the Coccyx.—The coccyx may be broken or be separated from the sacrum by a fall, a blow, a kick, or the straining of parturition. Its mobility is so great, however, that it does not often break.

Symptoms.—The chief symptom of fracture of the coccyx is pain, which is much aggravated by sitting, walking, or straining at stool. If the index-finger is inserted into the rectum, the displaced bone is felt; if the thumb of the same hand is also placed externally, a rocking motion will develop crepitus and preternatural mobility.

Treatment.—In treating fracture of the coccyx reduce by external pressure and by the manipulations of a finger in the rectum and put the patient to bed. In four weeks the fracture should be united. If union does not take place, defecation, micturition, rising from a chair, or even sitting, and all movements of the coccyx will cause excruciating pain by pressure on the last sacral nerve. A finger in the rectum will locate a very painful spot. This condition is known as *coccygodynia*. It was first described and named by Sir James Y. Simpson of Edinburgh in 1859.

It must not be understood that coccygodynia always results from fracture of the coccyx, or that fracture of the coccyx is the only cause. As a matter of fact, coccygodynia is a rare condition and is seldom a result of fracture of the coccyx. It may arise after confinement, or a fall or blow upon the region of the coccyx, may be due to caries, and may result from exposure to cold and wet.

In most cases it is a referred pain due to some central trouble, and is found particularly in various functional disorders of the nervous system. It is especially com-

mon in hysteric, neurasthenic, or anemic women. In the traumatic neuroses it is complained of not very unusually, and it is frequently associated with irritable spine. In very rare cases it is a neuralgia. The treatment is aimed at the causative condition. In very obstinate cases some surgeons make a subcutaneous division of the nerve or of the muscles which move the coccyx. Resection of the bone, which was suggested by Tillaux in 1885 and has been advocated by a number of surgeons is only justifiable when the bone is diseased or distorted. The operation weakens the pelvic floor (Yeomans, in "Tr. Amer. Proctolog. Soc.," 1914). Yeomans (Ibid.) warmly advocates injection of alcohol (80 per cent.) into and about the painful spot.



FIG. 342.—Fracture of the shaft of the clavicle (skiagraphed by Dr. Manges).

Fractures of the Vertebræ.—(See page 817.)

Fractures of the Skull.—(See page 744.)

Fractures of the Clavicle.—The clavicle is more often fractured than any other bone. The fracture may occur at any age, but is commonest before the sixth year (Hulke says one-half of the recorded cases). It may be simple, multiple, comminuted, oblique, transverse, complete, incomplete, or, very rarely, compound. Both clavicles may be broken. Fractures are most apt to occur just external to the middle, at the point where the inner or large curve meets the outer or small curve, at which junction



FIG. 343.—Fracture of the clavicle at the junction of the middle and outer thirds (Misericordia Hospital case; skiagraphed by Dr. Pfahler).

the bone is at its smallest diameter. Fractures of the acromial end are more frequent than fractures of the sternal end, and less frequent than fractures of the shaft. The *causes* of fracture of the clavicle are direct violence, indirect violence, and, very rarely, the contractions of "the deltoid and clavicular fibers of the great pectoral" (Treves in "Applied Anatomy," from Polaillon).

Fractures of the shaft are usually due to indirect violence, as falls upon the shoulder or upon the outstretched hand. In the latter accident, which is the usual mode of

origin, the concussion of the fall travels up and the body weight travels down, and these two forces compress the bone, which snaps at its weakest point. Fractures from indirect force are oblique, and in children are of the greenstick form. Fractures from direct force are usually transverse, and are occasionally comminuted. Fractures from muscular action have been recorded (Rubini the tenor, recorded by Melay).

Symptoms.—In fracture of the shaft of the clavicle the attitude of the patient is peculiar. He supports the elbow or wrist of the injured side with the hand of the sound side, and also pulls the extremity against the chest; the head is turned down toward the shoulder of the damaged side, as if trying to listen to something in the joint, thus relaxing the pull of the sternocleidomastoid muscle upon the inner fragment. The shoulder is nearer the sternum, on a lower level, and farther front than that of the sound side. Loss of function is shown by inability to abduct the arm, and in many cases by inability to place the hand on the top of the erect head. Considerable pain exists, which is increased by motion, by pressure, and by the extremity hanging down without support.

The deformity above noted is described by stating that the shoulder goes downward, inward, and forward (D. I. F.). The *downward* deformity is chiefly due to the weight of the extremity, which pulls down the unsupported outer fragment, and is contributed to by the action of the pectoralis minor muscle. The *inward* deformity is chiefly due to the contraction of the pectoralis minor and subclavius muscles assisted by the action of the pectoralis major. The *forward* deformity is due to rotation of the outer fragment, which is brought about by the serratus magnus muscle carrying the scapula forward. In this deformity the inner end of the outer fragment is below and behind the outer end of the inner fragment, which overrides it. The inner fragment, though pulled on by the sternocleidomastoid muscle and relatively higher than the outer fragment, is really but little, if at all, elevated, marked elevation being prevented by the attachment of the rhomboid ligament. After noting the deformity, detect with the finger the irregularity of bony contour. Examine for preternatural mobility and crepitus by raising and throwing back the shoulder. In looking for these signs in children it is to be remembered that the fracture is probably incomplete. The prognosis is good, the bone uniting solidly, but, if unoperated upon, with some shortening or inequality.



FIG. 344.—Dr. Louis Englerth's case of comminuted fracture of left clavicle.

Complications.—Fractures of the shaft are rarely compound because the sharp end of the outer fragment passes backward and because of the free play the skin makes over the bone (Pickering Pick). Both clavicles may be broken. One or more ribs may be fractured at the same time. In fractures from direct force deeper structures may be injured by fragments. Thus, injury of the brachial plexus will induce paralysis. There are 11 recorded cases of simple fracture of the clavicle complicated by laceration of a large vessel. Eight of these cases died. The vessel ruptured may be the subclavian vein, the subclavian artery, or the jugular vein. After a rupture a huge blood-clot forms (Galloid and Poillet in "Rev. de Chir.," July and Aug., 1901).

Treatment.—In treating a fracture of the shaft of the clavicle correct the deformity as soon as possible by throwing the shoulder upward, outward, and backward. If the patient is a girl, it is desirable to minimize the deformity. Place her upon her back upon a hard bed, with a small pillow under her head, a firm and narrow cushion between the shoulders, a bag of shot resting over the seat of fracture, and the forearm lying on the front of the chest, the arm being held to the side by a sand-bag. In three weeks there will be union, practically without deformity. In a child with an incomplete

fracture a handkerchief sling for the forearm, worn three weeks, is all that is needed. In a fracture of the collar-bone of an adult the Velpeau bandage is usually efficient. Before applying it, place lint around the chest and cotton over the elbow. Change the bandage every day for the first week, and after that period every third day. Each time it is changed rub the skin with alcohol, ethereal soap, or soap liniment, dry carefully, and examine for excoriations; if any are found, they are anointed with zinc ointment before the dressing is reapplied. The dressing is permanently removed at the end of four weeks, the arm being carried in a sling for another week. The classical apparatus of Desault is now rarely used. The posterior figure-of-8 bandage associated with the second roller of Desault, some turns being made from the elbow of the injured side to the shoulder of the sound side, can be used in cases in which the forward deformity is apt to return. The apparatus of Fox, which is very comfortable and useful, consists of a pad for the axilla, a sling for the forearm, and a ring for the opposite shoulder, to which ring are tied the tapes from both the pad and the sling (Fig. 345).

The dressing of Moore, of Rochester, is valuable in an emergency. It consists of a piece of cotton cloth, 2 yards long, and folded like a cravat until it is 8 inches in width at the middle. The center of the bandage rests upon the elbow, the posterior tail is carried across the front of the shoulder of the injured side. The forearm is at an acute angle with the arm, and the other end of the bandage is carried across the forearm, across the back over the opposite shoulder, and around the axilla, where the extremities are stitched together. The forearm is suspended in a bandage sling (S. D. Gross in "A System of Surgery"). The four-tailed bandage is preferred by Pick.



FIG. 345.—Fox's apparatus for fractured clavicle.

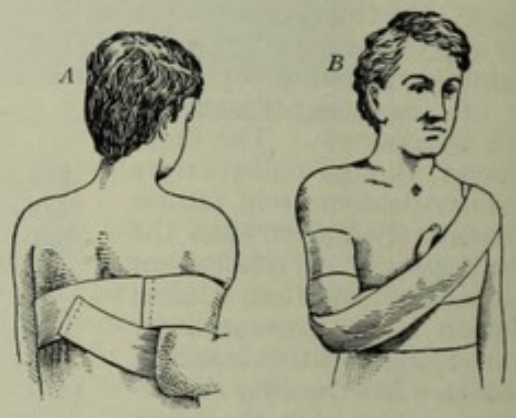


FIG. 346.—Sayre's adhesive-plaster dressing for fracture of the clavicle (Stimson): *A*, First piece; *B*, second piece.

Sayre's dressing has many advocates (Fig. 346). For this there are required two pieces of rubber plaster, each piece being 3 inches wide and sufficiently long to go around the chest one and a half times. The end of one piece encircles the arm of the injured side just below the armpit; the plaster strip is pulled across the back to the other side, to the front of the chest, and returns again to the middle of the back. This procedure pulls the elbow back and throws the shoulder out. The hand of the injured side is placed on the breast of the opposite side, cotton being interposed, and the second strip of plaster runs from the elbow of the injured side to the front of the opposite shoulder, around, and back, pressing the elbow forward, upward, and inward. If not changed frequently it may cause severe edema about the elbow. In children, if it is found difficult to immobilize the parts securely, the most satisfactory result is obtained by the application of the Velpeau bandage, which is overlaid by a thin plaster-of-Paris bandage. If the fragments cannot be coaptated, sterilize the parts, administer ether, incise, clear away the muscle from between the fragments, clear the ends, bore each end and hold them in contact by means of kangaroo-tendon or silver wire. The same procedure should be pursued when a fracture is compound or threatens to become so, or if signs indicate pressure upon vessels or nerves. If a large vessel has been injured, operation is imperatively necessary to arrest hemorrhage. If a pateint suffering under a fracture which threatens to become compound refuses the aid of operation, keep him in bed and hold the arm in abduction. In a number of cases I have wired

the fragments, with excellent results. Year by year I become more inclined to recommend wiring in cases of fractured collar-bone. It secures union without deformity, saves the vessels and nerves, and obviates the necessity of prolonged and very uncomfortable fixation of the arm and forearm.

After a broken collar-bone has united, if the shoulder is found to be stiff, make passive movements daily; if these fail, move the joint forcibly, first giving ether or nitrous oxid.

Fractures of the acromial end of the clavicle are due to direct force. If the fracture is between the two coracoclavicular ligaments, deformity is very slight, crepitus is elicited by manipulating with the fingers, and pain exists, but loss of function is not markedly manifest unless it is due to pain. These fractures are treated by interposing cotton between the arm and the side, binding the arm to the side with the second roller of Desault, and hanging the hand in a sling. In fractures external to the ligaments crepitus is manifest on moving the shoulder, the outline of the bone is irregular, severe pain is developed by movement, and deformity is pronounced. The deformity is due to the serratus magnus muscle rotating the scapula forward, the inner end of the outer fragment of the clavicle often coming in contact with the anterior surface of the outer portion of the inner fragment. Fracture of the acromial end of the clavicle is reduced by pulling both of the shoulders strongly backward, and it is kept reduced by the use of a posterior figure-of-8 bandage. In fracture external to the ligaments the displacement frequently cannot be corrected by position and manipulation. Such cases demand incision and wiring. In either variety of fracture the dressings are worn for four weeks.

Fractures of the sternal end of the clavicle are very rare. They are caused by either direct or indirect force. In such a fracture there are found crepitus, projection at the seat of fracture, rigidity of the sternocleidomastoid muscle, and shortening of the clavicle. The inner end of the outer fragment always passes forward, and often also downward and inward. Reduce these fractures by pulling the shoulders back, and treat them by means of the posterior figure-of-8 bandage worn for four weeks. Wiring may be necessary.

Fractures of the Scapula.—This bone is not often broken, as it rests upon thick muscles and elastic ribs; it is freely movable, and it has attached to it a bone which easily breaks.

Fractures of the Body of the Scapula.—These are due to direct violence. The *symptoms* are pain (which becomes agonizing on attempting to rotate the shoulder-blade), ecchymosis, and swelling. Crepitus is sought for by placing the hand over the bone and making movements of the arm; also by holding the point of the shoulder and lifting up the lower angle of the bone. The latter plan may develop mobility. The spine of the scapula is uneven only when it is itself fractured. Examine for unevenness of the vertebral border of the shoulder-blade. In fractures of the body of the scapula a shoulder-cap is applied, a gutta-percha splint is molded over the scapula, the arm is bound to the side, and the hand is carried in a sling. The apparatus is worn for four weeks.

Fractures of the spine of the scapula are treated as fractures of the body of the bone, and for the same time.

Fractures of the Neck of the Scapula.—Fracture of the *anatomic neck* has not been proved to exist. Fracture of the *surgical neck* is evinced by flattening of the shoulder, prominence of the acromion, and the presence of a lump in the axilla, crepitus being developed by pressing the axillary prominence upward and backward. The coracoid process descends with the humerus. The deformity is reduced with ease, but it at once recurs. The condition is treated by placing a pad in the axilla, a shoulder-cap on the shoulder, applying the second roller of Desault, and supporting the forearm and elbow in a sling. A Velpeau dressing can be used, associated with the application of a folded towel in the axilla. The dressing is to be worn for five weeks.

Fractures of the glenoid cavity are not very unusual, and may occur with or without dislocation. Fracture of this region arises from direct force applied to the shoulder. The existence of this fracture is determined by excluding fractures of other bones and by detecting crepitus when the arm is at a right angle to the body and the humerus is pushed against the glenoid cavity, the crepitus not being found when the arm hangs by the side. The *x*-rays make the diagnosis certain.

Treatment is by the second roller of Desault and a forearm sling worn for four weeks; careful passive movements limit ankylosis. If ankylosis occurs, adhesions must be broken up while the patient is under ether or nitrous oxid.

Fractures of the acromion process are often met with as the result of direct violence. The existence of fracture of the acromion is indicated by pain, by inability to abduct the arm, by flattening of the shoulder, by sudden lowering of the point of the shoulder, by mobility, and by crepitus. To treat a case of this kind put a large pad with the base down in the axilla, bind the arm over the pad with the second roller of Desault, lifting the elbow with turns of the roller carried over it and the opposite shoulder, thus splinting the bone in place by the head of the humerus pushing against the coraco-acromial ligaments. The dressing is to be worn for four weeks.

Fractures of the coracoid process rarely happen alone, and are usually due to direct force. Muscular action is very seldom the cause. Petty found in literature but 3 cases so caused. He adds one of his own ("Annals of Surgery," March, 1907). But little displacement is found. Crepitus and mobility are usually detected. Inability to shrug the shoulder inward was pointed out as a symptom by Byers. Such a case is well treated by a Velpeau bandage, which is to be worn for four weeks.

Fractures of the humerus are divided into: (1) fractures of the upper extremity; (2) fractures of the shaft, and (3) fractures of the lower extremity. In examining any fracture of the humerus, feel at once for the pulse, so as to ascertain if the artery has been torn; in any fracture near the head of the humerus be certain that dislocation does not exist.

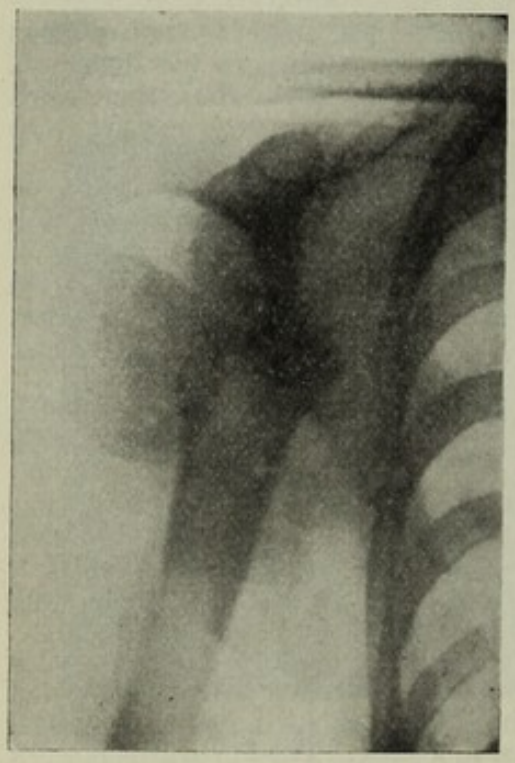


FIG. 347.—Fracture of head of humerus. The articular cartilage with a shell of bone is seen in the subcoracoid space (skiagraphed by Dr. Manges).

Examination of the Shoulder.—In some cases ether must be administered. Compare the injured shoulder with the sound shoulder, the patient, if not anesthetized, being seated on a chair or stool and facing the surgeon. The direction of the axis of the arm is noted. The surgeon grasps the flexed elbow with one hand and the shoulder with the other; he thus can move the extremity and palpate the joint and adjacent points. The shoulder is moved gently in every direction, and the surgeon notes if the head of the bone moves with the shaft. Examination shows if the head of the bone is in place or if the glenoid cavity is vacant—if the head of the bone is in an abnormal situation, if it is altered in contour, if there is crepitus or preternatural mobility and, if any movement is impaired. The acromion process, outer end of the clavicle, coracoid process of the scapula, and neck of the scapula are also investigated. The length of the arm is obtained by measuring from the apex of the acromion process of the scapula to the apex of the external condyle of the humerus, and it is compared with the length of the sound extremity.

Fractures of the upper extremity of the humerus include: (*a*) fractures of the anatomic neck; (*b*) fractures of the surgical neck; (*c*) fractures of the head, oblique and longitudinal, and (*d*) separation of the upper epiphysis.

Fractures of the Anatomic Neck of the Humerus.—The anatomic neck is the constricted circumference of the articular surface, and fractures of it, though rare, do occur, especially in the aged. The line of fracture in some cases follows the insertion of the capsule, in others it is entirely within the capsule, but in most it is without the capsule above and within the capsule below; hence the term "intracapsular" is rarely correct as a designation. Such a fracture may be impacted. The *cause* is direct violence or a fall or a blow upon the elbow when the arm is abducted. Polloson, of Lyons,[1] has reported a case due to muscular action. The patient died in eclampsia, and at the necropsy it was found that both humeral necks were fractured and impacted. The fractures must have been produced by the muscles throwing the heads of the bones violently against the glenoid cavities, probably by adduction.

The *symptoms* of fracture of the anatomic neck are pain, tenderness, swelling, ecchymosis, slight irregularity of the shoulder (which irregularity is soon hidden by

[1] "Rev. de Chir.," vol. viii, 1888.

tumefaction), and inability to abduct the arm actively. Deformity, as a rule, is slight or is absent, because the capsule is rarely entirely torn from the lower fragment. If deformity exists, it is due to the muscles inserted on the bicipital groove and to the coracobrachialis, which pull the lower fragment inward and forward. Treves says that

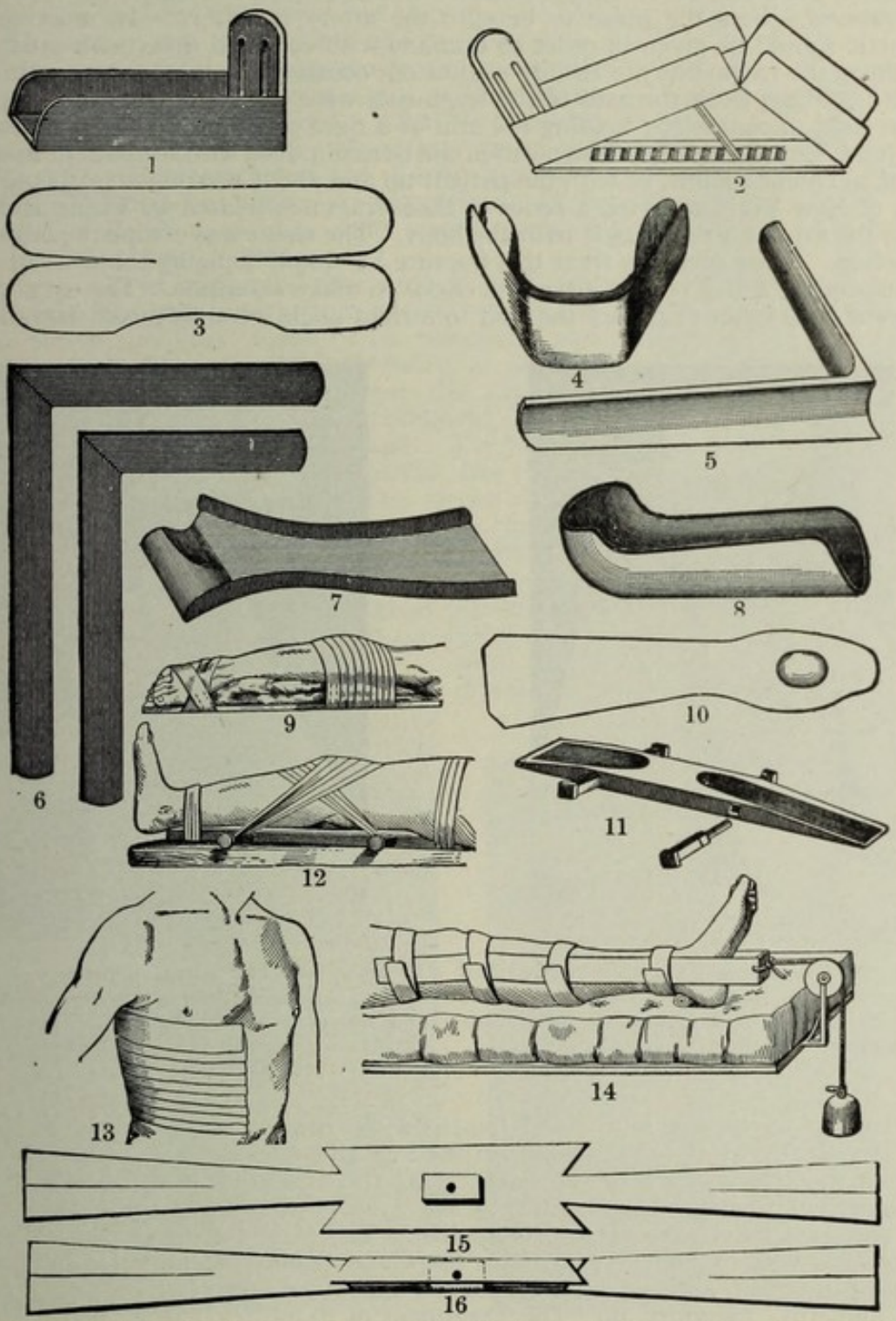


FIG. 348.—Splints: 1. Fracture-box. 2. Double inclined plane fracture-box. 3. Jaw-cup (unfolded). 4. Jaw-cup (folded). 5. Anterior angular splint. 6. Internal angular splint. 7. Bond splint. 8. Shoulder-cap. 9. Dupuytren splint in Pott's fracture. 12. Agnew splint applied. 13. Strapping the chest in fractured ribs. 14. Extension apparatus in fracture of the femur. 15, 16. Adhesive strips for extension apparatus.

a tear of the reflected fibers of the capsule leads to subsequent necrosis of bone because this joint has no ligamentum teres. In unimpacted cases there is crepitus, and mobility of the shaft can be detected near the head of the bone. In some cases impaction occurs, the upper fragment impacting into the lower. In this condition there are very

slight shortening and trivial shoulder flattening, no crepitus unless the tuberosity is broken off, no mobility, and, as Erichsen says, the head of the bone, while it can be felt through the axilla, is not in the axis of the limb.

The *prognosis* of fracture of the anatomic neck is usually good for bony union (Hamilton, Pick, and R. W. Smith), but a stiff joint is apt to result.

Treatment.—Feel the pulse to be sure the artery is untorn. In most cases an anesthetic should be given in order to examine with ease and dress with satisfaction. Sometimes the fragments are readily coaptated; occasionally they are not. In a case reported by Carl Beck the axes of the fragments were at right angles and they could only be kept in contact by holding the arm at a right angle to the body ("New York Med. Jour.," April 5, 1902). This position can be maintained with the patient in bed and wearing a Thomas splint, or with the patient up and about wearing an airplane splint. Albee, of New York, reported a series of these fractures treated by wiring and maintaining the arm at a right angle with the body. The result was complete preservation of function. Some surgeons treat this fracture by simply hanging the wrist in a sling and suspending a bag of shot from the elbow to make extension. The usual plan of treatment is as follows: abduct the arm to a right angle with the body, and carry up

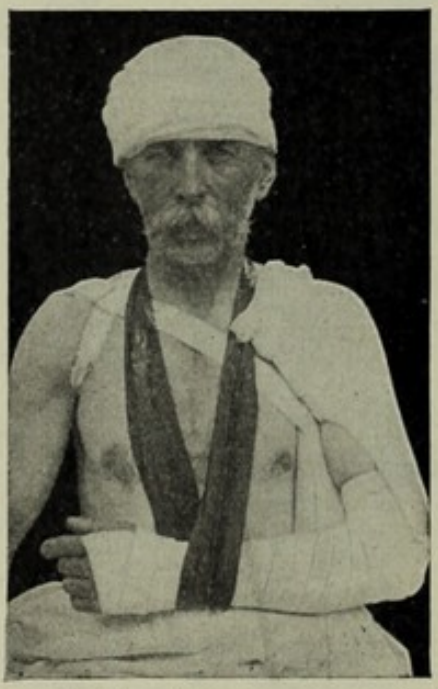


FIG. 349.—Fracture at upper end of the humerus. Note hand, forearm, and elbow bandaged; axillary pad and strap, plaster-of-Paris shoulder-cap, sling (Scudder).



FIG. 350.—Fracture at upper end of the humerus. Arm and elbow bandaged. Axillary pad and shoulder-cap in position. Application of circular bandage to trunk and shoulder. Sling not shown (Scudder).

from the base of the fingers to above the elbow the turns of a spiral reversed bandage made of flannel. Interpose lint between the arm and the side, and place a V-shaped pad with the apex upward in the axilla, tying the tapes over the opposite shoulder. A shoulder-cap made of pasteboard (Fig. 348, 8) or plaster-of-Paris (Fig. 349), molded to fit and well lined with cotton, is applied. The plaster-of-Paris cap is the most satisfactory. It is applied "so as to cover the whole shoulder, the anterior and posterior aspects of the chest, and the outer side of the upper arm down to the external condyle of the humerus" (Scudder, on "The Treatment of Fractures") (Fig. 349). The arm with the shoulder-cap is fixed to the side by the second roller of Desault, and the wrist is hung in a sling (Fig. 350). The edges of the bandage should be stitched together. This apparatus is changed daily for the first few days, the body and arm being rubbed at each change with alcohol, soap liniment, or ethereal soap. After this period a change every third or fourth day is often enough. Massage is begun at the end of one week, but rotation and motion of the joint are not employed until after three weeks. The dressings are removed at the end of four weeks, the forearm being carried in a sling for two weeks more. In impacted fracture do not pull apart the impaction, do not use a pad, but apply a cap to the shoulder and fix the arm to the side for five

weeks. The fracture unites usually with deformity, but the deformity is least if abduction appliances were used.

Fractures of the Surgical Neck of the Humerus.—The surgical neck is the constricted portion of bone between the tuberosities and the upper line of the insertion of the muscles on the bicipital groove. Fractures in this region are usually transverse, but they may be oblique. The *causes* are: direct force almost always; indirect force occasionally; and muscular action in rare instances. The common cause is a fall or blow upon the shoulder when the elbow is fixed. When the shoulder is fixed forcible abduction of the elbow may cause the fracture. The middle aged and the elderly are most liable to this fracture, but youths are not exempt. Over 13 per cent. of Ross's cases were under sixteen years of age ("Penn. Med. Jour.," 1914, xvii).



FIG. 351.—Internal angular splint and shoulder-cap in fracture of the surgical neck of the humerus.

The *symptoms* in fracture of the surgical neck are: pain running into the fingers from pressure upon the brachial plexus; crepitus; mobility on extension; and flattening, which differs from the flattening of dislocation in that it occurs farther below the acromion and that the bony process is not so prominent. Shortening to the extent of an inch is noted. The head of the bone can be felt in the glenoid cavity, but it does not move on rotating the arm. The upper end of the lower fragment is felt and moves on rotating the arm. The displacement is pronounced. The lower fragment is pulled upward by the deltoid, biceps, coracobrachialis, and triceps; inward by the muscles of the bicipital groove, and forward by the great pectoral; thus, the upper end of the lower fragment projects into the axilla, and the elbow stands out from the side and backward. Péan holds that the violence drives the lower fragment forward. The upper fragment is abducted, rotated outward, and flexed, which position is due, it is generally taught, to the action of the supraspinatus, infraspinatus, and teres minor muscles. In some cases displacement is forward, and in other cases it is not obvious. The lower fragment may impact into the upper, in which case the symptoms are obscure



FIG. 352.—Dr. J. J. Sweeney's case of comminuted fracture of surgical neck of humerus with luxation (slight) of head of humerus (radiographed by Sender).

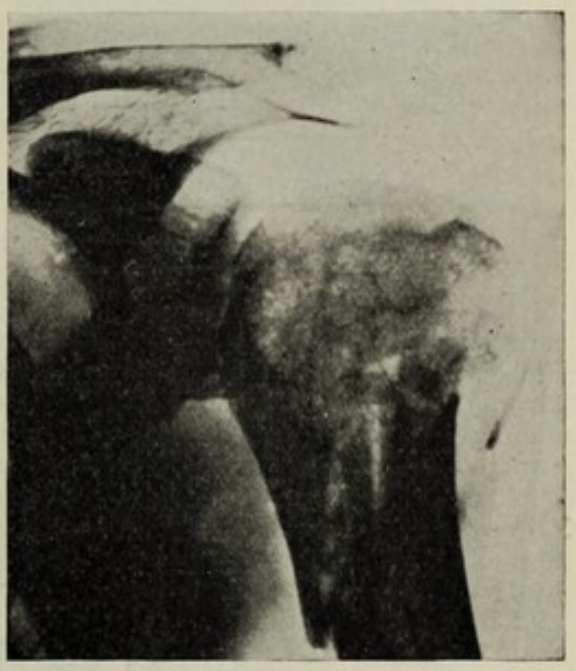


FIG. 353.—Fracture of surgical neck of the humerus (skiagraphed by Dr. Manges).

and the diagnosis is made by exclusion. If the impaction is solid and complete, there are the history of direct force, the impaired movements, the slight deformity, and the absence of crepitus. In all fractures of the upper end of the humerus the distinction can be made from dislocation by feeling the head of the bone under the acromion and by noting that it does not move on rotating the arm. Among complications are fracture of the tuberosities (nearly 18 per cent. of Ross's cases) and dislocation of the head of the bone (nearly 6 per cent. of Ross's cases).

The *prognosis* of fracture of the surgical neck of the bone is good.

Treatment.—Some surgeons treat a fracture of the surgical neck in exactly the same manner as a fracture of the anatomic neck. I prefer the following plan: In many cases give ether in order to examine and dress. Feel the pulse to see that the artery has not been damaged. Reduce by traction and manipulation, especially abduction. If there is an impaction do not pull it apart unless the fragments are in a vicious position. Take an internal angular splint (Fig. 348, 6) and pad it well, putting on extra padding at the points that are to rest against the palm, the inner condyle, and the axillary folds. Lay the arm and pronated forearm upon the splint. Apply a padded shoulder-cap. Fix the splint and cap in place with a spiral reversed bandage terminating as a spica of the shoulder, and hang the hand or forearm in a sling (Fig. 351). The dressing is to be worn for four weeks, and the rules to be followed in changing it are the same as in fracture of the anatomic neck. Massage is used after one week,

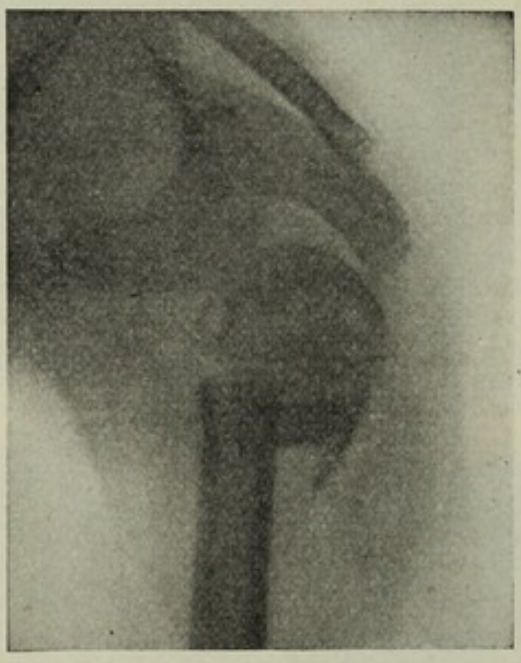


FIG. 354.—Fracture of humerus below surgical neck.



FIG. 355.—Fracture of middle of humerus.

and passive motion to amend stiffness after four weeks. Forcible breaking up of adhesions is not admissible for at least three months. In rare cases—those with strong anterior projection of the lower end of the upper fragment—apply an anterior angular splint. If the deformity strongly tends to recur, support by a plaster-of-Paris trough on the back and sides of the arm and shoulder, or sling the extremity and obtain extension by weights and pulleys used with a frame, the patient being kept in bed (Jones's extension splint is a very valuable appliance). In a case with great deformity abduction with extension is a very useful method. I have reached the conclusion that quite a number of cases of fracture of the surgical neck are best treated by incision and fixation. Operation is most often necessary if the upper end of the lower fragment is displaced to the outer side. If the fracture is complicated by a complete dislocation operation is needed to replace the head and fix the fragments. A partial dislocation may disappear under extension (Ross, Ibid.).

Longitudinal and Oblique Fractures of the Head of the Humerus.—By this term may be designated separation of the great tuberosity or separation of a portion of the articular surface, together with the great tuberosity from the shaft and lesser tuberosity (Pickering Pick, Guthrie, and Ogston). The *cause* is usually direct violence to the front of the shoulder, but the greater tuberosity may be torn off by muscular action.

The *symptoms* in longitudinal and oblique fracture of the head are broadening

and flattening of the shoulder, with projection of the acromion. The upper fragment passes upward and outward, and the lower fragment passes upward and inward to rest on the margin of the glenoid cavity below the coracoid process. The elbow is drawn from the side, there is some shortening, and the patient cannot abduct his arm. If the surgeon grasps the patient's elbow and holds it to the side and rotates the arm while with his other hand he grasps the upper fragment, crepitus is very positive. Examination develops wide separation of the fragments. The deformity cannot be entirely corrected because the biceps tendon is apt to get between the fragments (Ogston), but a useful limb can usually be obtained.

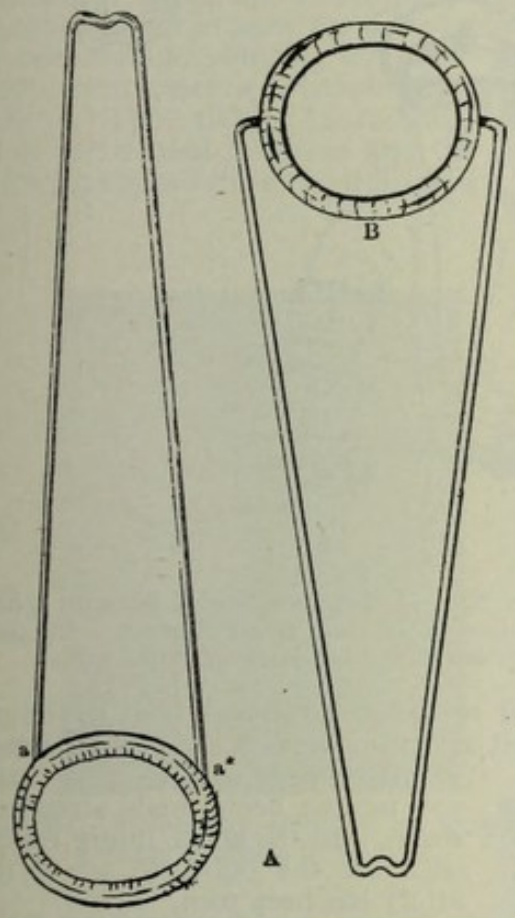


FIG. 356.—A, Thomas's splint for arm. This is bent to nearly a right angle at a, a* for transport on a stretcher. B, Thomas's arm splint with swivel.

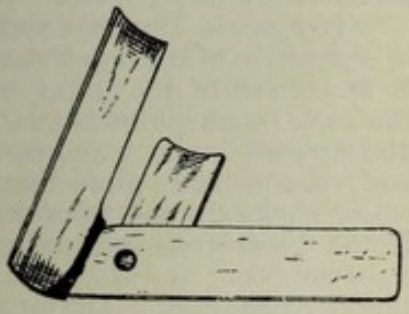


FIG. 357.—Bowlby's or Clarke's arm splint.

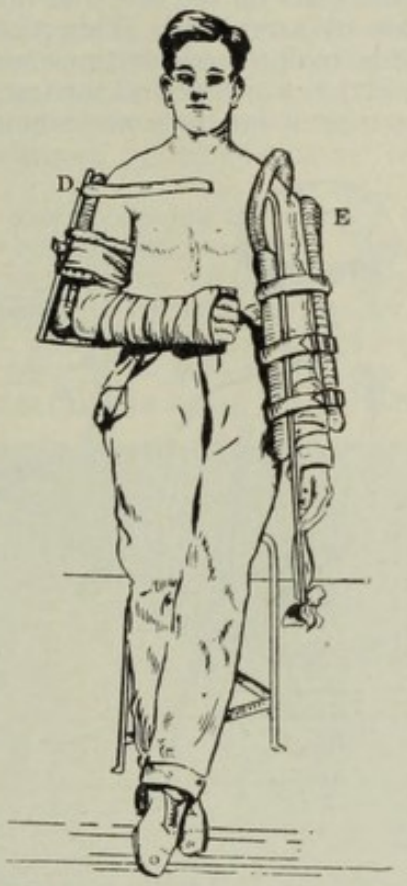


FIG. 358.—D, Bowlby's splint applied for fracture of right humerus. A narrow sling should also be used. E, Thomas's arm splint (bent near ring), applied for low fracture of left humerus.



FIG. 359.—A, Depage modified humerus splint. B, Applied for fracture of right humerus.

Treatment.—The plan which gives the best result in treating longitudinal and

oblique fracture of the head of the bone is to place the patient on his back upon a hard bed with a small, firm pillow under his head, abduct the arm above the head, rotate it outward so that the back of the hand rests on the bed, and hold it in place by sand-bags. This position should be maintained for three weeks, at the end of which period the fracture can be treated for three weeks more as a fracture of the anatomic neck. If the patient refuses to go to bed, treat the injury as a fracture of the anatomic neck, padding well over the tuberosities. The dressings should be worn for five weeks, passive motion being made after four weeks. In the above injury feel at once for the pulse, to see if the artery has been torn.

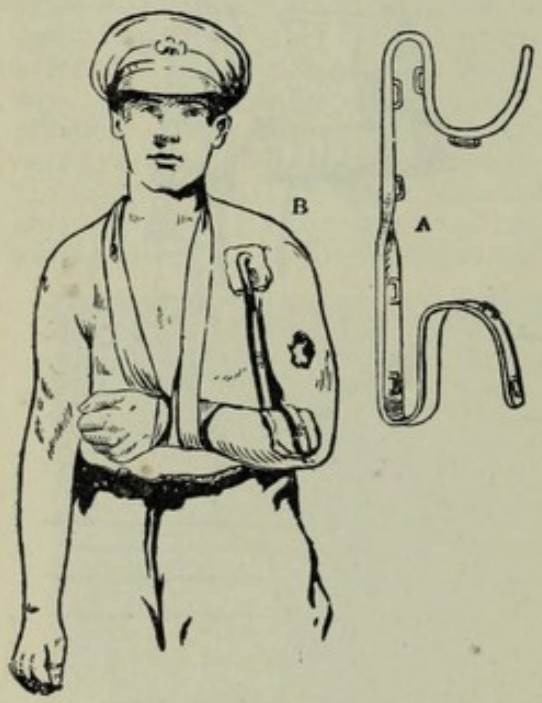


FIG. 360.—A, Extempore aluminum or strong wire splint for fracture of humerus. B, Applied for fracture of left humerus.

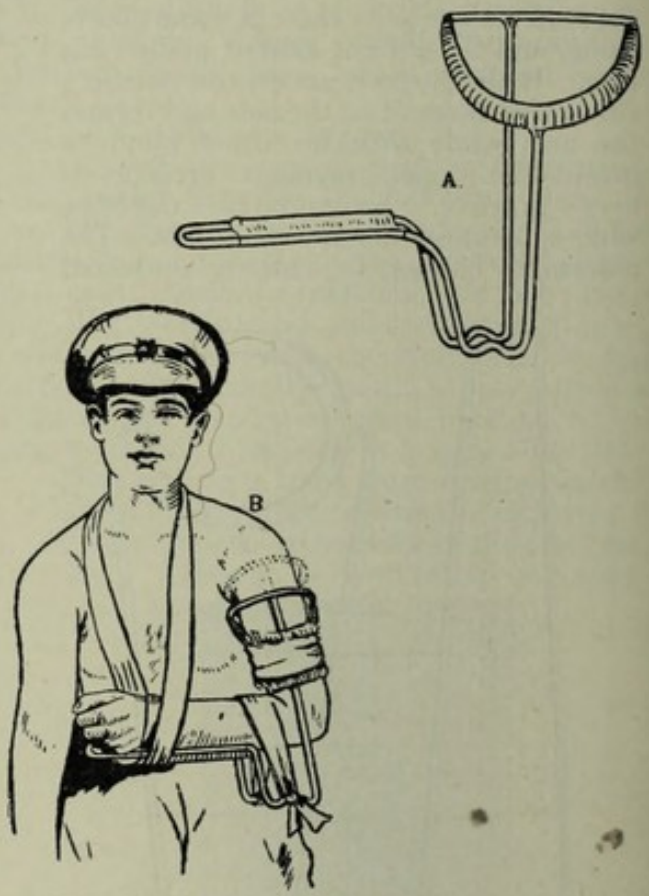


FIG. 361.—A, Jones's extension humerus splint. B, Applied for fracture of left humerus. The padded portion should be higher up in the axilla.

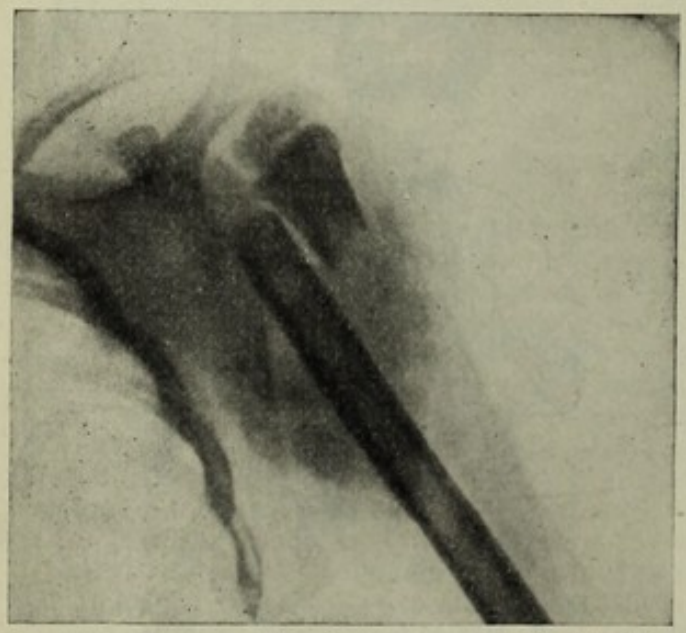


FIG. 362.—Fracture through the upper third of the humerus (skiagraphed by Dr. Manges).

Separation of the Upper Epiphysis of the Humerus.—The epiphysis is united during the twentieth year. Separation is a rare accident and is produced by direct force.

Symptoms.—The chief symptom in separation of the upper epiphysis is projection of the upper end of the lower fragment inward, forward, and upward beneath the coracoid, and consequently a projection of the elbow backward and from the side. If the lower fragment passes forward and not inward, the elbow simply passes back. The upper end of the lower fragment is smooth and convex. Rotation of the shaft develops soft crepitus when the fragments are in contact.

The *prognosis* is good for bony union, though the future growth of the limb may be impaired.

The *treatment* for separation of the upper epiphysis is a pad in the axilla, a shoulder-cap, binding the arm to the side, and hanging the hand in a sling. Wear the dressing for four weeks, and begin passive motion as directed when dealing with fracture of the upper end of the humerus.

Fracture of the shaft of the humerus is a very common accident. The *cause* is usually direct violence, such as a blow. The fracture may arise from indirect violence, such as a fall upon the elbow. Muscular action is occasionally a cause, as in throwing a ball, in catching a tree limb while falling, or in turning another's wrist outward as a test of strength (Treves). This test of strength is known by the French as "le tour de poignet."

The opponents sit opposite to each other and each rests his elbow on a table. They clasp hands and each one strives to rotate the other's hand outward. Ashhurst collected 57 cases due to throwing a ball and 23 cases due to "le tour de poignet." He believes that in some cases the humerus is broken as a stick may be broken by holding one end and swinging the other through the air, and that in other cases fracture results from twisting (Astley P. C. Ashhurst in "University of Pennsylvania Med. Bulletin," Feb., 1906). In fracture due to muscular action the break is nearly always below the deltoid insertion and the line of fracture approaches the transverse.

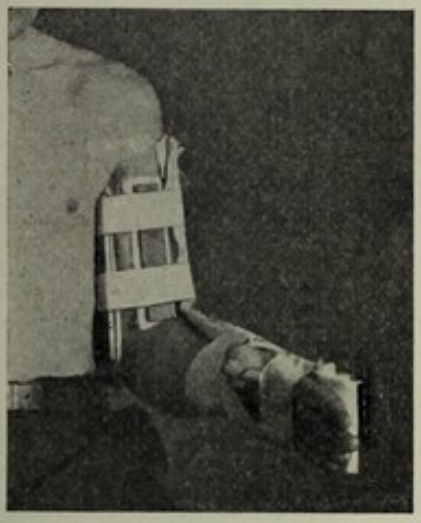


FIG. 363.—Preliminary splinting for complete dressing as shown in Fig. 364.

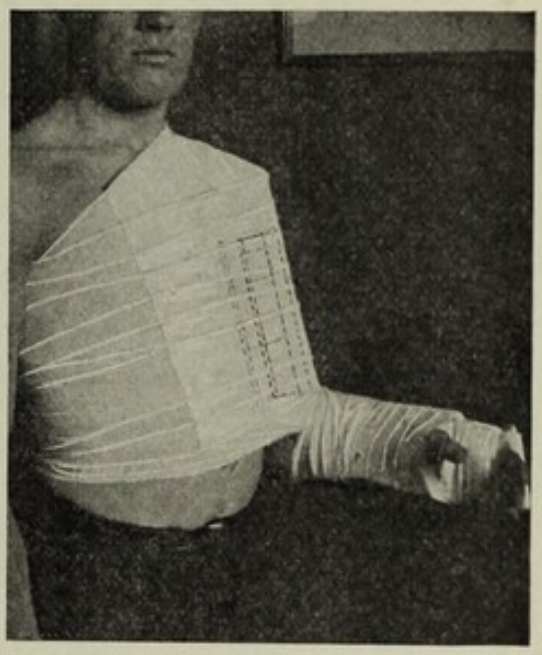


FIG. 364.—Apparatus for fracture of the shaft of humerus.

The *symptoms* of fracture of the shaft of the humerus are pain, tenderness, swelling, ecchymosis, inability to move the arm, mobility, and distinct crepitus. Shortening to the extent of ¾ inch occurs. The displacement varies with the situation of the fracture and the direction of the force. If the fracture is above the insertion of the deltoid, the lower fragment is pulled up by the triceps, biceps, and deltoid, and pulled out by the deltoid, and the upper fragment is pulled inward by the arm pit muscles. In fracture below the deltoid this muscle is apt to pull the lower end of the upper fragment outward, while the lower fragment passes inward and upward because of the action of the biceps and triceps. Injury of the *musculospiral nerve* sometimes occurs. The nerve may be contused, producing pain at the seat of bruising, and tingling and numbness in the region supplied by the nerve. In most cases the symptoms soon pass away, but sometimes neuritis ensues. A severe contusion produces not only pain, but paralysis of the muscles supplied by the nerve, and surface anesthesia. In most cases this condition is recovered from in a few weeks, but sometimes it lasts a long while or even permanently. In musculospiral paralysis the patient is unable to extend the wrist and fingers or to supinate the forearm. There is "complete loss or impaired sensation in the lower half of the outer and anterior aspect of the arm and in the middle of the back of the forearm as far as the wrist" (Scudder in "The Treatment of Fractures"). The nerve may be divided by a sharp fragment, paralysis of motion and anesthesia resulting at once. In some cases the nerve is caught in and compressed by callus, scar tissue, or fragments, motor and sensory disturbances resulting.

The *prognosis* is good, but the fact should always be remembered that ununited fractures are commoner in the humerus than in any other bone. Treves believes this to be due to entanglement of muscle between the fragments, lack of fixation of the shoulder-joint, and imperfect elbow support. Hamilton believes that it is due to the fact that the elbow soon becomes fixed at a right angle, and that any movement of the forearm moves the seat of fracture and not the elbow.

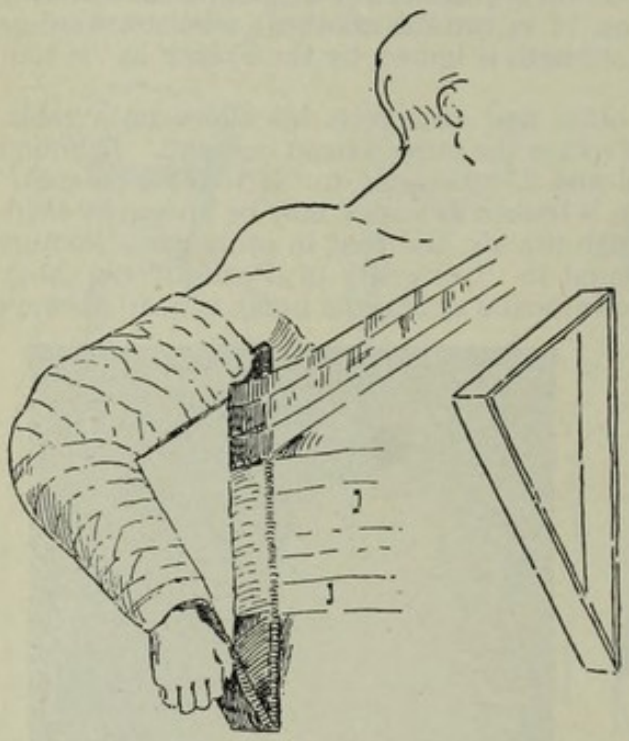


FIG. 365.—The humerus triangle. This splint is one of the most useful splints for the treatment of fractures of the arm and forearm (Hull).



FIG. 366.—Modified Thomas splint used by Sir Robert Jones in cases of fracture of the humerus (Hull).

Treatment.—It is rarely necessary to anesthetize unless the patient be a nervous woman or an excitable child. Feel the pulse, to be certain the artery has not been lacerated. Reduce the fracture by extension, counterextension, and manipulation. The injury may be treated by Bowlby's splint (Fig. 358), Jones's extension splint

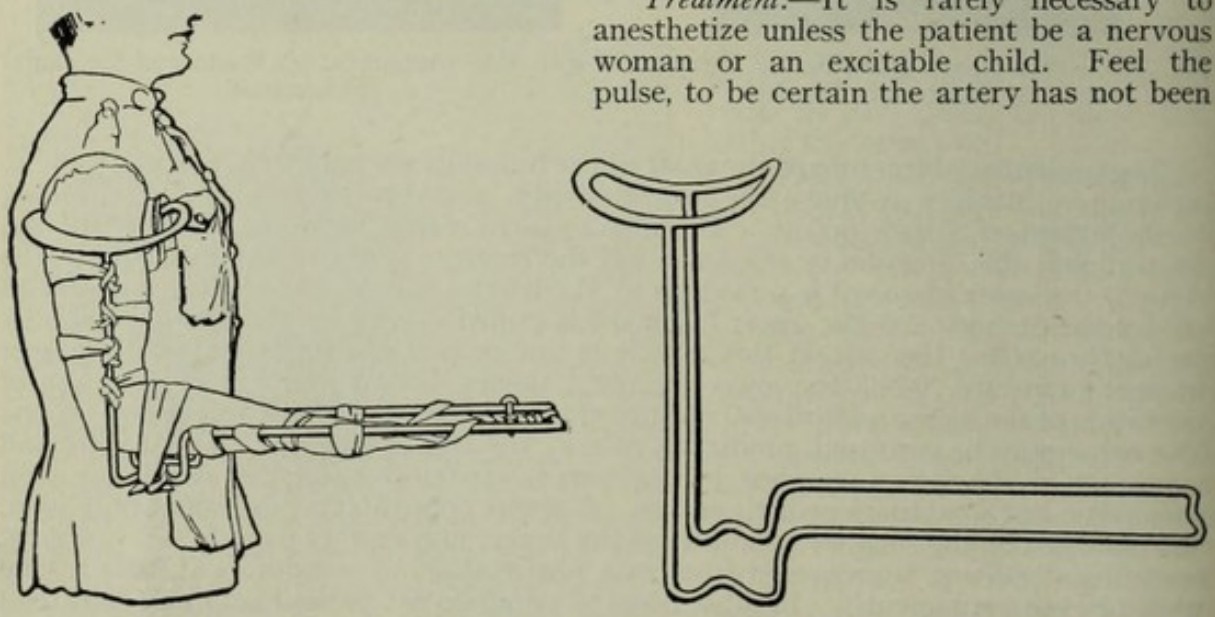


FIG. 367.—Jones's humerus traction splint. The American pattern of the splint is here illustrated. By changing the pattern of the axillary crutch the splint is made adaptable to either side of the body. By slightly lengthening the forearm piece traction on the forearm may be obtained (Osgood).

(Figs. 351, 366, 367), or Thomas's splint (Figs. 356, 358), or the humerus triangle (Fig. 365). Depage's splint (Figs. 359, 360) is a useful improvised appliance. Many use humeral splints (Fig. 355). The internal splint reaches from the axilla to just above the internal condyle of the humerus. A short straight splint is applied front and another back, each being the length of the arm. A shoulder-cap is applied, which cap "is prolonged below into an external angular splint reaching as far down as the lower third of the forearm" ("Manual of Surgical Treatment," by Cheyne and Burghard). The elbow is brought to a right angle with the arm and the forearm is placed midway between pronation and supination. As Cheyne and Burghard say: "It is necessary that the arm should hang vertically at the side with the long axis of the forearm parallel with the anteroposterior diameter of the trunk; if the forearm be brought at all forward across the chest, rotation of the lower fragment upon its vertical axis is apt to take place." Splints are to be worn for five or six weeks, and after the removal of the splints the wrist is hung in a sling. The sling is dispensed with eight weeks after the infliction of the injury. Passive movements are not to be made until the fracture is well united (after five or six weeks), for, if made too soon, they predispose to non-union, and, as no joint is involved, genuine ankylosis will not occur. Many surgeons

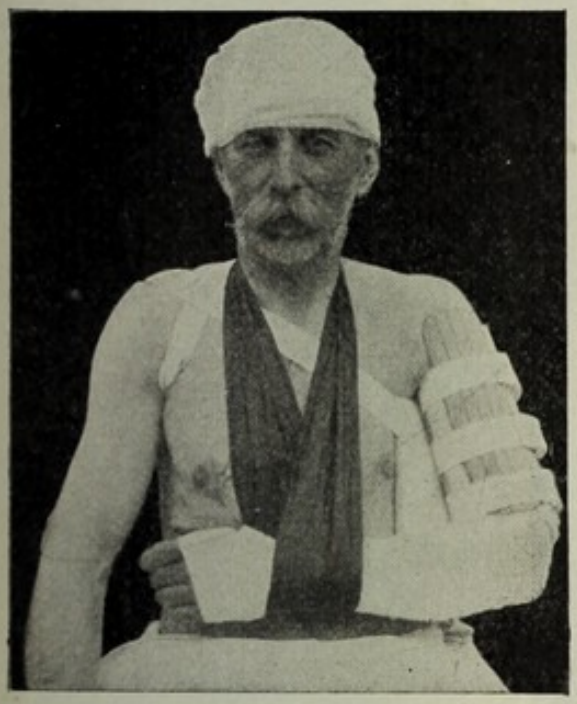


FIG. 368.—Fracture of the shaft of the humerus. Note bandage to hand, forearm, and elbow; axillary pad and strap; coaptation splints and sling. Bandage does not cover fracture (Scudder).

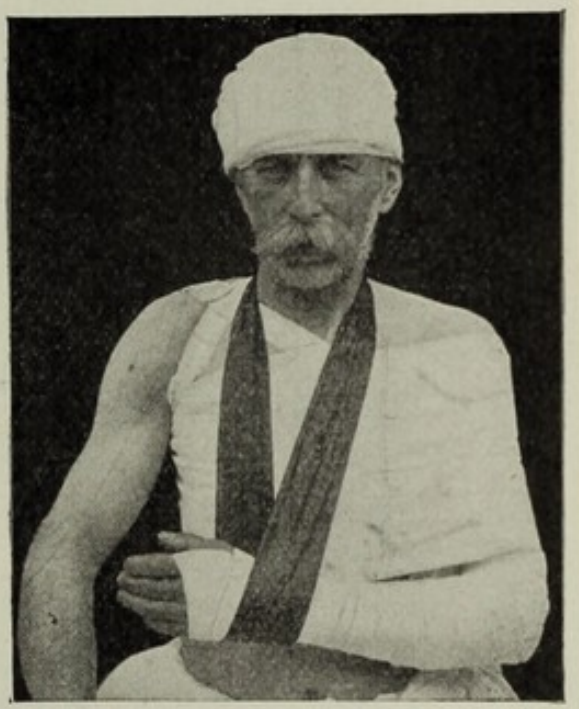


FIG. 369.—Fracture of the shaft of the humerus. Note bandage to hand, forearm, and elbow; adhesive-plaster swathe holding arm upon axillary pad and covering coaptation splints. Sling (Scudder).

treat these fractures by applying plaster of Paris to the forearm and the arm (the elbow being flexed to a right angle), binding the arm to the side, and hanging the wrist in a sling. Others apply a trough to the arm and forearm. With Scudder I usually prefer to bandage the hand, forearm, and elbow, and apply an axillary pad, coaptation splints, a swathe of adhesive plaster holding arm to the side, and a sling (Figs. 368, 369). In any case in which it is impossible to obtain and maintain correct apposition of the fragments, cut down upon them, and apply a plate. If the nerve is divided, an incision must be made at once, the nerve sutured, and the bone plated. If the nerve is caught in the callus after repair has taken place, it must be liberated by chiseling the callus away. Neuritis is treated by blisters over the nerve, the use of the descending galvanic current, and the administration of salicylate of ammonium and the bromids.

Fractures of the Lower Extremity of the Humerus.—These fractures are spoken of as fractures in, or in the neighborhood of, the elbow-joint, and they include: (*a*) fractures of the external condyle; (*b*) fractures of the internal condyle; (*c*) fractures of the internal epicondyle; (*d*) fractures at the base of the condyles; (*e*) T- or Y-shaped fractures; (*f*) epiphyseal separation, and (*g*) fractures of the capitellum and trochlea.

There may be more than one fracture, or there may be also a dislocation of the radius, of the ulna, or of both bones. Rarely the fracture is compound. These fractures are frequent injuries in childhood, and are not uncommon in adults.

Method of Examination.—A fracture of the elbow is rapidly followed by great swelling, and the diagnosis is often very difficult. When possible, the *x*-rays should be used in arriving at a diagnosis. In every case in which the *x*-rays are not used, and in most cases in which they are, the surgeon examines the parts carefully while the patient is under ether. If swelling is very great, it is necessary to abate it in order to reach any conclusion as to the condition. We can bandage the arm, rest it semiflexed on a pillow, and apply evaporating lotions or even an ice-bag for a few hours, or, what is better, temporarily diminish the swelling by Gerster's plan, which is as follows: Apply an Esmarch bandage from the hand to well above the seat of fracture; this will drive away extra-articular swelling and permit of thorough examination. It is a great advantage to have the patient anesthetized, for then not



FIG. 370.—Loss of "carrying function" after fracture of inner condyle of the humerus.



FIG. 371.—Anterior view of sprain fracture of right external condyle of humerus (Dr. J. Gowen, St. Joseph's Hospital Dispensary; rayed by Dr. Sender).

only can we make an accurate diagnosis, but we can reduce the fracture satisfactorily and apply a careful first dressing.

Compare the injured with the sound elbow. Note swelling and local ecchymosis. Feel for the radial pulse. Note the "carrying angle" (Fig. 374). Measure each arm from the tip of the acromion process of the scapula to the tip of the external condyle of the humerus. Feel each prominent bony point and note if it is mobile (condyles, olecranon, head of ulna). Feel the shaft just above the condyles. Mark with an anilin pencil on each elbow the tip of the external condyle, the tip of the internal condyle, and the tip of the olecranon, and observe the relation between these points of each elbow in flexion and in extension. In an uninjured elbow a straight line transverse to the long axis of the limb with the joint in extension will pass through the condyles and leave the tip of the olecranon just a shade above it. "When the elbow is at a right angle, these three points will be found in the same plane with the back of the upper arm" (Scudder in "The Treatment of Fractures"). Rotate the radius while a thumb is held against the head of the bone. Make flexion and extension of the elbow and determine if there is any lateral motion. Test for mobility just above the condyles.

The above maneuvers will determine the presence or absence of crepitus, preternatural mobility, deformity, etc.

Fractures of the External Condyle of the Humerus (Fig. 371).—A fracture of the external condyle runs into the joint and the capitellum is usually broken off. Such an injury occurs oftenest in children, being due to falling on the hand: but it may occur from direct force, and may happen to adults.

The *symptoms* of fracture of the external condyle are severe pain, great swelling, and crepitus (found on pressing or moving the condyle and on rotating the radius). Mobility may also be discovered. A projection is felt on the outer and posterior surface of the elbow. The forearm is semiflexed and supinated. The patient cannot use the joint.

Fractures of the Inner Epicondyle of the Humerus.—The inner epicondyle is an epiphysis which unites during the seventeenth year. It not infrequently breaks from muscular action or from direct violence, and the fracture does not involve the joint. Crepitus and mobility can be detected. Displacement is slight. The *outer epicondyle* is never fractured alone.

Fractures of the Internal Condyle of the Humerus.—The line of fracture after a break of the internal condyle runs into the joint through the trochlear surface of the humerus. The *cause* is nearly always direct violence. Packard, of Philadelphia, observed a case in which the condyle had been torn off while lifting a tub.



FIG. 372.—Fracture of the humerus at the base of the condyles (skiagraphed by Dr. Manges).

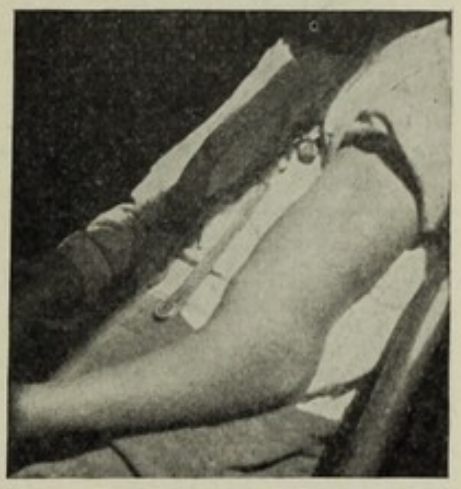


FIG. 373.—Dr. Ellis E. W. Given's case of supracondyloid fracture of humerus.

Symptoms.—In fracture of the internal condyle the fragment, accompanied by the ulna, goes upward and backward, and when the forearm is extended the ulna projects posteriorly, the lower end of the humerus being felt in front. The fragment forms a projection back of the elbow. Crepitus and preternatural mobility can be found if swelling is not too great. Crepitus is detected by flexing and extending the forearm. The space between the condyles is broader than normal, and the forearm takes a bend toward the ulnar side, the "carrying function" of the forearm being lost (Fig. 370). When a person carries a heavy object, such as a bucket of coal, he instinctively rests the inner condyle upon the pelvis, and the normal deviation of the forearm outward keeps the bucket from striking the leg. This deviation outward when the inner condyle rests against the ilium gives us the carrying function. In fracture of the inner condyle the broken condyle ascends and the "carrying function" is lost (Figs. 370 and 374). This deformity is known as *gunstock deformity*.

Fractures at the Base of the Condyles of the Humerus (Figs. 372, 373, 375, 376).—A fracture in this region is just above the level of the tip of the olecranon and is on a higher level behind than in front. The *cause* is direct force acting upon the olecranon.

The *symptoms* are loss of function, and pain from injury to the median or ulnar nerve. Crepitus and mobility are readily found. The lower fragment is drawn backward and upward by the action of the triceps, biceps, and brachialis anticus muscles. The lower end of the upper fragment projects in front of the joint. This lesion may

be mistaken for dislocation of the bones of the forearm backward. In fracture the limb is mobile; in dislocation it is rigid. In fracture the deformity is easily reduced and strongly tends to recur; in dislocation the deformity is reduced with difficulty and does not tend to recur. In dislocation there is shortening of the forearm, but not of the arm; in fracture there is shortening of the arm, but not of the forearm. In dislocation there is a smooth, large projection below the crease in front of the blow; in fracture there is a sharp projection above the crease. In fracture there is crepitus; in dislocation there is no crepitus.

The *diagnosis* can be settled by the *x*-rays.

T-fractures of the Humerus.—A T-fracture consists of a transverse fracture above the condyles plus a vertical fracture between them. The *cause* is violent direct force applied posteriorly.

The *symptoms* are increase in breadth of the joint (Fig. 377), preternatural mobility, crepitus, pain, and swelling. The internal condyle mounts up back of the elbow on

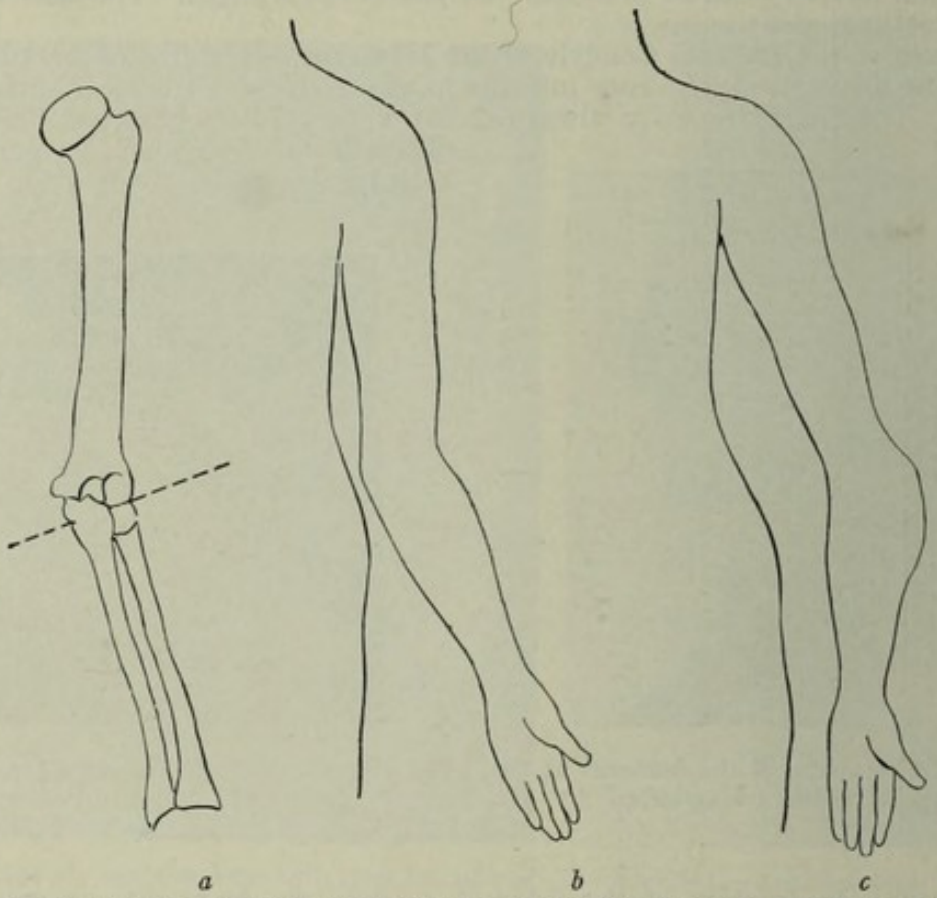


FIG. 374.—Diagram to exhibit the "carrying function" of the forearm, and the loss of this function in fracture of the inner condyle of the humerus: *a* and *b* show the normal relation of the parts when carrying; *c* shows the alteration of axis of the forearm when the inner condyle is fractured, what is known as gunstock deformity resulting (after Allis).

the inner side of the joint. The external condyle mounts up back of the elbow on the outer side of the joint. The forearm is semiflexed and supinated, and the carrying function is lost.

Prognosis of Fractures In or Near the Elbow-joint.—In some fractures it is difficult or impossible to obtain reduction, and in some it is impossible to maintain reduction. Stimson is undoubtedly right when he says that "in intercondyloid fracture with marked separation there is no practicable means merely to maintain reduction."[1] In fracture in or about the elbow-joint I have regarded the prognosis for complete restoration of function as poor, and believed that in most of these fractures some deformity and considerable stiffness are inevitable. Of late, however, influenced largely by Astley P. C. Ashhurst's study of "Fractures of the Lower End of the Humerus" ("Samuel D. Gross Prize Essay of Phila. Acad. of Surgery," 1910), I have been studying this question anew, and as a result take a less gloomy view of the situation, and am disposed to agree with Ashhurst that "in the vast majority of cases the ultimate results will be

[1] "Transactions American Surgical Association," vol. ix.

perfectly satisfactory." Nevertheless I am still cautious as to what I can safely predict to the patient and the patient's family. Ankylosis, partial or complete, is always a possible sequence. Ankylosis may result from prolonged immobilization, the muscles contracting and becoming fibrous, the fascia and ligaments about the joint shortening, the capsule shrinking and thickening, some of the cartilages becoming fibrous, and the joint being partly obliterated. It may result from extravasation of blood into the joint and tendon-sheaths with subsequent formation of fibrous tissue. It may arise from organization of inflammatory exudate within and about the joint and in the sheaths of muscles and tendons. It may arise from the formation of an excess of callus. Bruns claims that in fracture in the joint excess of callus rarely forms, and that masses of callus form chiefly in a line of fracture near but not in a joint.[1] Excessive callus formation is sure to take place if reduction is not thoroughly accomplished or if the fragments are not well immobilized, but move upon each other. A mass of callus in or about a joint limits or prevents motion. The two greatest causes of impaired function are blocking by callus and stiffness from traumatic arthritis (Jones, of Liverpool).

Treatment of Fractures In or Near the Elbow-joint.—Thoroughly set the fracture while the patient is under ether. It is advisable, when it can be done, to use the *x*-rays to confirm the diagnosis and to use them again after dressings have been applied, to be sure that the bones remain in good position. If swelling is very great, it may be necessary to delay setting for two or even three days, the arm being bandaged and laid upon a pillow or lightly supported on an anterior angular splint during the waiting period.

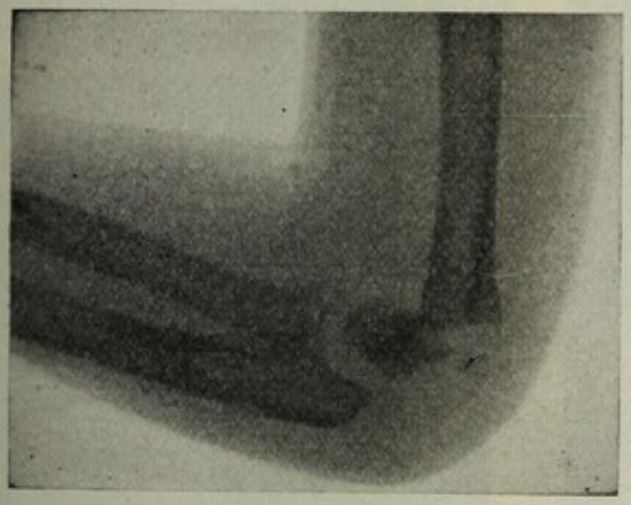


FIG. 375.—Supracondylar fracture of the humerus.

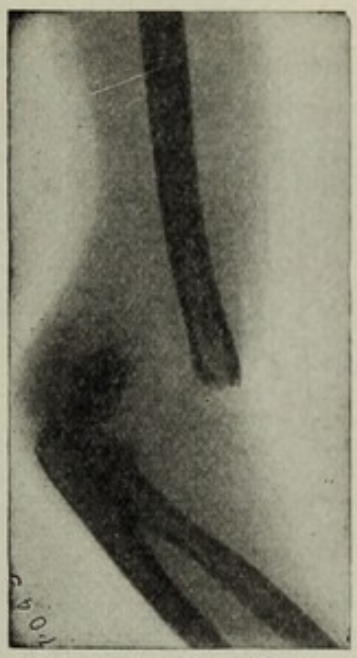


FIG. 376.—Fracture of the humerus above the condyles.

In all cases except transverse fracture above the condyles and fracture of the olecranon reduction is best effected by drawing upon the forearm, supinating it, extending it, and then bending it slowly into a position of acute flexion, the degree of flexion being in inverse ratio to the amount of swelling.

In transverse fracture above the condyles reduction is effected by drawing the forearm and the lower fragment downward and forward and at the same time pushing the upper fragment back.

Some surgeons advocate dressing the fracture on an anterior angular splint, the forearm being fully supinated (Fig. 348, 5). The advantage claimed for this splint is that if ankylosis occurs the joint is in a position to be useful, which it is not if ankylosed in extension. Some deformity is usually apparent after treating a case with this splint; the deformity following fracture of the inner condyle is not corrected by it, but if the splint is carefully applied the result is usually a useful extremity in all cases except fracture of the inner condyle. In transverse fracture of the shaft of the humerus above the condyles the anterior angular splint is the best method of treatment, as it prevents displacement. The splint must not be applied when there is great swelling, and swelling must be removed by resting the extremity on a pillow, the elbow being semiflexed, applying evaporating lotions or even an ice-bag, employing massage,

[1] Max Oberst in Volkmann's "Sammlung Vorträge."

and gently compressing by bandaging. In some cases the joint should be aspirated. In order to apply this dressing, take a right-angled splint and pad its outer surface, being careful to place thick, soft pads over the convexity which will press in front of the elbow and over each end of the splint. Fasten the upper end to the arm, then make extension of the forearm, and if the fracture is found to be completely reduced, fasten the hand and forearm to the splint (Fig. 378). If the hand and forearm are first fixed to the splint, there will be no extension from the elbow, and deformity will result. If posterior projection exists, a pasteboard cup is molded over the elbow. The extremity is hung in a triangular sling. At night the extremity is kept in the sling or laid on a pillow. Every third or fourth day, while the extremity is carefully steadied, the splint is removed, the arm and forearm well rubbed with alcohol, massaged, and the splint reapplied. The splint is worn between five and six weeks. At the end of the third week, after removing the dressings, slightly flex, slightly extend, and slightly pronate the forearm, and reapply the splint. At the end of the fourth week repeat this maneuver, making movements of greater range. In the middle of the fifth week and at the end of the fifth week do it again, and flex and extend as much as possible. Very early and very frequent passive motion is objectionable, as it leads to overproduction of callus and ankylosis, but passive motion as above described is imperatively necessary. Many surgeons at the end of the second week apply a Stromeyer splint, which permits the patient and the surgeon to make some motion by means of the screw without removing the dressings. In very stout persons an anterior angular splint will not stay in place. In such a case the forearm may be placed at a right angle to the arm and plaster



FIG. 377.—Deformity following T-fracture of the humerus.

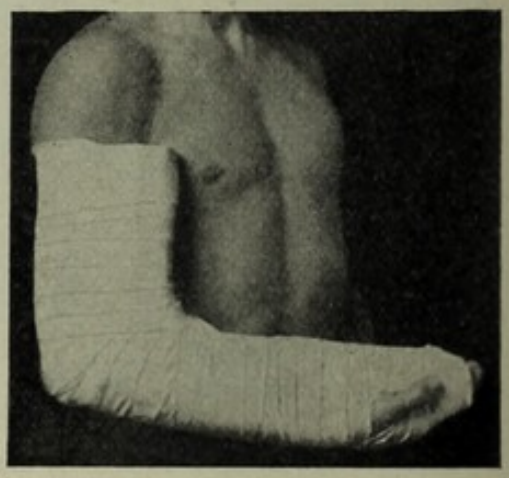


FIG. 378.—Anterior angular splint for fractures in or near the elbow-joint.

of Paris be used. After the dressings are removed employ passive motion, massage, hot and cold douches, baking, inunctions of ichthyol or mercurial ointment, iodin locally, corrosive sublimate and iodid of potassium internally, and direct the patient to use the arm systematically. If in any case after four weeks non-union exists, put up the arm in a plaster splint for three or four weeks more. Some surgeons use a posterior right-angled trough instead of an anterior angular splint.

Allis warmly advocated treating fractures in and about the joint in extension. He maintained that the extended position secures the best circulation, and if either condyle is unbroken secures the benefit derivable from a natural splint. Furthermore, in fractures of the inner condyle it restores the carrying function, which the flexed position does not do. For one week after the accident the patient stays in bed, with his arm extended upon a pillow. After swelling subsides the limb is wrapped firmly in a spiral flannel bandage and plaster of Paris is rubbed in or the bandage is covered with plaster.

Some surgeons extend the limb and apply an ordinary plaster bandage, and in about three weeks substitute an anterior angular splint. The trouble with treatment in extension is that if ankylosis ensues the limb is nearly useless. Furthermore, treatment in extension requires confinement to bed for at least a week.

Jones, of Liverpool, thinks that splints and bandages are largely responsible for

the stiffness which so commonly ensues upon an elbow injury. He advocates treatment by supination and acute flexion in all elbow injuries except fracture of the olecranon. It has been demonstrated that the position of acute flexion forces the fragments into place and holds them firmly between the coronoid process of the ulna, the trochlear surface of the humerus, the fascia, and the triceps tendon. The surgeon must be certain that the radial pulse is perceptible *after* the elbow has been flexed. Flexion is maintained by fastening a bandage around the wrist and neck. The bandage around the neck passes through a rubber tube, which serves to protect the neck. The ball of the thumb should rest against the neck. The bandage is fastened to a leather band around the wrist or to a glove the fingers of which have been cut off. The most convenient dressing to maintain Jones's position is shown in Fig. 379.

After the dressing has been applied certain precautions are to be observed. For the first week or ten days look at the arm daily. If the swelling grows worse, diminish the degree of flexion, and do the same if there is severe pain. If the radial pulse disappears, diminish the flexion until free circulation is obtained. This position is maintained from three to six weeks.[1] After the first two weeks lower the wrist an inch or two. At the end of three weeks make a little passive motion (just one movement in each direction). Passive motion and massage are applied as if an anterior splint were being used. The author has treated many cases by Jones's method, and now prefers

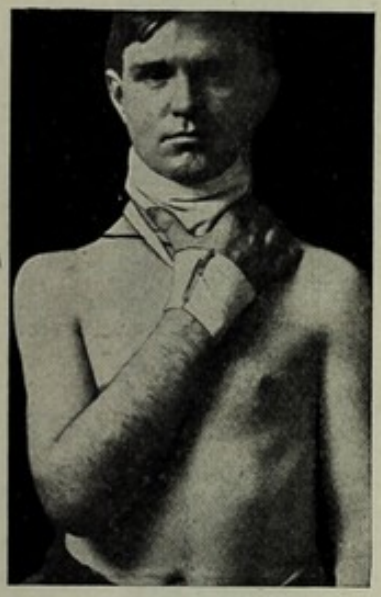


FIG. 379.—Jones's dressing for injuries of the elbow-joint.

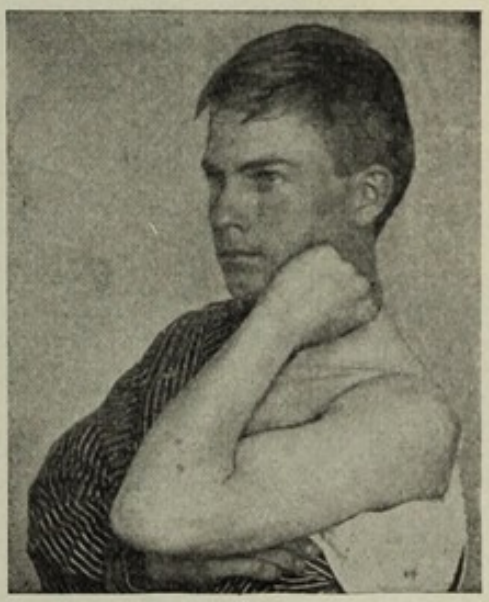


FIG. 380.—Fracture between the condyles treated by Jones's position. Degree of voluntary flexion obtained.

it to any other plan in all fractures of the elbow except fracture of the olecranon, transverse fracture above the condyles, fracture of the inner condyle near the line of the ulnar nerve, and fracture between the condyles in which the coronoid process gets between the fragments in flexion. The first-mentioned injury must be dressed in extension, the transverse fracture above the condyles requires an anterior angular splint, and the other two injuries should be treated in extension. If a fracture near the line of the ulnar nerve is treated in acute flexion, the callus poured out will be apt to entangle and press upon the nerve.

If it is found impossible to reduce the fragments or to maintain reduction we should make an incision and nail or screw the fragments in place. A comminuted fracture requires operation.

In *young children* the anterior angular splint must not be used. It will become loosened, and motion will inevitably take place at the seat of fracture. Such cases can be treated satisfactorily in Jones's position, the arm being held to the chest by plaster-of-Paris bandages, or they can be treated in extension. Bertomier's plan is very useful in young children.[2] The extremity is dressed without pressure in extension and supination. This can be effected by flannel bandages. In from four to eight days a silicate of sodium bandage is applied in order to prevent pronation. About the

[1] "Provincial Medical Jour.," Dec., 1894, and Jan., 1895.

[2] "Révue de Chir.," vol. viii, 1888.

sixteenth day the bandage is cut so as to form two troughs. From this period every third day the splints are removed and gentle passive motion is made. The splints are removed permanently at the end of four weeks.

If *false ankylosis* follows fracture of the elbow, the adhesions should be broken up under ether, and for some time the hot-air apparatus should be used daily, and massage, passive motion, and the hot and cold douche should be employed. In *true ankylosis* an operation should be performed and the interlocking callus or the interposed tissue or fragment be removed, if a skiagraph shows that operation promises success. If gunstock deformity results and produces marked disablement, it should be operated upon. An osteotomy is performed on the inner condyle. The arm is set in the extended position, plaster of Paris applied, and is not removed for six weeks.[1]

Separation of the lower epiphysis of the humerus is not a very unusual accident. The inferior extremity of the humerus may be separated, or the condyles may be separated from each other and from the shaft of the bone.

The *symptoms* are prominence in front of the joint, caused by the lower end of the shaft of the humerus; projection backward of the olecranon; the forearm rests



FIG. 381.—Fracture between the condyles treated by Jones's position. Degree of voluntary extension obtained.

midway between pronation and supination. Epiphyseal separation may retard growth and produce deformity.

Treatment.—Jones's position or an anterior splint as above directed.

Fractures of the ulna comprise the following varieties: (1) Fracture of the coronoid process; (2) fracture of the olecranon process; (3) fracture of the shaft, and (4) fracture of the styloid process.

Fractures of the coronoid process of the ulna (Fig. 382) are rarely observed, and practically occur only as a complication of backward dislocation of the ulna or in association with other fractures.

Symptoms.—When fracture of the coronoid process is associated with a dislocation, crepitus is appreciated on reduction, and it is found that the deformity of the dislocation promptly returns on cessation of extension. The upper fragment may be pulled upward by the brachialis anticus muscle, and there exists an inability to flex the forearm completely. The position is one of extension with posterior projection of the olecranon. The broken piece is felt in front of the joint.

The *treatment* is by an anterior splint the angle of which is less than a right angle. Jones's position may be used in treating such a case. A stiff joint may follow.

[1] G. G. Davis, "Phila. Med. Jour.," May 13, 1889.

Fractures of the olecranon process of the ulna occur not uncommonly in adults. Hulke states that such a fracture never occurs before the age of fifteen, but the writer has seen in the Jefferson Medical College Hospital a girl aged fourteen with a fractured olecranon. The *cause* is direct violence or muscular action. Only a small fragment may be torn away, or the entire olecranon may be broken off, and the break may be comminuted or may even be compound (Figs. 383, 384).

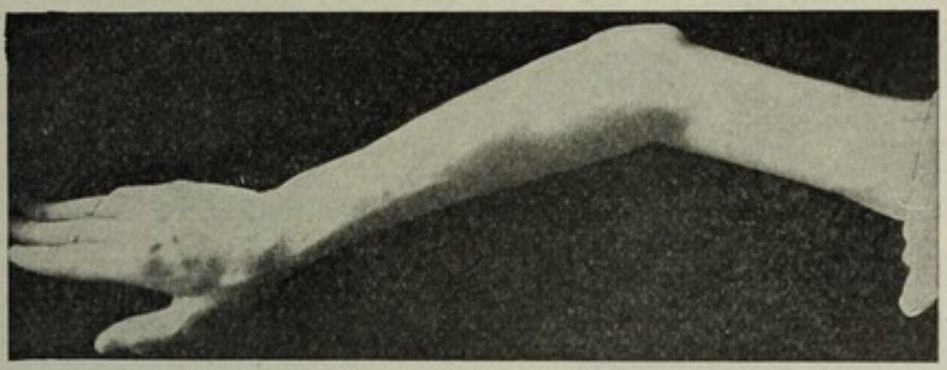


FIG. 382.—Fracture of coronoid process.

The *symptoms* of most fractures of the olecranon are: swelling; partial flexion of the forearm; separation of the fragments, the upper piece being pulled up from ½ inch to 2 inches by the triceps; the space between the fragments is increased by flexion at the elbow, and lessened by extension at the elbow; and there is inability to extend the arm. Bulging of the triceps and crepitus on approximating the fragments are observed. In some few cases there is no separation, the periosteum being untorn or the fascial expansions from the triceps holding the fragments in apposition. In such cases crepitus can be elicited by rocking the upper fragment from side to side.



FIG. 383.—Fracture of the olecranon process of the ulna (skiagraphed by Dr. Manges).



FIG. 384.—Comminuted fracture of the olecranon process of the ulna (Misericordia Hospital case; skiagraphed by Dr. Pfahler).

When treated by non-operative methods the *prognosis* is usually fair, fibrous union being the rule. Some joint stiffness usually occurs, and much ankylosis may be unavoidable. The prospect of a freely movable joint is better when extra-articular wiring is practised.

Treatment.—Fracture of the olecranon is usually treated with a well-padded anterior splint almost, but not quite, straight. A perfectly straight splint is uncomfortable, and by opening a retiring angle between the fragments and into the joint favors non-union and ankylosis. The splint should reach from a level with the axillary margin to below the fingers. If the upper fragment does not come in contact with the lower, pull it down by adhesive plaster and fasten the strips to the splint. The author

in one case employed a glove to which strings from the adhesive plaster were attached. While wearing the splint keep the patient in bed, otherwise the dependent position will cause much swelling. At least, if the patient sits up, keep the extremity on a pillow. The danger of ankylosis in this fracture is very great, and, in case it occurs in the position of extension, an almost useless arm results. Follow the rule of T. Pickering Pick, and at the end of three weeks anesthetize the patient, press the thumb firmly down upon the top of the olecranon, carry the forearm slowly to a right angle, and apply an anterior angular splint and direct it to be worn for two weeks. When the anterior splint has been applied, passive motion should be made every other day, or every third day, and massage should be used at the same time. When the splint is removed, try to increase the range of motion as previously directed. Surgeons usually incise and apply wires only when it is found impossible to secure apposition of the fragments after fracture of the olecranon. Such a course is, I am persuaded, injudicious conservatism. I do not advise that the rule should be to treat fractures of the olecranon as a routine by opening and wiring, but I do advise that we should treat them by extra-articular operation

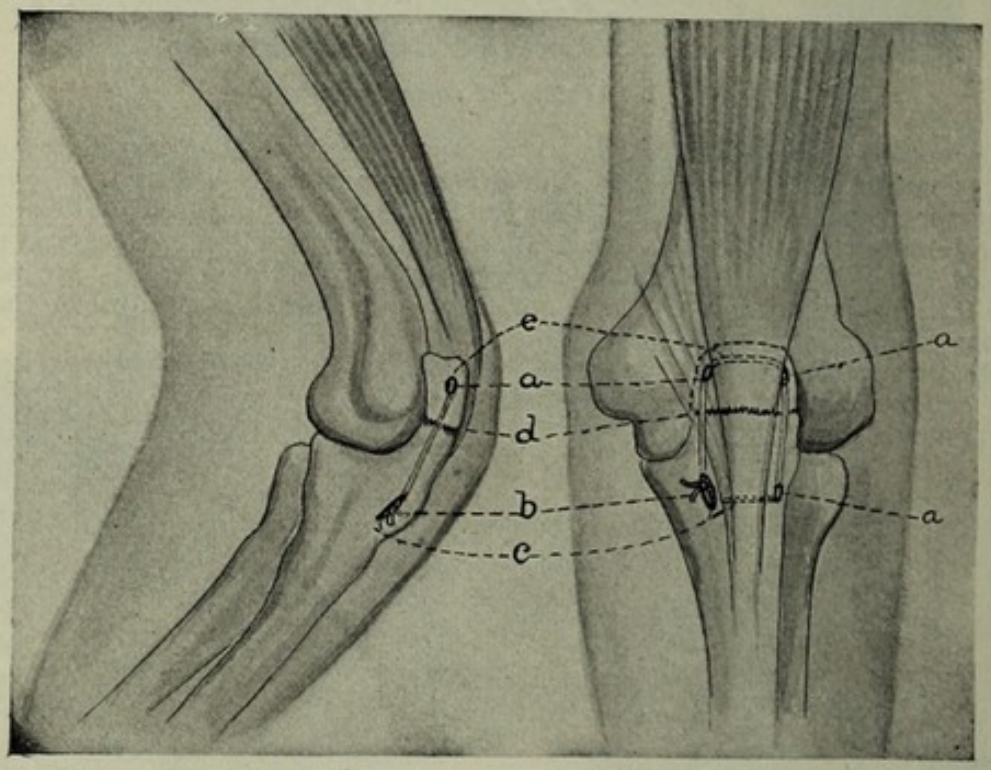


FIG. 385.—Murphy's method of treating fracture of the olecranon by subcutaneous extra-articular wiring. Lateral view and posterior view. Wiring the fragments of the olecranon together: *a*, Incision; *b*, twist or tie of wire; *c*, hole drilled in bone for passage of wire; *d*, fracture; *e*, passage of wire through tendon of triceps. (Murphy.)

and wiring as advocated by John B. Murphy ("Jour. Amer. Med. Assoc.," Jan. 27, 1906). The conservative non-operative treatment often fails. Sometimes the fragments cannot be approximated, frequently they cannot be maintained in approximation, and not unusually a stiff or actually ankylosed joint results. Murphy thus describes the operation which should be done ("Jour. Amer. Med. Assoc.," Jan. 27, 1906) (Fig. 385): "A longitudinal incision ⅓ inch long was made on the external aspect of the ulna, ½ inch from its articular surface, and tissues were divided to the bone. A smaller incision was made on the corresponding inner side. I perforated the base of the olecranon with an eyelet drill, which ran transversely from outward inward. I threaded the drill with a fine aluminum-bronze wire, drawing it through this transverse canal. The wire was carried upward under the skin on the inner surface of the elbow and then drawn out through another small incision, 1/16 inch, made at the level of the apex of the olecranon. The wire was then reinserted and directed transversely from inward outward, passing it through the tendon of the triceps above the olecranon, and then drawn out to corresponding outward point through a very small incision similar to that made on the inner side. The wire was again reinserted and pushed downward under the skin until it was finally brought out through the initial external

incision. The circle once completed, traction was exerted on the wire until I was sure that the two fragments were in perfect coaptation, the latter being easily and satisfactorily accomplished. The ends of the wire were twisted several times and then divided by scissors close to the bone. By this procedure the skin was incised at four points, the largest incision being ⅛ inch in length." The extremity is placed in flexion upon an anterior splint, which is worn for four weeks. Passive motion is begun on the third day. A compound fracture and a comminuted fracture always require operation, in which the joint is freely opened. Non-union requires opening of the joint and wiring of the fragments.

Fractures of the shaft of the ulna alone are most usual near the middle of the bone, are always due to direct violence, and are not infrequently compound. An injury which breaks the ulna is very apt to break the radius also.

Symptoms.—By running the finger along the inner surface of the bone there are detected inequality and depression; crepitus and mobility are easily developed; there

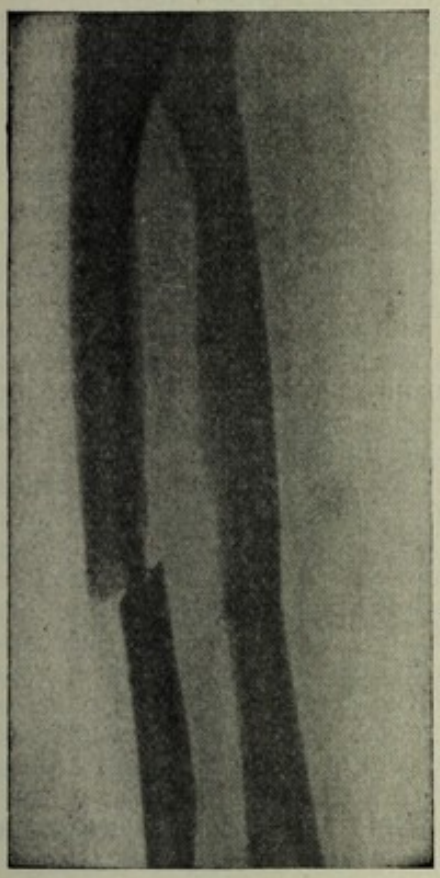


FIG. 386.—Fracture of the shaft of the ulna (case in the Pennsylvania Hospital; skiagraphed by Dr. Gaston Torrance).

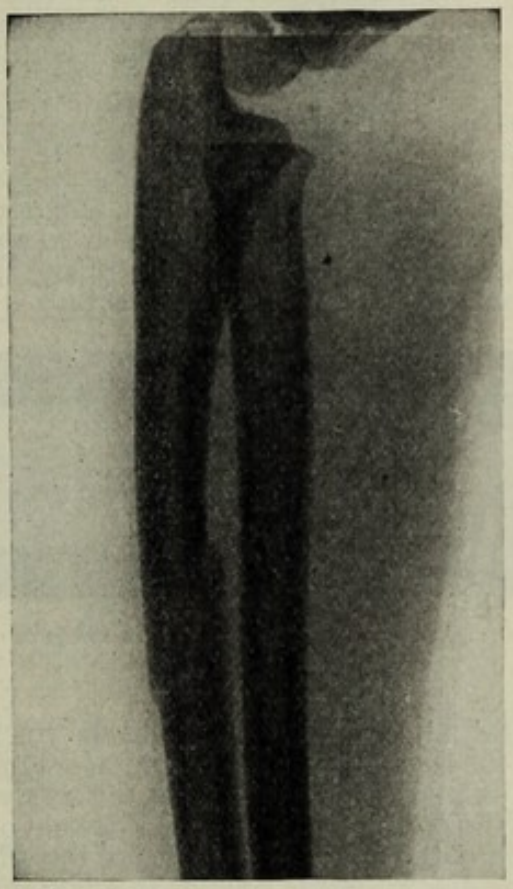


FIG. 387.—Fracture (oblique) of shaft of the left ulna. Lateral view.

are pain and the evidence of direct violence. The long axis of the hand is not on a line with the long axis of the forearm, but is internal to it. If deformity exists, it is due to the lower fragment passing into the interosseous space because of the action of the pronator quadratus; the upper fragment, acted on by the brachialis anticus, passes a little forward (Figs. 386 and 387). The forearm at and below the seat of fracture is narrower and thicker than normal.

Treatment.—In treating fracture of the shaft of the ulna place the forearm midway between pronation and supination, so as to bring the fragments together and to obtain the widest possible interosseous space, and thus limit the danger of union taking place between the radius and ulna. The position midway between pronation and supination is obtained by flexing the forearm to a right angle with the arm and pointing the thumb to the nose. Take two well-padded straight splints, one long enough to reach from the inner condyle to below the fingers, the other from the outer condyle to below the wrist; place a long pad of lint over the interosseous space on the flexor side of the limb, and another on the extensor side; apply the splints and hang the forearm in a triangular sling (Fig. 388). Passive motion is to be begun in the third week, and the

splints are to be worn for four weeks. Fractures of the ulna can be treated very efficiently by plaster of Paris. The best results are secured by wiring or plating.

Fractures of the styloid process of the ulna are due to direct force. The displacement is obvious.

Treatment.—In treating fracture of the styloid process push the fragment back into place and use a Bond splint with a compress for four weeks, or apply a plaster-of-Paris dressing.

Fractures of the radius include the following varieties: (*a*) Fractures of the head; (*b*) fractures of the neck; (*c*) fractures of the shaft, and (*d*) fractures of the lower extremity.

Fracture of the head of the radius has been studied by Dr. T. Turner Thomas ("University of Penna. Med. Bulletin," Oct., 1905; and "Annals of Surgery," Aug., 1907). He has furnished me with the following résumé of his views, with which I entirely agree:

"Fracture of the head of the radius is not infrequent, and is usually the result of a fall on the hand with the elbow in extension and the forearm in pronation. In extension of the elbow the capitellum of the humerus is in contact with only the anterior part of the radial head. Since the carpus articulates almost entirely with the radius, the force of the usual fall on the hand is transmitted almost entirely through this bone, and at the elbow is received by only the anterior part of the radial head. According to the degree of violence applied, more or less damage may be done to the head, or head and neck. The anterior portion of the rim may be split off, the intact ulna preventing the humerus from pursuing the detached fragment and pushing it away from its fellow, and the intact orbicular ligament holding the two in close apposition. This uncomplicated fracture is the most common, but the least troublesome. Union with ultimately good function is the rule, even though the fracture go unrecognized and untreated, because of the close splinting by the untorn orbicular ligament. Since it is a fall on the outstretched hand, which usually produces Colles's fracture, fracture of the external condyle of the humerus, fracture of the neck of the radius, fracture of the coronoid process of the ulna, posterior dislocation of both bones of the forearm, and fracture of the clavicle, any one or several of these injuries may complicate the fracture of the radial head. When the anterior part of the head breaks off the bony resistance to the descent of the capitellum by the radius is lost, so that if the force of the accident is severe enough, lateral bending of the elbow to the radial side with further descent of the capitellum may result with greater separation of the fragments, tearing of the orbicular ligament, and more damage to the head. The descent of the condyle in a posterior dislocation may carry before it the detached fragment of the head, and this fragment be left buried in the tissues of the forearm a considerable distance below its normal position after the dislocation has been reduced.

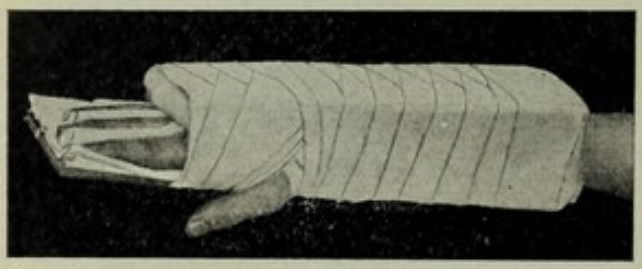


FIG. 388.—Two straight splints in fracture of both bones of the forearm.

"*Prognosis.*—In the vertical or oblique fissured fracture of the head with close approximation of the fragments, after union takes place, limitation of all movements of the elbow results from adhesions and slight irregularities in the bone. The function rapidly returns in the succeeding weeks, although some limitation of extension will continue for months. More marked irregularity in the circumference of the head may last much longer and may produce permanent limitation of rotation. Bony union between the head and corresponding surface of the ulna will prevent all rotation of the forearm. In either case flexion and extension usually return almost if not completely. Non-union of the fragments may induce pain and limitation of movement, especially on rotation; but with close approximation of the fragments and an untorn orbicular ligament, an apparently perfect return of function may follow, the fragments moving smoothly as one piece within the ligament. The prognosis will depend chiefly upon the degree of damage done to the head and the separation of the fragments.

"*Symptoms.*—The most characteristic feature of this fracture is its obscurity. The thick muscular covering of the radial head, except posteriorly, the splinting effect of the orbicular ligament, and the close contact of the head with the humerus and

ulna, make the diagnosis of the small intra-articular fracture particularly difficult. In the uncomplicated vertical fracture there will usually be no movements of the fragments on each other, and, therefore, no crepitus, and there will be no deformity. A history of a fall on the hand; some swelling of the elbow, particularly on the radial side; severe pain and limitation in all movements of the elbow, particularly on rotation; pain and tenderness distinctly localized to the head of the radius; and the exclusion of fracture of the humerus, ulna, and the shaft of the radius, will point strongly to a fracture of the head of the radius. If the injury is treated as a fracture, and two or three weeks later, when fixation is removed, there is marked limitation of all movements of the elbow, the diagnosis will be more than reasonably assured. The *x*-ray may be misleading unless directed in the line of the fracture, and this is not easy to accomplish, since the position of the fragments in their relation to the humerus varies with every change in rotation of the forearm. In most cases an exposure to the *x*-ray in the transverse plane of the humeral condyles, with the forearm in pronation, will give a successful skiagraph. If the *x*-ray is directed at right angles to the line of fracture the skiagraph will usually be negative. If the fragments are freely separated and if crepitus is elicited, the diagnosis will be more easily determined.

"*Treatment.*—In the uncomplicated fracture without crepitus or deformity, Jones's position or a right-angled splint for three weeks will be sufficient. The resulting fibrous ankylosis will largely disappear from forced use in the following weeks, but several months will be necessary before extension is complete. If crepitus is present, four or five weeks' fixation will be better, and in this case the return of function will probably take longer. As a rule, if union is obtained, function will return. If pain on movement persists for many months, a detached fragment or the whole head should be excised. Marked limitation of movement from enlargement of the head or bony union between it and the ulna calls for excision of the head."

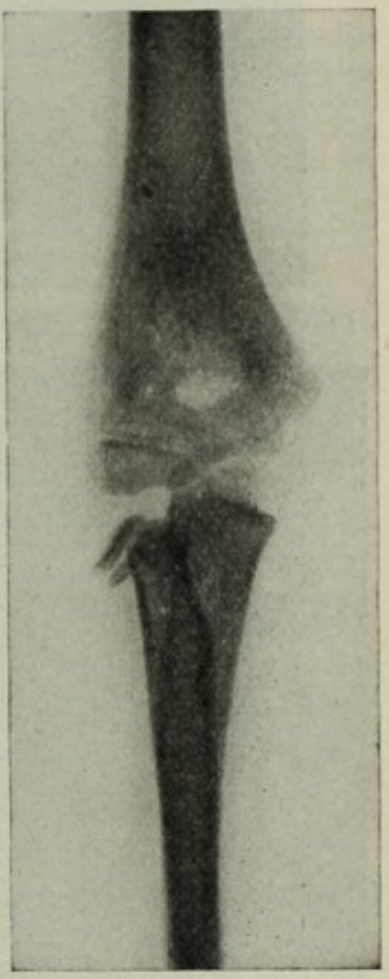


FIG. 389.—Professor Gibbon's case of fracture of the neck of the radius, with an epiphyseal separation and separation of a portion of the diaphysis (Manges).

Fracture of the neck of the radius (Figs. 389, 390) is by no means so rare an accident as was thought before the discovery of the *x*-rays. It seldom occurs alone and is usually associated with fracture of the radial head. These fractures are transverse and frequently impacted. The cause is a fall upon the pronated hand when the forearm is extended.

Symptoms.—In this fracture the forearm is pronated and the patient is found to have lost the power of voluntary pronation and supination. Under forced pronation and supination it will be noted that the head of the radius does not move unless there is impaction. Crepitus is sometimes absent because of impaction. Thomas points out that there is angulation of the neck due to driving of the radial head downward and forward ("Annals of Surgery," Aug., 1907). Reduction is always difficult and may be impossible.

The *treatment* for fracture of the neck of the radius is the same as for other fractures of the elbow-joint, namely, an anterior angular splint or Jones's position.

Fracture of the shaft of the radius (Fig. 391) is far commoner than fracture of the shaft of the ulna. It may occur above or below the insertion of the pronator radii teres muscle. It may arise from either direct or indirect force. Fracture of the shaft of the ulna may coexist as a result of the same accident.

Fracture of the Shaft of the Radius Above the Insertion of the Pronator Radii Teres Muscle.—*Symptoms.*—The upper fragment is drawn forward by the biceps and is fully supinated by the biceps and the supinator brevis. The lower fragment is fully pronated by the pronator quadratus and pronator radii teres, and its upper end is pulled into the interosseous space. There are crepitus, mobility, pain, narrowing and thickening of the forearm below the seat of fracture, and loss of the power



FIG. 390.—Fracture of the neck of the radius.

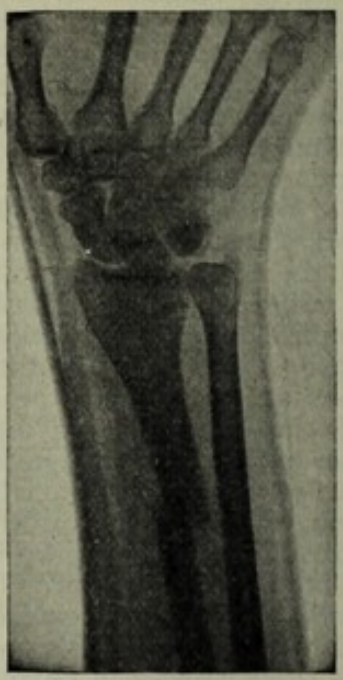


FIG 391.—Fracture of the shaft of the radius alone.

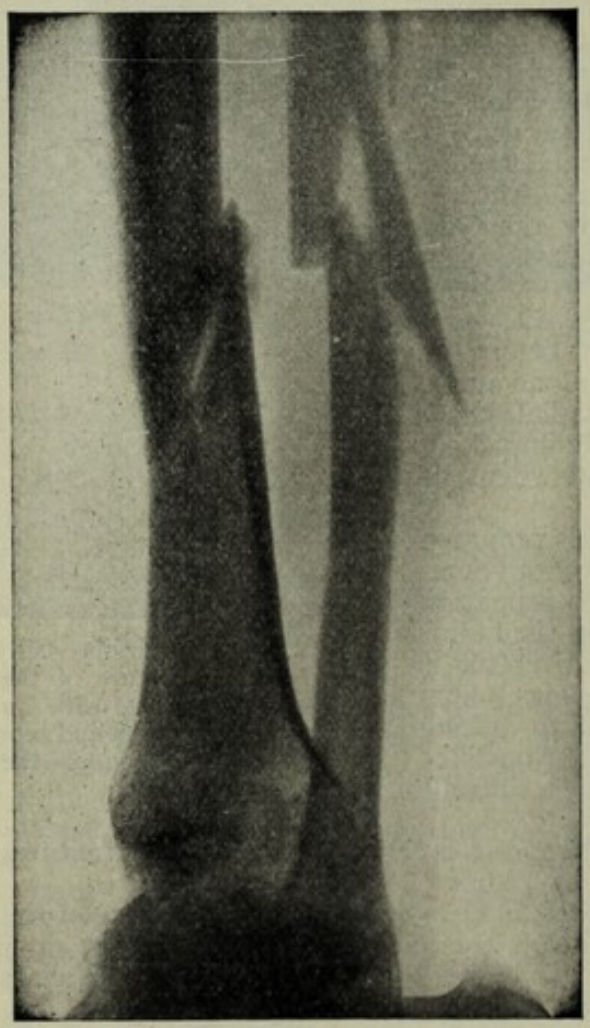


FIG. 392.

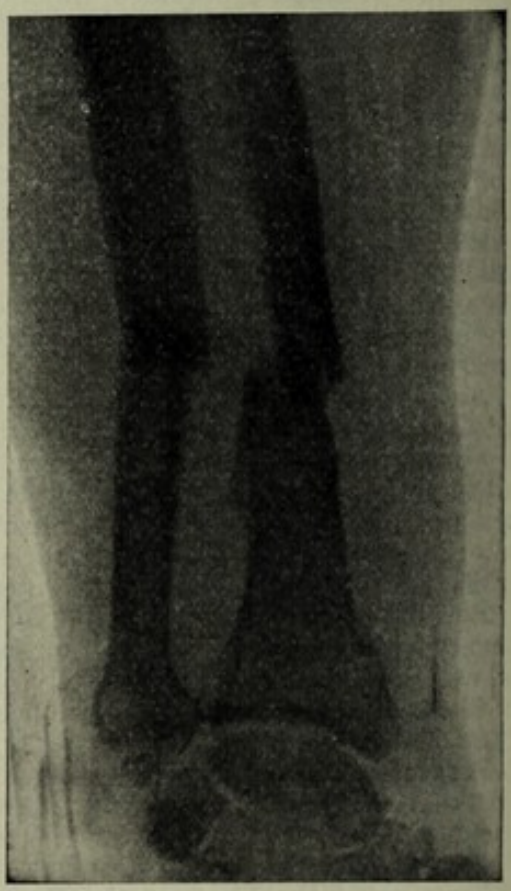


FIG. 393.

FIGS. 392, 393.—Fracture of both bones of the forearm (shafts).

of pronation and supination. The head of the bone is motionless during passive pronation and supination. The hand is prone.

Treatment.—In treating this fracture do not put the forearm midway between pronation and supination, as this position will not bring the fragments into contact, the upper fragment remaining flexed and supinated. To bring the lower fragment in contact with the upper, flex and fully supinate the forearm. Apply an anterior angular splint to the extremity for four weeks, and begin passive motion in the third week.

Fracture of the Shaft of the Radius Below the Insertion of the Pronator Radii Teres Muscle (Fig. 391).—In this variety of fracture the upper fragment is acted on by the biceps, the supinator brevis, and the pronator radii teres, and it remains about midway between pronation and supination, passing forward and also into the interosseous space. The lower fragment is acted on by the supinator longus and the pronator quadratus, the latter being the more powerful of the two, hence the lower fragment is moderately pronated, its upper extremity being drawn into the interosseous space. Other symptoms are identical with those of fracture above the insertion of the pronator radii teres.

Treatment.—In treating fracture below the insertion of the pronator radii teres the forearm is flexed to a right angle with the arm and is placed midway between pronation and supination; two interosseous pads and two straight splints are applied as for fracture of the ulna (see Fig. 388). The splints are worn for four weeks, and passive motion is begun in the third week. Plaster of Paris is a most satisfactory dressing. Loss of function is best obviated in this fracture by incision and fixation.

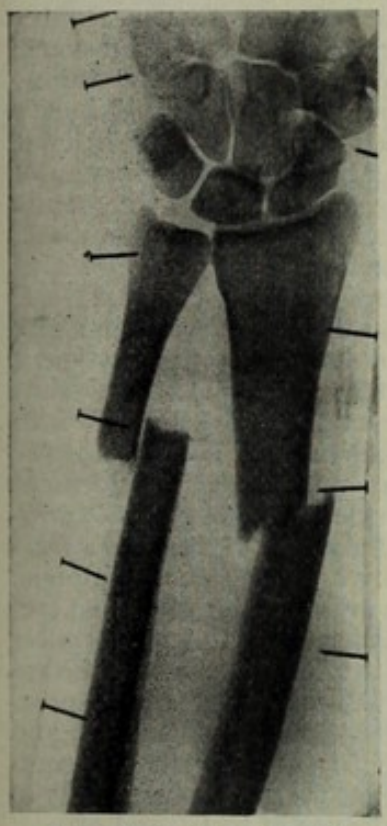


FIG. 394.—Dr. L. Englarth's case of fracture of radius and ulna (radiographer Dr. George Lindow).

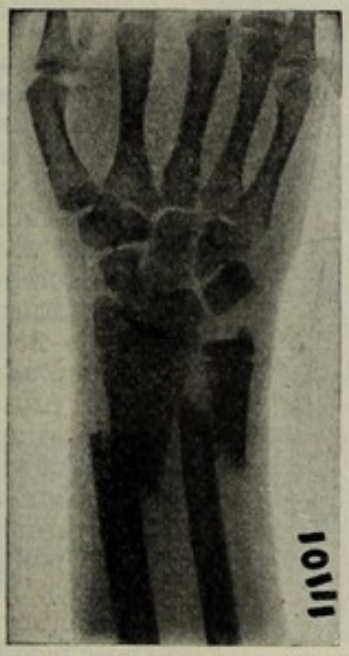


FIG 395.—Fracture of both bones in the lower third of the forearm.



FIG. 396.—Dr. J. A. Kelly's case of comminuted Barton's fracture of radius (automobile fracture).

Fracture of the shafts of both bones of the forearm (Figs. 392–395) is not frequently seen. It is caused either by direct or indirect force. If due to indirect force the radius breaks first.

Symptoms.—After fracture of both bones of the forearm the hand is pronated, and the two lower fragments come together and are drawn upward and backward or upward and forward by the combined force of flexor and extensor muscles, shortening being manifest and the projection of the lower fragments being detected on either the dorsal or the flexor surface of the forearm. The upper fragment of the ulna is somewhat flexed by the brachialis anticus; the upper fragment of the radius is flexed by the biceps and is pronated and drawn toward the ulna by the pronator radii teres. The forearm is narrower than it should be (the ends of the fragments having passed into the interosseous space) and is thicker than normal from front to back (the contents of the interosseous space having been forced out). Crepitus, mobility, pain, and inequality exist, the power of rotation is lost, and on passive rotation the head of the radius does not move. The forearm is prone and semiflexed.

Treatment of this fracture usually consists in the application of two straight splints and two interosseous pads, the forearm being flexed to a right angle and placed midway between pronation and supination (see Fig. 388). As a matter of fact if the ulna is held straight the radius will take care of itself (Sir Robert Jones in "Amer. Jour. of Orthop. Surg.," 1913, xi). The splints are worn for four weeks, and passive motion is begun in the third week. Before the callus has become hard the surgeon must ascertain that supination is possible. Instead of these splints a plaster-of-Paris dressing can be used. I am persuaded that pronation and supination are best preserved by incision and fixation.

Fractures of the Lower Extremity of the Radius.—Until comparatively recent years what we call Colles's fracture was called backward dislocation of the wrist. It was long taught that all wrist injuries were dislocations. Poutean, of Lyons, was the first to describe fracture of the lower end of the radius. He did so in 1783 ("Dislocations and Joint Fractures," by Cotton). In 1814 Colles, of Dublin, fully described the fracture which bears his name. His own description can be read in the "Edinburgh Med. Jour.," 1817. In 1820 Dupuytren made a study of it, and it is known to the French of today as Dupuytren's fracture. It took long years for the views of Colles and Dupuytren to gain general acceptance. *Colles's fracture* is a transverse or nearly transverse fracture of the lower end of the radius, between the limits of $\frac{1}{4}$ inch and $1\frac{1}{2}$ inches above the wrist-joint, the lower fragment sometimes mounting upon the dorsum of the upper fragment, the two fragments sometimes impacting. In 1838 John Rhea Barton described what is now known as Barton's fracture ("Med. Exam. Phil.," 1838). The posterior superior articular surface is broken off without involvement of the radial styloid. *Reversed Colles's fracture* was described by R. W. Smith in 1850 and by Callender in 1865. In it the lower fragment undergoes displacement to the flexor side, producing the "*gardener's spade deformity.*" *Chauffeur's fracture* is caused by cranking an automobile. It "may be of various types, the most frequent of which is one splitting off the outer surface of the articular surface of the radius through the base of the styloid process" (Ashhurst's "Surgery, Principles and Practice"). Colles's fracture is a very common injury, is met with most frequently in those beyond the age of forty, and oftener in women than in men. It is due to transmitted force (a fall upon the palm of the pronated hand). Some think that the force is received by the ball of the thumb and passes to the carpal bones and the edges of the radius; a fracture beginning posteriorly rather than anteriorly and the force driving the lower fragment upon the dorsal surface of the radius, the carpus and lower fragment moving upward and outward. It is much more likely that this fracture is due to cross-strain on the bone. There is sudden traction upon the anterior ligaments, which drag upon the bone and break it at a point where the cancellous end of the radius joins the compact shaft (Fig. 398). The fragments are not unusually impacted (Fig. 397). In the author's experience dislocation of the lower end of the ulna is not a very unusual complication. It arises from a fracture of the ulnar styloid or tearing off of the internal lateral ligament of the wrist.

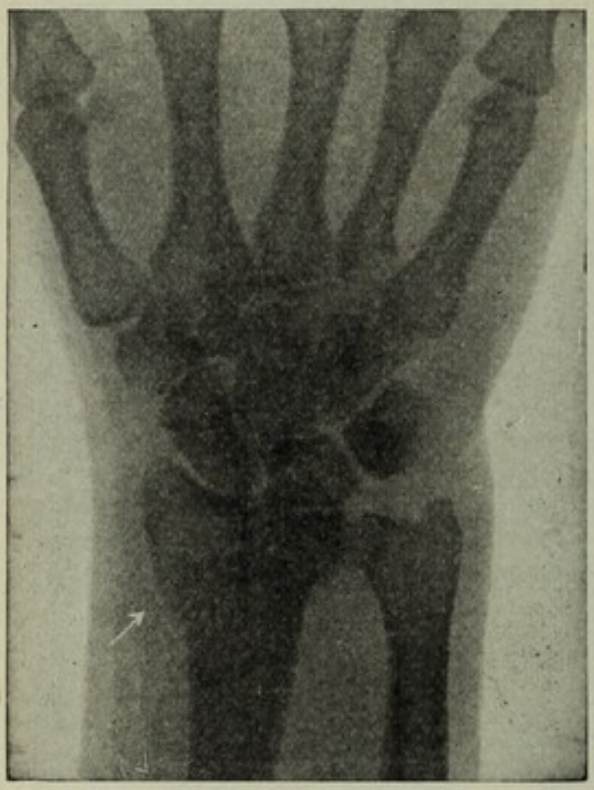


FIG. 397.—Impacted Colles's fracture.

Symptoms.—In Colles's fracture there are pain, swelling, tenderness of the region, and very acute tenderness along the line of fracture. This line of tenderness can be tracked by the pressure of a lead-pencil all the way around the radius (Dwight in "Surg. Report of Roosevelt Hosp. of N. Y.," 1915).

The hand is abducted (drawn to the radial side of the forearm) and pronated, the head of the ulna is prominent, the styloid process of the radius is raised, and the lower

fragment may mount on the back of the lower end of the upper fragment, causing a dorsal projection, termed by Liston the "*silver-fork deformity*" (Figs. 399, 400). Silver-fork deformity is present in from 60 to 70 per cent. of cases. The lower end of the upper fragment can be felt beneath the flexor tendons above the wrist. The position in deformity is produced by the force. Some believe that it is maintained by the action of the supinator longus and the flexor and extensor muscles, but particularly

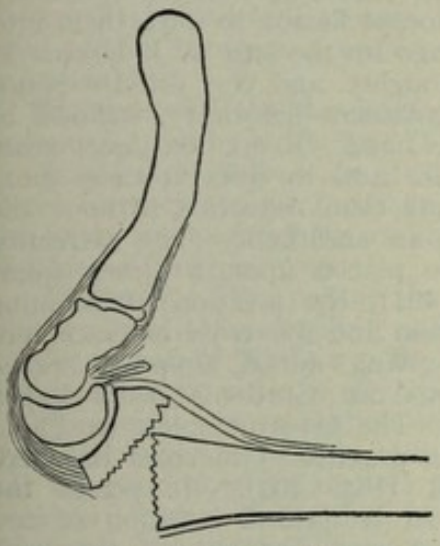


FIG. 398.—Effect upon the lower end of the radius of the cross-breaking strain produced by extreme backward flexion of the hand (Pilcher).

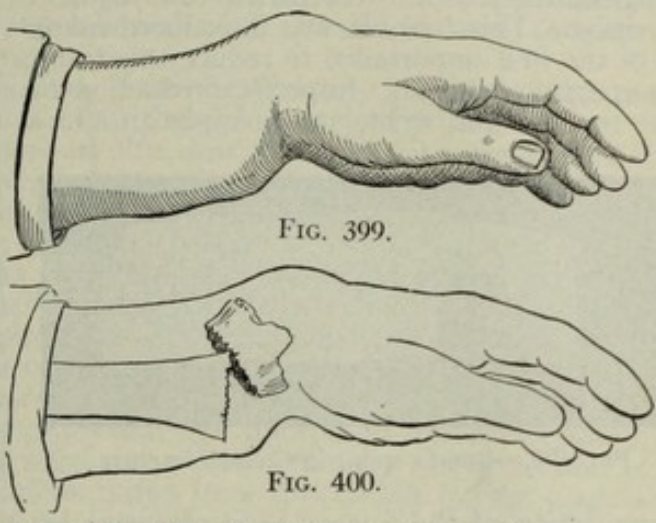


FIG. 399.

FIG. 400.

FIGS. 399, 400.—Deformity at the wrist consequent upon displacement backward of the lower fragment of the radius after fracture at its lower extremity (Levis).

by the extensors of the thumb. Pilcher has demonstrated the fact that in this fracture a portion of the dorsal periosteum is untorn, and this untorn portion acts as a binding band to hold the fragments in deformity (Fig. 398.). Pronation and supination are lost. In this fracture the hand can be greatly hyperextended (*Maisonneuve's sign*). Crepitus, which is best obtained by alternate hyperextension and flexion, can be secured unless swelling is great or impaction exists. Crepitus on side movements is rarely

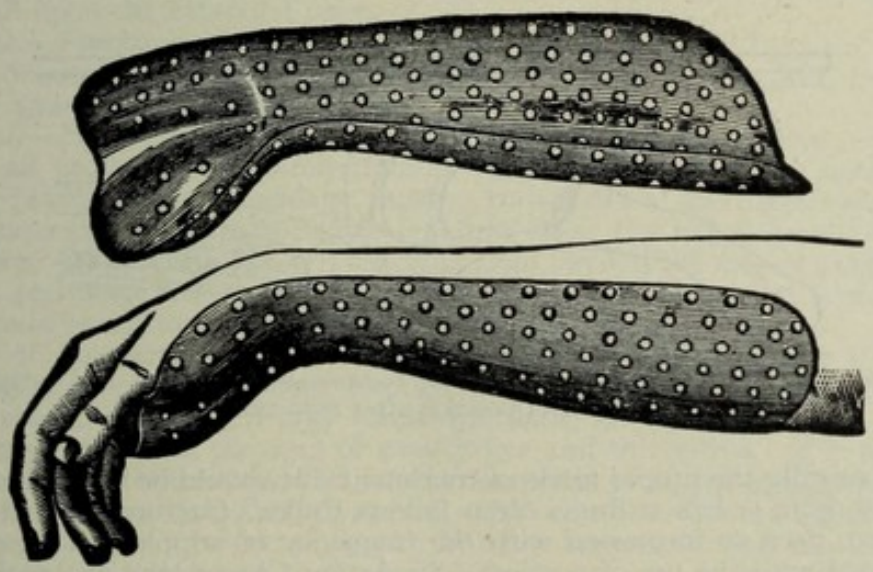


FIG. 401.—Levis's radius splints, right and left, for fracture of the lower end of the radius.

obtainable. Impaction may greatly modify the deformity, though displacement generally exists to some extent, and the fragments do not ride easily on each other. The styloid process of the ulna may be broken, or the inferior radio-ulnar articulation may be separated (dislocation of the lower end of the ulna). This latter complication allows the lower fragment to roll freely upon the upper, and the characteristic silver-fork deformity does not appear. If the styloid process of the ulna is broken, pressure over

it causes great pain. If a person in falling strikes the back of the hand and a fracture of the radius occurs, the lower fragment is driven upon the front surface of the upper fragment and is felt under the flexor tendons at the wrist (*reversed deformity*). An elaborate study of fracture of the radius with forward displacement of the lower fragment has been published by John B. Roberts.[1]

Treatment.—In treating an ordinary Colles's fracture reduce the deformity by hyperextension to unlock the fragments and relax the dorsal periosteum, follow by longitudinal traction to separate the fragments, and forced flexion to force them into position. This formula was introduced many years ago by the late R. J. Levis. It is of the first importance to reduce this fracture thoroughly, and very often it is not thoroughly reduced. Imperfect reduction means permanent deformity, stiffness of the tendons and wrist, and possibly an almost useless hand. Reduction under ether is easier and in difficult cases more complete than reduction without the aid of an anesthetic. The extremity can be placed upon a Levis splint (Fig. 401), the position maintaining reduction and the tense extensor tendons giving dorsal support. Some surgeons use Gordon's pistol-shaped splint. The favorite splint in Philadelphia practice in the past has been Bond's (Fig. 402). It places the hand in a natural position of rest (semiflexion of the fingers, semi-extension of the wrist, and deviation of the hand toward the ulna). Two pads are used: a dorsal pad which overlies the lower fragment, and a pad for the flexor surface which overlies the lower end of the upper fragment. A bandage is applied, the thumb and fingers being left free (Fig. 402). Passive motion is begun upon the fingers in three or four days, and upon the wrist during the second week. The splint is removed in three weeks, and a bandage is worn for a week or two more because of the swelling. In applying the Bond splint, do not pull the hand too much up on the block, or the fracture will unite with a projection upon the flexor surface of the extremity and the tendons of the wrist will be apt to be caught in the callus. The most satisfactory dressing is the straight dorsal splint advised by Roberts (Fig. 403). It runs from just below the external condyle to the beginning of the fingers. I use it almost invariably. It prevents the recurrence of deformity

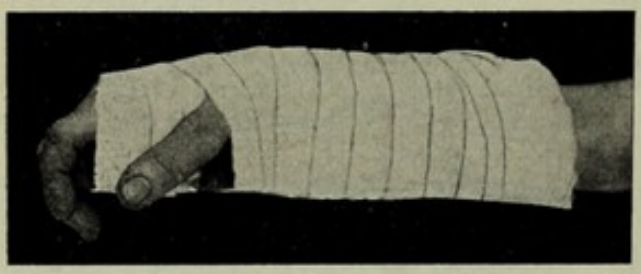


FIG. 402.—Bond's splint in Colles's fracture.

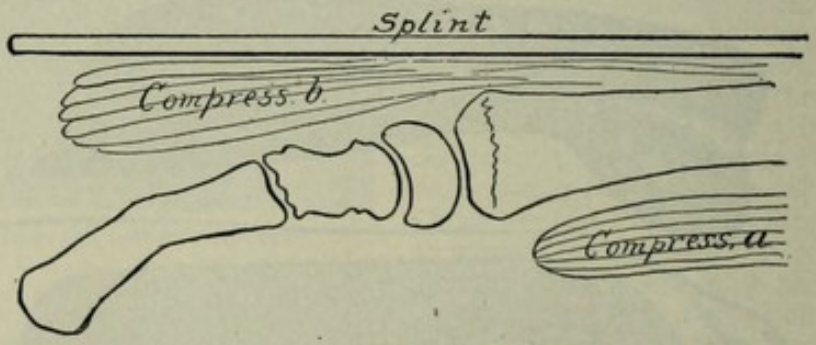


FIG. 403.—Diagram showing the arrangement of compresses and splint best adapted to retain fragments in proper position after reduction (Pilcher).

and is mechanically the proper mode of treatment. It should be worn for three weeks. Undoubtedly more or less stiffness often follows Colles's fracture, and some very able surgeons have been so impressed with the frequency of crippling stiffness that they have dispensed with the use of a splint. Sir Astley Cooper long ago spoke of simply placing the arm in a sling as proper treatment for fracture of the radius. Moore, of Rochester, applied a cylindric compress over the ulna, held in place for six hours by adhesive plaster, then cut the plaster, placed the forearm in a sling, and let the hand hang over the edge of the sling. Pilcher applies a band of adhesive plaster around the wrist and supports the wrist in a sling, but, as Storp says, dispensary patients are apt to disarrange this dressing. Storp wraps a piece of rubber plaster 4 inches wide around the wrist, and places a second piece around the first so arranged as to form a fold over

[1] "Amer. Jour. Med. Sci.," Jan., 1897.

the radius; an opening is made through the fold for the passage of a sling. In ten days the plaster is removed and the forearm is carried in a sling. Massage is begun in the third week. Impaired function follows in about 40 per cent. of these fractures. If a stiff joint and limited tendon motion eventuate from the fracture, use massage, frictions, sorbefacient ointments, tincture of iodin, electricity, hot and cold douches, and the hot-air apparatus, or give ether and forcibly break up adhesions. If reduction was not thoroughly effected and too great a length of time has not elapsed, and the hand is helpless and painful, the bone should be refractured. In a young or middle-aged person, in whom a useless hand has followed an ill-reduced fracture, osteotomy is justifiable.

Fracture of Both the Radius and Ulna Near the Wrist.—Colles's fracture may be complicated by a fracture of the ulna other than of its styloid process.

Symptoms.—In fracture of the radius and ulna near the wrist the lower ends of the upper fragments come together, the upper fragment of the radius is pronated, and the lower fragment of the radius is drawn up. Pain, crepitus, mobility, shortening, and loss of function exist.

Treatment.—Fracture of the radius and ulna near the wrist should be treated by the straight dorsal splint, as is Colles's fracture.

Separation of the Lower Radial Epiphysis.—This accident occurs in children from falling upon the palm of the hand. It never happens after the twentieth year.

Symptoms.—In separation of the lower radial epiphysis the lower fragment mounts upon the upper and produces a dorsal projection like that found in Colles's fracture, but the hand does not deviate to the radial side. The deformity resembles that of a backward carpal dislocation, but is differentiated from dislocation by the unaltered relation in the fracture between the styloid processes and the carpal bones.

The *treatment* in separation of the lower radial epiphysis is the same as for Colles's fracture.

Fractures of the carpus were until recently thought to be infrequent, but the *x*-rays have taught us differently, and we now know that many supposed sprains of the wrist are, in reality, simple fractures of the carpus. Ernest Amory Codman and Henry Melville Chase show that a majority of carpal injuries "are either simple fractures of the scaphoid or anterior dislocations of the semilunar bone," the two injuries being frequently combined ("The Diagnosis and Treatment of Fracture of the Carpal Scaphoid and Dislocation of the Semilunar Bone," in "Annals of Surgery," March and June, 1905). The author sustained a fracture of the cuneiform bone as a result of a fall upon the extended palm. The *cause* of carpal fracture may be violent direct force or a fall upon the extended palm.

Symptoms.—Fractures of the carpus in general are indicated by pain, tenderness, swelling, evidences of the infliction of direct force, sometimes crepitus, loss of power in the hand, and a very little displacement.

Treatment.—Many compound comminuted fractures of the carpus require amputation. In an ordinary compound fracture asepticize, drain, dress with antiseptic gauze and a plaster-of-Paris bandage, cutting trap-doors in the plaster over the ends of the drainage opening. In a simple fracture dress the hand upon a well-padded straight palmar splint (Fig. 348, 10) reaching from beyond the fingers to the middle of the forearm, and place the hand and forearm in a sling. The splint is worn for four weeks, and passive motion of the wrist is begun in the second week.

Fracture of the carpal scaphoid (see previously quoted article by Codman and Chase) is the most common carpal fracture and usually results from falls upon the palm of the extended hand. It may result from back-fire by a gas engine. It is most common in males between the ages of twenty-five and thirty-five. It is rarely recognized at the time of the accident; the patient complains of severe pain, tenderness, and disability and is thought to have a sprain. According to Codman and Chase, the symptoms improve up to a certain point, but not beyond it, and the joint remains in a condition of irritation and weakness. After months or, perhaps, years the diagnosis is made. In one case of my own, a locomotive engineer, the injury resulted from a blow on the palm with the reverse lever. He came to me three years after the injury, when I recognized the condition as the one described by Codman and Chase. These writers say that the fingers are normally flexible, active and passive movements of the wrist are restricted to one-half or more of the normal excursion, and movements of flexion or extension beyond this are limited by muscular spasm, resembling the spasm occurring in a tuberculous joint. Any attempt forcibly to overcome the spasm produces violent pain. Crepitus is absent. The radial side of the wrist-joint exhibits some swell-

ing, which obscures somewhat the flexor tendons of the thumbs. There is tenderness on pressure over the scaphoid and it is most acute in the anatomic snuff-box. The *x*-ray shows a transverse fracture of the scaphoid bone ("Annals of Surgery," March and June, 1905). Professor Dwight considers the above-described injury to be due to the two portions of the bone (there are two centers of ossification) having never formed a bony union and having been wrenched apart by violence. Codman believes the injury is the result of violence acting on a normal bone, the resulting non-union being due to lack of fixation and the presence of synovial fluid between the fragments.



FIG. 404.—Fracture of a portion of the carpal scaphoid (U. S. Naval Hospital, League Island, Pa.; skiagraphed by Lieut. George U. Pillmore, Medical Corps, U. S. Navy).

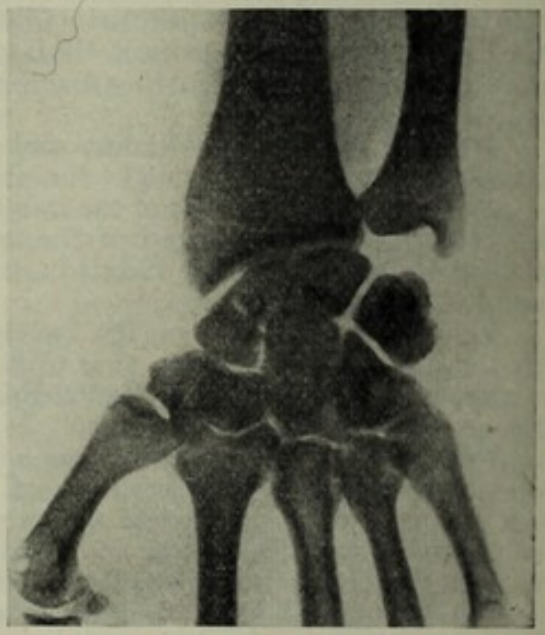


FIG. 405.—Fracture of the carpal scaphoid (U. S. Naval Hospital, League Island, Pa.; skiagraphed by Lieut. George U. Pillmore, Medical Corps, U. S. Navy).

The fracture may be accompanied by forward dislocation of the semilunar bone. If for several weeks after an accident causing fracture of the scaphoid the wrist is immobilized, union may occur, otherwise non-union will surely result (Figs. 404, 405).

Treatment.—This injury should be thought of when violence has been applied to the carpus. It may be treated by a straight palmar splint if the case is seen early.

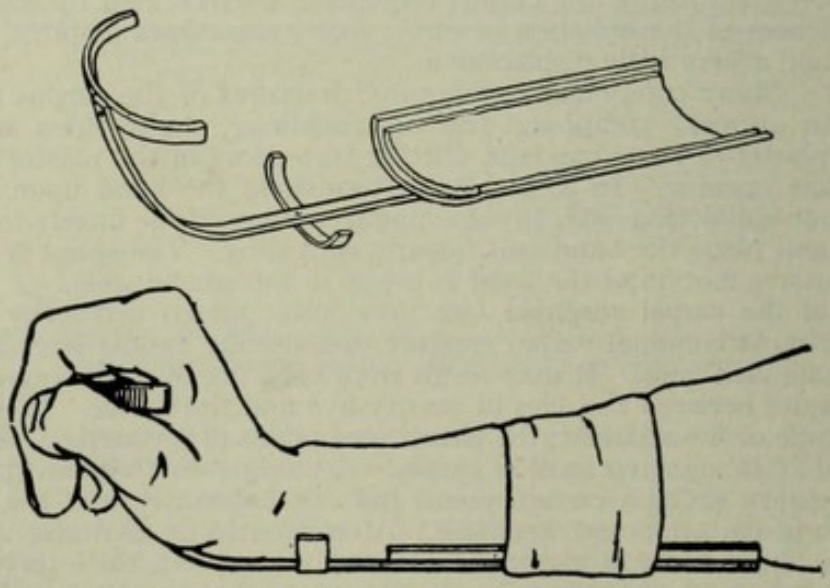


FIG. 406.—Jones's "cock-up" or "crab" wrist splint (Osgood).

Cases do best when treated with the wrist in dorsiflexion (Fig. 406). If seen when there is non-union, the proximal half of the scaphoid should be excised (the incision being posterior and external to the extensor communis digitorum tendons) and passive motion should be begun within one week (Codman and Chase, Ibid.).

Fractures of the Metacarpal Bones.—Fractures of the metacarpus are very common. One or more bones may be broken. The first metacarpal bone is oftenest broken; the third is seldom broken (Hulke). The *cause* is direct or indirect force. Fracture at the base of the first metacarpal bone was described by E. H. Bennett in 1881. It is called *Bennett's fracture*, or, as its discoverer named it, *stave of the thumb*. The fracture may be transverse at the neck or longitudinal, "the anterior basal projection being broken off" (Raymond Russ in "Jour. Amer. Med. Assoc.," June 16, 1906). This injury results from violent force applied to the distal end of the metacarpal (as in striking with the fist) or to the end of the extended thumb, and Russ regards it as the most common metacarpal fracture. It is usually mistaken for a sprain of the thumb and is sometimes regarded as subluxation backward of the first metacarpal.

Symptoms.—The signs of a metacarpal fracture are dorsal projection of the upper end of the lower fragment or the lower end of the upper fragment, pain, crepitus, and often evidences of direct violence. In fracture of the first metacarpal (Bennett's fracture) there is swelling, particularly evident in the flexor tendon sheaths on the thenar eminence (Russ), disability, pain, tenderness near the base of the metacarpal, and deformity, apparent shortening of the thumb, and crepitus on reduction. The *x*-rays solve a doubtful case.

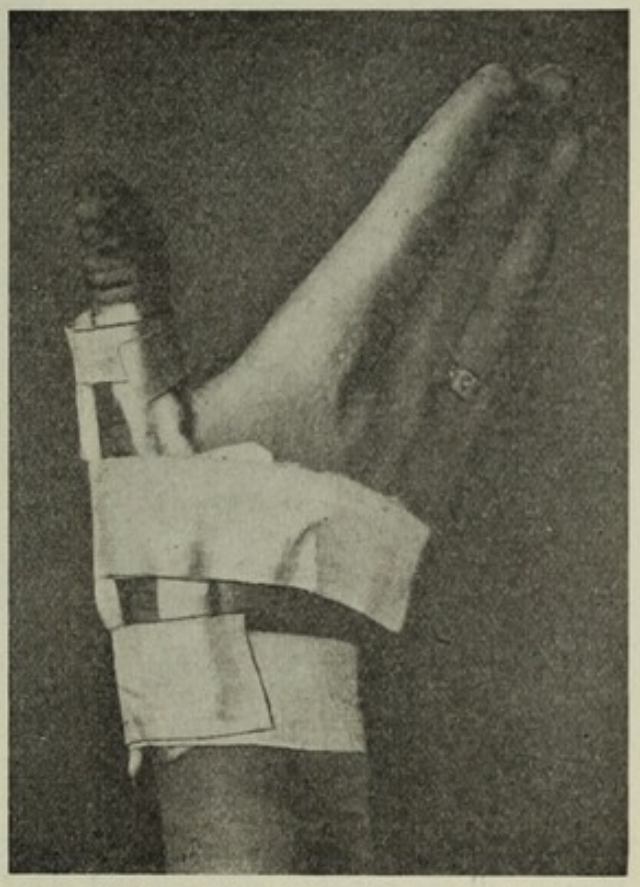


FIG. 407.—Coaptation traction splint of Russ.

Treatment.—To treat a fracture of a metacarpal bone reduce by extension; place a large ball of oakum, cotton, or gauze in the palm to maintain the natural rotundity, and apply a straight palmar splint like that used for fracture of the carpus. It may be necessary to apply a compress over the dorsal projection. The duration of treatment is three weeks, and passive motion is begun after two weeks. A plaster-of-Paris dressing is often used. Raymond Russ ("Jour. Amer. Med. Assoc.," June 16, 1906) describes the following splint as successfully used in a case of Bennett's fracture (Fig. 407). I have used it in a case with much satisfaction. "The thumb was put in strong abduction and 3 wooden butcher's skewers neatly padded were placed about the metacarpal, one posteriorly in the interosseous space, one along the outer border, and the third over the thenar eminence. These extended from well above the metacarpal bone to the first phalangeal joint. They were fastened tightly in place by two strips of adhesive plaster. Traction was then exerted on the thumb and maintained by strips of adhesive plaster passing about the first phalanx and the projecting ends of the 3 skewers. This dressing was reinforced by a rectangular cardboard splint. Accurate coaptation and sufficient traction to overcome the deformity and muscular action are most necessary in the treatment of this fracture. Slate pencils or small lead pencils can be used in place of the wooden skewers. The soapstone slate pencils are less brittle than the ordinary kind."

Fracture of the Sesamoid Bones of the Thumb.—There are two sesamoid bones on the palmar surface of the metacarpophalangeal articulation of the thumb, one lying in the tendon of the flexor brevis pollicis, and one in the palmar surface of the interphalangeal joint of the thumb. Skillern ("Annals of Surgery," 1915, lxii) reports a case of fracture of the ulnar sesamoid of the thumb and says 3 cases have been reported previously. The condition causes swelling of the thumb, ecchymosis of the thenar eminence, and acute tenderness at the base of the first metacarpal bone. The treatment is immobilization for four weeks and then passive motion and massage.

Fractures of the Phalanges.—The phalanges are often broken. The fracture may be compound. The *cause* usually is direct force.

Symptoms.—Fracture of a phalangeal bone is indicated by pain, tenderness, bruising, crepitus, and mobility, with very little or no displacement.

Treatment.—If the middle or distal phalanx is broken, mould on a trough-like splint of gutta-percha or of pasteboard, which splint does not need to reach into the palm. If the proximal phalanx is broken, carry the splint into the palm of the hand. Make the splint of gutta-percha, pasteboard, wood, or leather. The splint is worn three weeks. A sling must be worn, otherwise the finger will be knocked and hurt. Some cases require a dorsal as well as a palmar splint. These cases may be treated very satisfactorily with a silicate of sodium or plaster-of-Paris bandage.

Fracture of the femur is a very common injury. The divisions of the femur are: (1) The upper extremity; (2) the shaft; (3) the lower extremity.

Fractures of the upper extremity of the femur are divided into: (*a*) Intracapsular; (*b*) extracapsular; (*c*) of the great trochanter, and (*d*) epiphyseal separation (either of the great trochanter or the head).



FIG. 408.—Dr. J. A. Kelly's case of intracapsular fracture of the neck of the femur (radiographer, Sender).

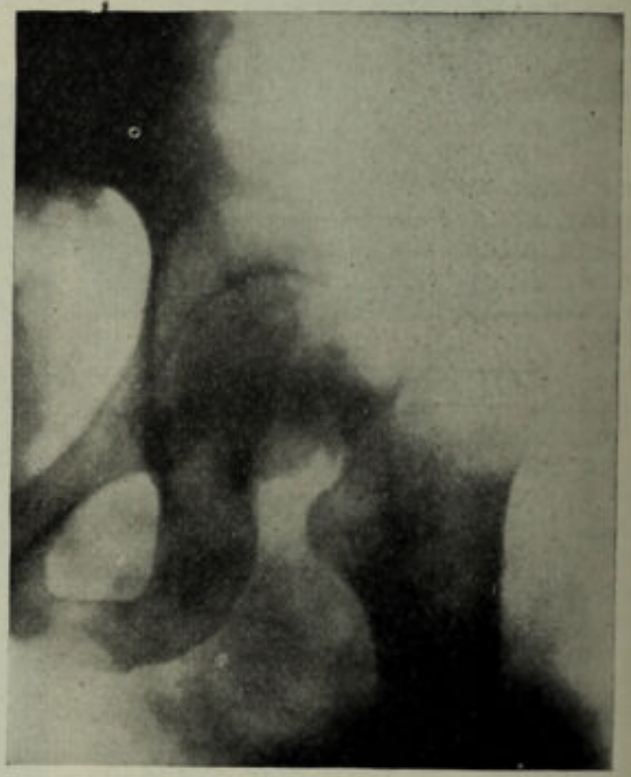


FIG. 409.—Intracapsular fracture of the neck of the femur (skiagraphed by Dr. Manges).

Examination of the Hip.—It is sometimes though seldom necessary to give ether. Remove all the patient's clothing and place him recumbent upon a table. Note the position of the extremity. Feel with care the great trochanter and femoral neck. Very gradually and gently make movements to determine if there be impairment of motion, undue mobility, or crepitus. Never make sudden or violent movements in looking for crepitus. The diagnosis can be made even if crepitus is not obtained, and rapid or violent movements may tear apart an impaction. Measure the sound extremity and the injured extremity. The measurement is made from the anterior superior spine of the ilium to the inner malleolus. Other symptoms to be looked for are set forth on pages 547, 548, 549.

Intracapsular Fracture of the Femur.—Intracapsular fracture of the neck of the femur is transverse or only slightly oblique (Figs. 408–411), and is not unusually impacted (see Fig. 412). Stokes follows Gordon, of Belfast, in classifying fractures of the femoral neck. He divides them into intracapsular and extracapsular, and subdivides intracapsular fractures into fracture with penetration of the cervix into the head; fracture with reciprocal penetration; intraperiosteal fracture at the junction of the cervix and head; intraperiosteal fracture of the center of the cervix; extraperiosteal fracture, with laceration of the cervical ligaments. The last-named fracture

is the most common. The first four forms may unite by bone, the fifth form will not because of non-apposition, lack of nutrition, effusion of blood, synovitis, or interstitial absorption.[1] Stokes points out that we may have penetration without impaction. The *cause* is often slight indirect force, of the nature of a twist, acting upon a person of advanced years (more often a woman than a man), but not unusually a fall upon the great trochanter is the cause. A fall upon the knees, a trip, or an attempt to prevent a fall may produce this fracture. It often happens that the fall is due to the fracture rather than that the fracture arises from the fall. Intracapsular fracture is never caused by direct force unless it is due to gunshot violence. The aged are more liable to intracapsular fracture than the young or the middle-aged, because, first, the angle which the neck forms with the axis of the femur becomes less obtuse with advancing years, and may even become a right angle; this change is more pronounced in women than in men; second, the compact tissue becomes thinned by absorption, the cancelli diminish, the spaces between them enlarge, the bony portions of the cancellous structure are thinned and destroyed, and the cancellous structure becomes fatty and degenerated. The injury is not, however, limited to the aged. It has been positively shown

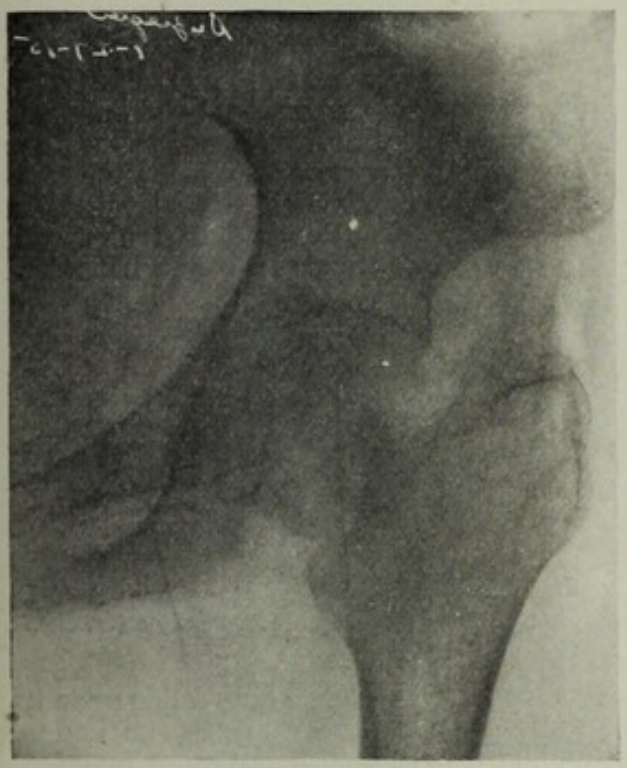


FIG. 410.—Dr. J. W. Ziegler's case of intracapsular fracture of the neck of the femur (*x*-ray by Sender).

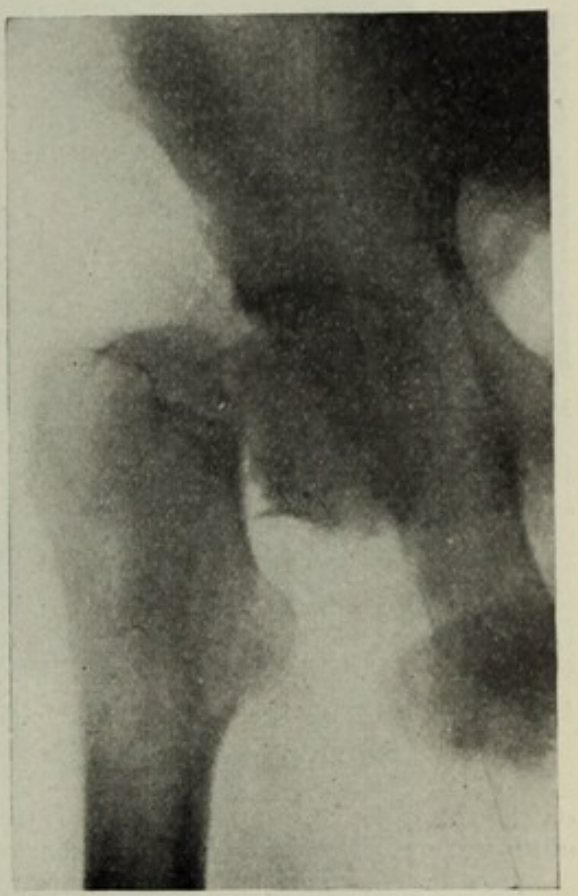


FIG. 411.—Intracapsular fracture of the neck of the femur (skiagraphed by Dr. Manges).

that this fracture may occur in the young, even before the union of the epiphyses. In fact, fracture of the femoral neck is not very uncommon in children and in young and vigorous adults (Royal Whitman, "Med. Record," March 19, 1904). In a child an intracapsular fracture is of the neck and almost never of the epiphysis. I have seen one case in a man of twenty-five, one in a man of twenty-eight, and several cases in those under forty-five. In the aged the fracture is, of course, complete, but in children and even in young adults it is usually incomplete, and for this reason the fracture is often not recognized in children and young adults.

Symptoms.—In intracapsular fracture there is usually *shortening* to the extent of from ½ to 1 inch, but in some cases no shortening can be detected. Shortening of ¼ inch does not count in making a diagnosis, for one limb is often naturally a little shorter than the other. If the reflected portion of the capsule is not torn, the shortening is trivial in amount or is entirely absent. In some cases shortening gradually or suddenly increases some little time after the accident. This is due to separation of a penetration or of an impaction, tearing of the previously unlacerated fibrous

[1] Stokes in "Brit. Med. Jour.," Oct. 12, 1895.

synovial reflection, or restoration of muscular strength after traumatic paresis has passed away. A gradually increasing shortening arises from absorption of the head of the bone. Shortening is due chiefly to pulling upon the lower fragment by the hamstring, the glutei, and the rectus muscles.

Pain is usually present anteriorly, posteriorly, and to the side. The area of pain is localized, and motion or pressure greatly increases the suffering. Pain is not commonly severe except upon motion or from pressure, when it may be localized in the joint. In some cases the pain is violent.

Eversion exists and is spoken of as *helpless eversion*, though in a very few instances the patient can still invert the leg. The eversion is due to the force of gravity, the limb rolling outward because the line of gravity has moved externally. That eversion is not due to the action of the external rotator muscles, as was taught by Sir Astley Cooper, is proved by the fact that when a fracture happens in the shaft below the insertion of these muscles the lower fragment still rotates outward. This is further demonstrated by the considerations that the internal rotators are more powerful than the external, that some patients can still invert the limb after a fracture, and that eversion persists during anesthesia.[1] In some unusual cases *inversion* attends the fracture. Inversion, if it exists, is due to the fact that the limb was adducted and inverted at the time of the accident, and after the accident it remains in this position (Stokes). Besides shortening and eversion, the leg is somewhat flexed

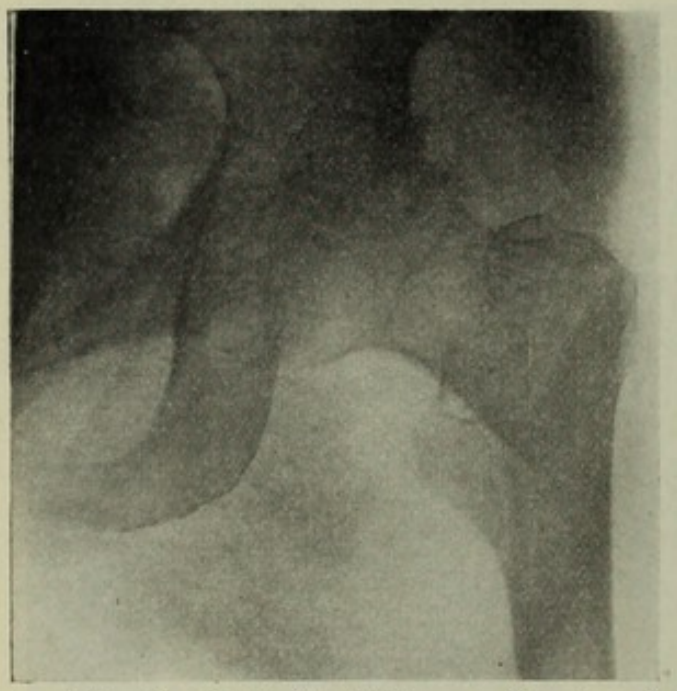


FIG. 412.—Dr. M. M. Franklin's case of fracture of neck of the femur, impacted (picture by Sender).

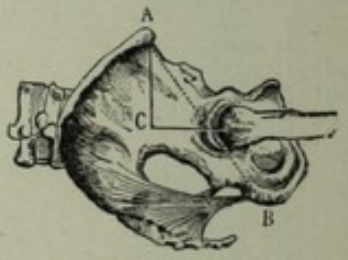


FIG. 413.—A–B, Nélaton's line; A–C–D, Bryant's iliofemoral triangle (Owen).

on the thigh and the thigh on the pelvis, the extremity when rolled out resting upon its outer surface. *Abduction* is commonly present. Limited abduction suggests impaction.

Loss of power is a prominent symptom: the limb can seldom be raised or inverted; although in rare cases, when the fibrous synovial envelope is untorn, the patient may stand or even take steps. *Crepitus* often cannot be found, either because the fragments cannot be approximated, because there is impaction or penetration, or because the bone is greatly softened by fatty change. To obtain crepitus the front of the joint must be examined while the limb is extended and rotated inward. But why try to obtain crepitus? The diagnosis is readily made without it; in many cases it cannot be detected, and the endeavor to obtain it inflicts pain and may produce damage. These fractures in the aged have a not very flattering chance for repair, and efforts to find crepitus may produce serious damage.

Altered Arc of Rotation of the Great Trochanter (*Desault's Sign*).—The pivot on which the great trochanter revolves is no longer the acetabulum, and the great trochanter no longer describes the segment of a circle, but rotates only as the apex of the femur, which rotates around its own axis. It is needless to try to obtain this sign; to do so inflicts violence on the parts.

Relaxation of the fascia lata (*Allis's sign*) simply means *shortening*. The fascia lata is attached to the ilium and the tibia (iliotibial band), and when shortening brings the tibia nearer to the ilium, this band relaxes and permits the surgeon to push his fingers more deeply inward on the injured side, between the great trochanter and the

[1] Edmund Owen, "A Manual of Anatomy."

iliac crest, and nearer the knee above the outer condyle, than on the sound side. In this examination each limb should be adducted. Allis has pointed out another sign: when the patient is recumbent the sound thigh cannot be lifted to the perpendicular without flexing the leg; the injured thigh can be.

Lagoria's sign is relaxation of the extensor muscles.

Ascent of the Great Trochanter Above Nélaton's Line.—This line is taken from the anterior superior iliac spine to the most prominent part of the ischial tuberosity (Fig. 413). In health the great trochanter is below, and in intracapsular fracture it is above, this line.

Relation of the Trochanter to Bryant's Triangle (Fig. 413).—Place the patient recumbent, carry a line around the body on a level with the anterior superior iliac spines, draw a line from the anterior iliac spine on each side to the summit of the corresponding great trochanter, and measure the base of the triangle from the great trochanter to the perpendicular line to determine the amount of ascent. The difference in measurement between the two sides shows the amount of ascent of the trochanter; that is, shows the extent of shortening.

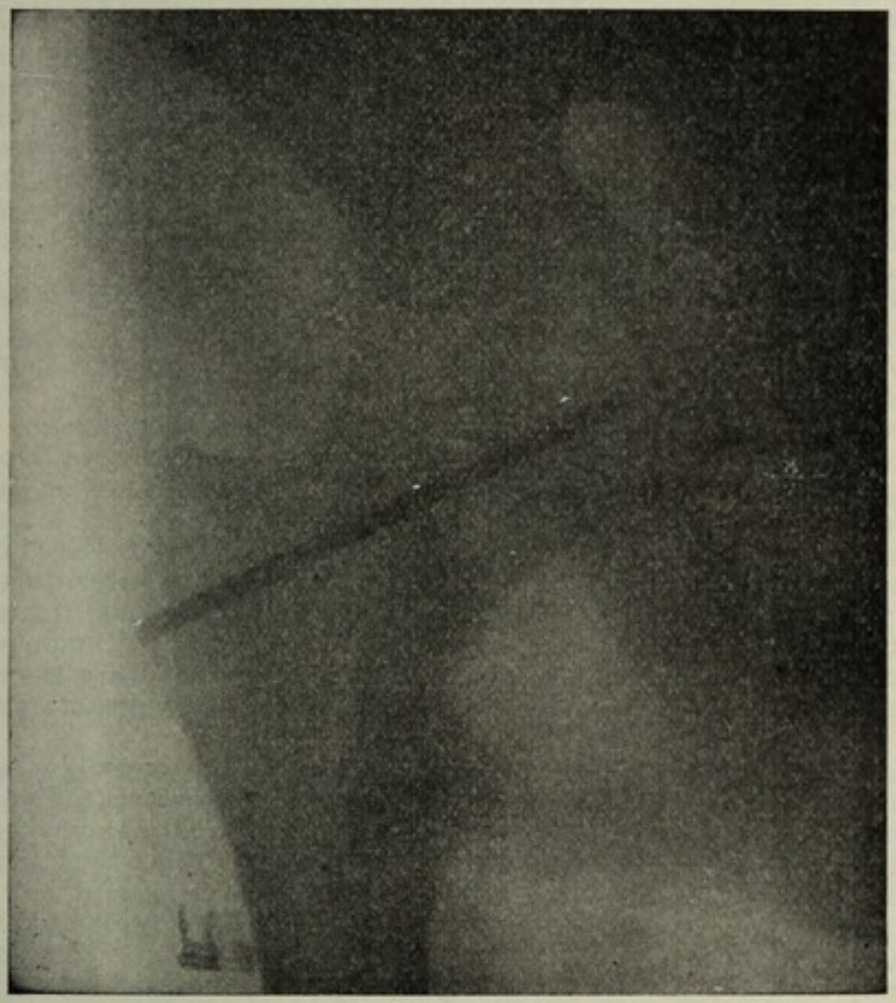


FIG. 414.—Author's case of recent intracapsular fracture in a woman aged forty successfully nailed. Nail is still in place after five years.

Morris's measurement shows the extent of inward displacement. Measure from the median line of the body to a perpendicular line drawn through the trochanter on each side of the body.

Diagnosis.—The *x*-rays are a valuable aid to diagnosis. Intracapsular fracture without separation of fragments may be mistaken for a mere contusion, and the diagnosis may continue obscure unless the fragments separate. Loss of function in contusion is rarely complete or prolonged, although occasionally the head of the bone undergoes absorption. Early after a contusion, and usually throughout the case, there is no alteration between the relation of the spine of the ilium and the trochanter, and no shortening. Some time *after* a severe contusion the head of the bone may be absorbed. Contusion of a rheumatic joint leads to much difficulty in

diagnosis. Intracapsular fracture may be confused with *extracapsular* fracture or with dislocation of the hip-joint. Extracapsular fracture, which is common in advanced life, but is met with not unusually in middle life and even occasionally in the young, results usually from great violence over the great trochanter; if non-impacted, there are noted shortening of from 1½ to 3 inches, crepitus over the great trochanter, and usually, but not invariably, eversion; if impacted, there is less eversion, crepitus is absent, and the shortening is limited to about an inch. The extensor muscles are relaxed. Great tenderness exists over the great trochanter in both impacted and non-impacted fractures. In dislocation on the dorsum of the ilium the patient is usually a strong young adult. There is a history of forcible internal rotation. There are inversion (the ball of the great toe resting on the instep of the sound foot), rigidity, ascent of the great trochanter above Nélaton's line, and shortening of from 1 to 3 inches. The head of the bone is felt on the dorsum of the ilium, and the trochanter mounts up toward the spine of the ilium, and pressure upon it causes no pain. In dislocation into the thyroid notch there is possibly eversion, but it is linked with lengthening. Gay points out that a diagnosis of dislocation has no standing in the aged, that occasionally a person with fracture "can rotate the limb slightly, or even raise it from the bed" and that the cardinal symptoms of a hip fracture are "loss of function, eversion of the foot, and severe pain on motion" (George W. Gay in "Boston Med. and Surg. Jour.," Sept. 5, 1918).

In *fracture of the brim of the acetabulum* there is shortening, which occurs on the removal of extension, inversion, abduction, flexion of the knee, the head of bone is drawn upward and backward with the acetabular fragment, and there is retention of the power of eversion and of adduction (Stokes). Crepitus is most distinctly appreciated by a hand resting on the ilium.

In *fracture of the fundus of the acetabulum* (see Fig. 341) there is shortening, and the head of the bone enters the pelvis (Stokes).

The *prognosis* is not favorable for perfect restoration of function. Some aged patients die in a day or two from shock. Not a few perish later from hypostatic congestion of the lungs, kidney failure, or exhaustion. The majority of cases recover with a little shortening, some stiffness, and a permanent limp. There is a much better chance for firm union if the fracture is impacted than if it is not. Even if non-union results after an intracapsular fracture, and it is not unusual, a patient may get about fairly well with a proper support. In some cases after intracapsular fracture rheumatoid arthritis develops. Many surgeons have maintained that bony union never occurs, but it certainly does sometimes take place. Stokes holds that bony union is possible in fractures with penetration, and even in fractures without penetration when the fracture is within the periosteum.[1]

Treatment.—In treating a very feeble old person for intracapsular fracture make no attempt to obtain union. Keep the patient in bed for two weeks; give lateral support by sand-bags; tie around the ankle a fillet, attach a weight of a few pounds to the fillet, and hang the weight over the foot-board of the bed. When pain and tenderness abate, order the patient to get into a reclining-chair, and permit him very soon to get about on crutches. If hypostatic congestion of the lungs sets in, if bed-sores appear, if the appetite and digestion utterly fail, or if diarrhea persists, abandon attempts at cure in any case, and get the patient up and take him into the sunshine and fresh air, simply immobilizing the fracture as thoroughly as possible by means of pasteboard splints or plaster of Paris. In the vast majority of cases, no matter how old the patient may be, undertake treatment. We may be forced to abandon it, but should at least attempt to obtain a cure. If it is determined to treat the case, place the patient on a hair mattress, several boards being laid transversely under the mattress in order to prevent unevenness and the formation of hollows. A fracture-bed is a valuable adjunct to treatment.

Treatment by the Extension Apparatus of Gurdon Buck.—Extend the knee and place the leg in a natural posture, and put a pillow beneath the knee. Combine extension with lateral support by means of sand-bags. The extension should be gentle, never forcible. It is not wise to pull apart an impaction in an old person, but it should always be done in a young or middle-aged person. Place the subject on a firm mattress or a fracture-bed. Shave the leg. Cut a foot-piece out of a cigar-box, perforate it to admit the passage of a cord, wrap it with adhesive plaster as shown in Fig. 348, 15, 16, run the weight-cord through the opening in the wood, and fasten a piece of adhesive plaster on each side of the leg, from just below the seat of fracture to above the malleolus

[1] See the masterly paper by Stokes, before quoted.

(Fig. 348, 14). The plaster is guarded from sticking to the malleoli by having another piece stuck to its under surface opposite each of these points. Apply an ascending spiral reversed bandage over the plaster to the groin (Fig. 415) and finish the bandage by a spica of the groin. Slightly abduct the extremity. Put a brick under each leg

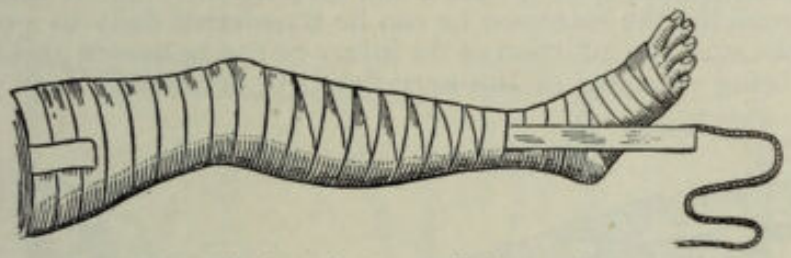


FIG. 415.—Adhesive plaster applied to make extension.

of the bed at its foot, thus obtaining counterextension by the weight of the body. Run a cord over a pulley at the foot of the bed, and obtain extension by the use of weights (Fig. 348, 14). In an adult from 15 to 20 pounds will probably be necessary at first, but after a few days from 8 to 10 pounds will be found sufficient (remember that a brick weighs about 5 pounds). Dawbarn's rule as to the proper weight to be attached is 1 pound

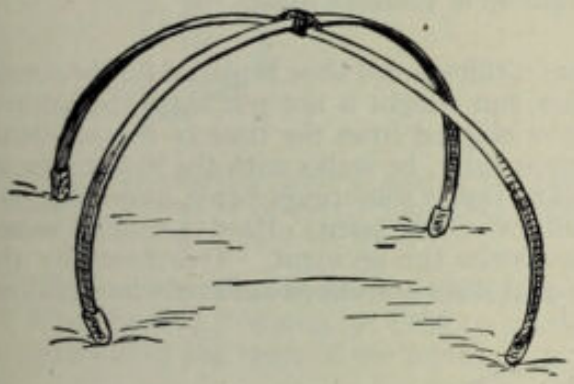


FIG. 416.

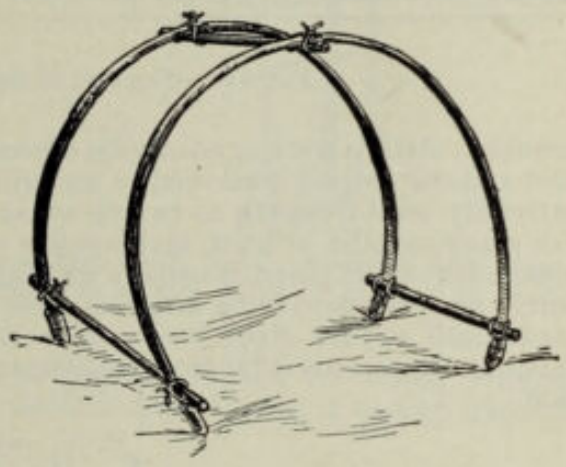


FIG. 417.

FIGS. 416, 417.—Cradle to keep clothing from leg, made from two barrel-hoops (Scudder).

for every year up to twenty. When the foot of the bed is raised and the weight to make extension is applied, very gently rotate the extremity to correct eversion, put the foot at a right angle with the leg, and make a bird's-nest pad of cotton or oakum to save the heel from pressure. Take two canvas bags, one long enough to reach from the crest

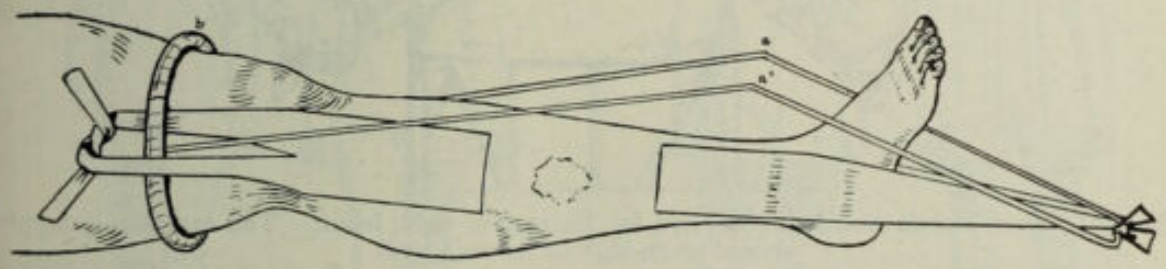


FIG. 418.—Method of using Thomas's arm splint for fracture of leg bones (in C. C. S. or base hospital only). The lower and upper strips of plaster make extension and counterextension respectively, and are prevented from slipping by encircling bandage or plaster strapping. Perforated zinc or calico bandage slings support the fragments and popliteal space. Rotation of the foot is prevented by padding on each side or by a wire "foot piece." The splint is slung from a, a*, and b (Captain R. D. Laurie).

of the ilium to the outer malleolus, the other long enough to reach from the perineum to the inner malleolus. Fill the bags three-quarters full of dry sand, sew up their ends, cover the bags with slips, and put the bags in place in order to correct eversion. The slips may be changed every third or fourth day. Keep the bedclothing from coming in

contact with the extremity by means of a cradle (Figs. 416, 417). The bowels are to be emptied and the urine is to be voided in a bed-pan, unless using a fracture-bed. For two weeks the patient remains recumbent, after which time he can be propped up on pillows. Maintain extension for three weeks, then simply maintain support by sand-bags or molded pasteboard splints upon the part, and keep up this support three to five weeks more. After removing the extension he can be transferred daily to a couch. In from six to eight weeks after the infliction of the injury he can be moved about in a wheeling-chair, the leg being extended or the knee flexed in accordance with the dictates of

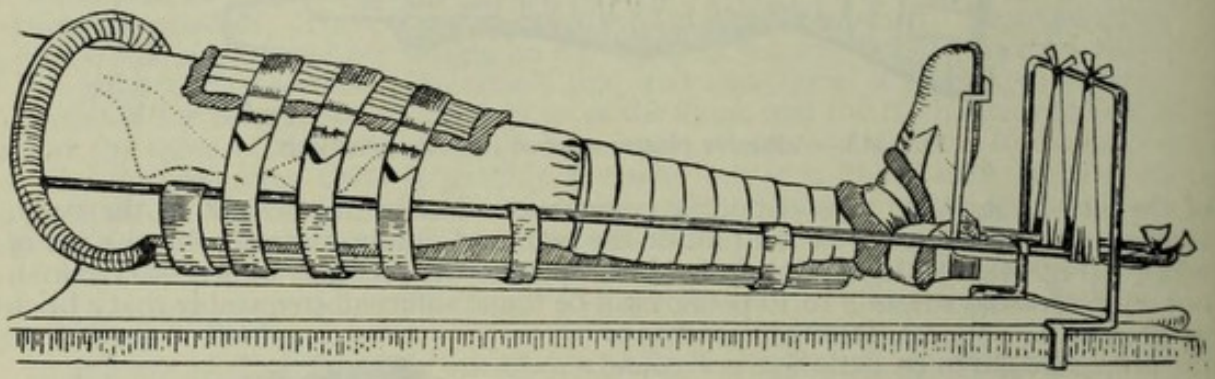


FIG. 419.—Fracture of thigh put up in Thomas's splint.

comfort. After a week or so of such movement a thick-soled shoe is placed on the sound foot and the patient is allowed to use crutches, but weight is not put upon the injured extremity until from ten to twelve weeks have elapsed from the time of the accident. For many months, at least, and possibly permanently, he walks with the aid of a cane. Union, if it takes place, is usually cartilaginous, but is sometimes bony, and there will surely be some shortening and also some stiffness of the joint. Passive motion is not made until at least eight weeks have elapsed since the accident. Treatment by the extension apparatus is far from satisfactory, as it does not afford sufficient immobilization.

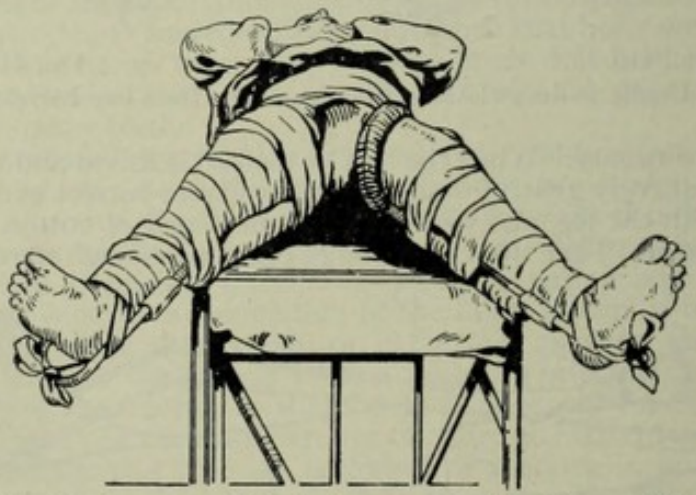


FIG. 420.—Jones's abduction frame applied for fracture of right femur. The extension strapping should reach high up on each limb.

Treatment by Thomas's Splint.—Scudder, in his valuable treatise on "The Treatment of Fractures," advocates in intracapsular fracture the use of Thomas's hip splint. If the bones are unimpacted, the fragments are brought into apposition by extension, inversion, and pressure upon the great trochanter, and the Thomas splint is bent to fit, is padded, and is applied (Figs. 422, 423). When the bed-pan is to be used or the bed is to be smoothed, the patient can be lifted without disturbing the fracture. He can be turned on the sound side. If hypostatic congestion is developing, raise the head of the bed and tie the splint to the iron of the head of the bed. In addition to the use of the splint Scudder advocates the making of lateral pressure over the great trochanter by a graduated compress and a bandage. The splint is worn for

six or eight weeks. It is then removed, the patient remaining in bed four weeks longer without any apparatus (Scudder, from Ridlon).

Jones, of Liverpool, treats fractures of the femoral neck by means of an extension frame (see Fig. 420). Some surgeons use the Hodgen splint (Fig. 325) or the Balkan frame (Fig. 421).

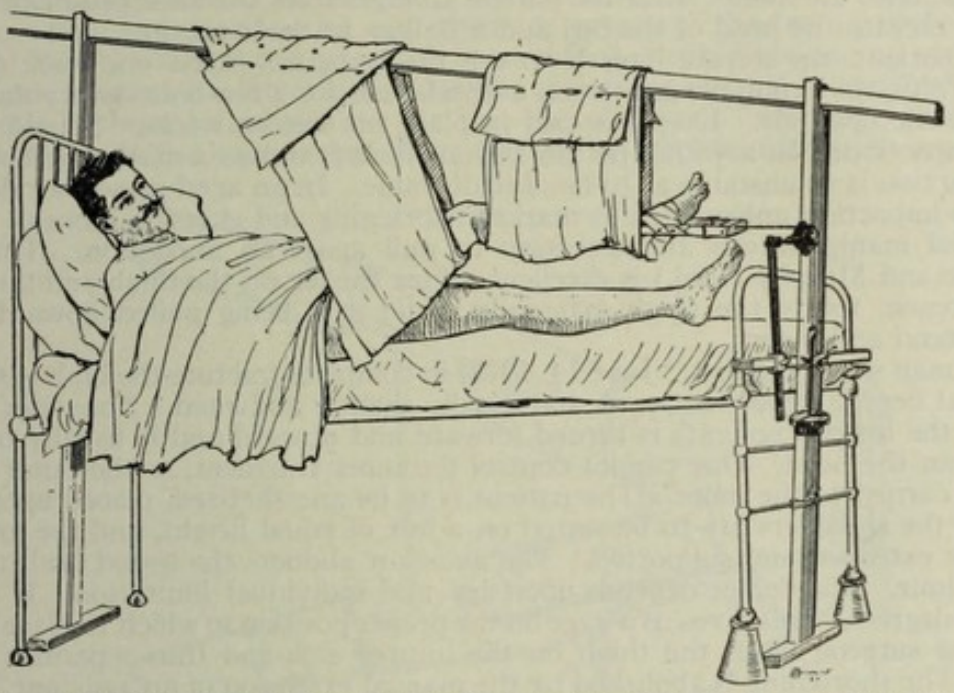


FIG. 421.—Balkan splint as used at the American Ambulance, Neuilly-sur-Seine, Paris, France. (Crile in "Annals of Surgery," July, 1915. Attributed to Lt.-Col. Miles by Sir Geo. H. Makins, "Brit. Med. Jour.," June 16, 1917.)

Whitman's Treatment in Abduction.—The plan advocated by Royal Whitman ("Med. Record," March 19, 1904) is a most excellent one. It aims to abolish traumatic depression of the neck of the femur.

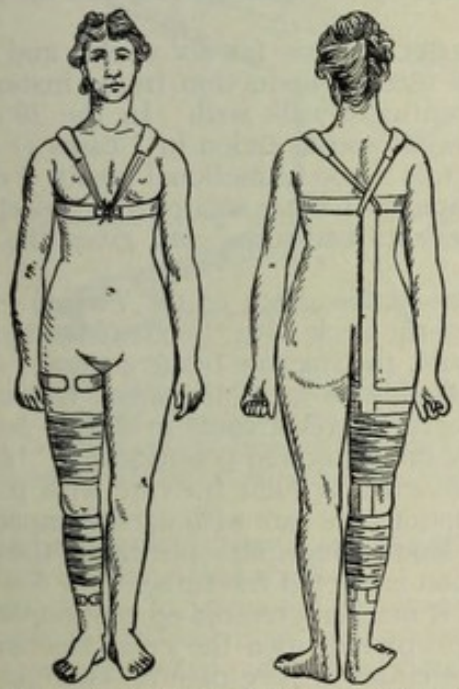


FIG. 422.—Thomas's single hip-splint in position (Ridlon).

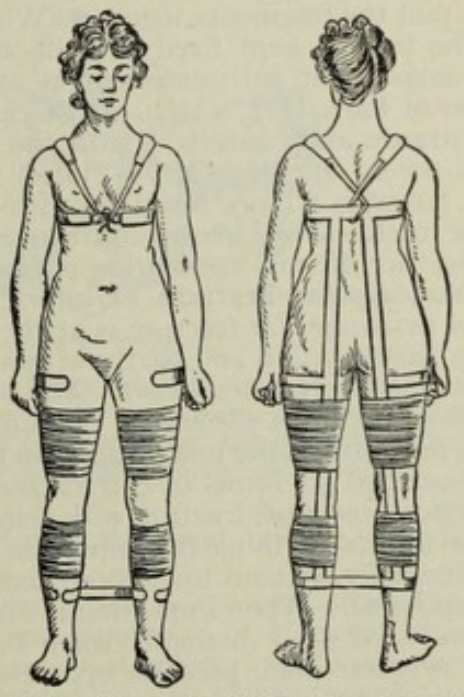


FIG. 423.—Thomas's double hip-splint in position (Ridlon).

I believe that when open surgical treatment is not indicated that abduction and the use of a plaster spica will give better results than any other method (Dorrance and Murphy, "Med. Soc. of State of Penna.," 1921). There is no age limit. Patients of

eighty have been so treated. The extension operating table is a great help and a general anesthetic is necessary. The neck of the bone is "brought to a horizontal plane. The capsule surrounds both fragments; the head is fixed in the acetabulum, consequently the tension of the capsule aligns the two fragments and forces an end-to-end contact" (Dorrance and Murphy, Ibid.). The plaster spica, reinforced by a rod of iron, passes to and includes the foot. After the patient emerges from the anesthetic Dorrance and Murphy elevate the head of the bed and a Balkan frame is set up.

The patient can elevate himself to use the bed-pan. After one week (Dorrance and Murphy, Ibid.) put the patient on a wheel-chair for a few hours every day and get him into the open air. Keep the cast in place for sixteen weeks. Should we break up an impaction? In a young person, beyond doubt; and, as a matter of fact, in them the impaction is so unstable as to be of little value. In an aged person we do not pull apart an impaction unless there is marked shortening and eversion (Jones).

Special manipulations are necessary to pull apart an impaction. The plan of Dorrance and Murphy (Ibid.) is excellent. Flex the leg on the thigh and the thigh on the abdomen, rotate the thigh externally while it is being pulled upward forcibly. Then extend and invert.

Whitman says ("Lancet," June 14, 1913) in complete fracture the limb is shortened, somewhat flexed, rotated outward, and usually slightly abducted. The outer fragment (that is, the lower fragment) is turned forward and upward and is usually on a lower plane than the head. One cannot control the inner fragment, so the outer fragment must be carried to the inner. The patient is to be anesthetized, placed upon a sacral support, the shoulders are to be rested on a box of equal height, and the lower limbs are to be extended and supported. The assistant abducts the sound limb to the anatomic limit. The degree depends upon age and individual limitation. It is usually 40 to 50 degrees. This gives us a gage on the proper position in which to place the other hip. The surgeon flexes the thigh on the injured side and thus separates the fragments. The shortening is abolished by the manual extension of an assistant. He then performs inward rotation and abduction to the proper degree. The abduction relaxes the muscles which interfere with reduction and carries the outer fragment against the inner.

The extremity is set in extension and extreme abduction. The tension of the capsule pushes the outer fragment against the inner and holds it; fixation is obtained by the neck of the femur being in contact with the acetabulum and the great trochanter with the pelvis; deformity cannot be caused by muscular action, and the psoas helps pull the fragments together (Whitman).

The limb is kept fixed in abduction by plaster of Paris for six weeks, and then a Thomas splint with extension is used. Jones uses an abduction frame instead of plaster of Paris (Fig. 424). Most cases will eventually walk well. In the 20 cases of Dorrance and Murphy (Ibid.) the *x*-rays showed osseous union in 2 cases (1 aged thirty-seven, the other fifty), 2 died, in 9 there was a good functional result, 3 could walk, but with a limp, 5 walked with aid of a cane, in 1 there was partial absorption of the neck. This treatment relieves pain, prevents bed-sores, and gives the best prospect for life and restoration of function.

Extracapsular Fracture (*Fracture of the Base of the Neck of the Femur*).—The line of extracapsular fracture is at the junction of the neck with the great trochanter, and is partly within and partly without the capsule, the fracture being generally comminuted and often impacted. The *cause* is violent force over the great trochanter (as by falling upon the side of the hip). This fracture is most usual in elderly people, but is met with in the middle aged and is not very uncommon in young adults. Stokes has described six forms of extracapsular fracture: extracapsular fracture with partial impaction posterior; fracture with complete impaction; fracture with partial impaction above; fracture with partial impaction below, the shaft being split; splitting of the neck longitudinally without impaction; comminuted non-impacted fracture.[1]

Symptoms.—When impaction is absent there is marked crepitus on motion, which is manifested most distinctly when the fingers are placed upon the great trochanter; there is severe pain, pressure upon the great trochanter is very painful, swelling and ecchymosis are marked; there is absolute inability on the part of the patient to move the limb, and passive movements cause violent pain; there is shortening to the extent of at least 1½ inches, and sometimes to the extent of 3 inches, and this shortening is made manifest by noting the ascent of the trochanter above Nélaton's line, by a comparison of measurements of the injured limb and the sound limb, and by measuring

[1] "Brit. Med. Jour.," Oct. 12, 1895.

the base-line of Bryant's triangle on each side. Absolute eversion usually exists with slight flexion both of the leg and the thigh. In some rare cases there is inversion. This happens if at the time of the accident the limb was inverted and adducted (Stokes). Langoria's sign, Desault's sign, and Allis's sign are present. All these symptoms follow violent direct lateral force to the great trochanter. In the *impacted* form of extracapsular fracture, in addition to the aid given the surgeon by the history, there is severe pain, which is intensified by movement or pressure; shortening probably to the extent of 1 inch, which is not corrected by extension; limited abduction; great loss of function; and whereas the limb may be straight or even inverted, it is usually everted. The trochanter is above Nélaton's line, the base-line of Bryant's triangle is shortened, but not so much as in the unimpacted form; there is no crepitus unless the impaction

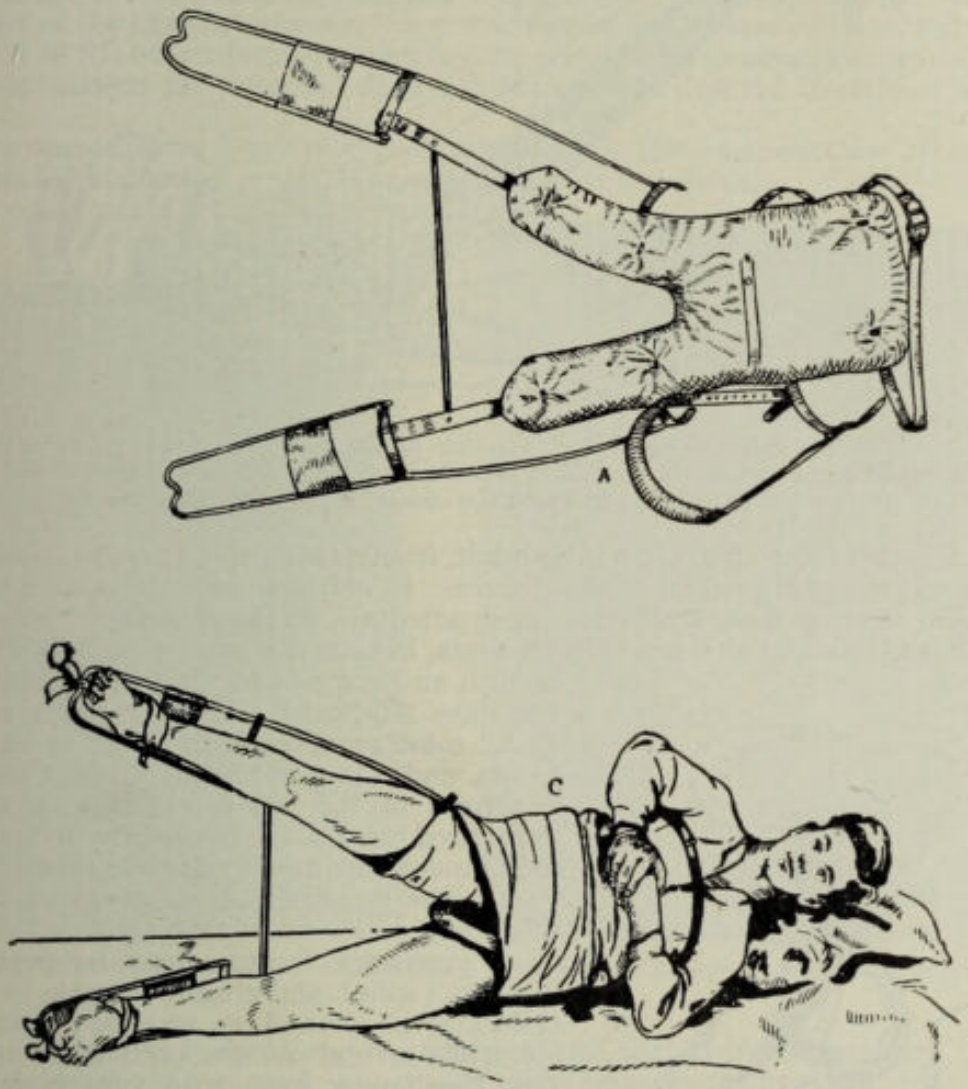


FIG. 424.—A, Jones's abduction frame for fracture of femur, when the accompanying wounds prevent the use of Thomas's splint outfit. These frames ought to be made with joints opposite the hip, so that they can be used for either side and can be "closed" for transport on a stretcher. C, To show the method of application. Temporary clove-hitch used around each ankle.

is loose or is pulled apart, and the arc of rotation of the great trochanter is larger than in a non-impacted fracture.

Treatment.—In impacted extracapsular fracture it is best to pull apart the impaction if the patient is in good physical condition. Southam, of Manchester, in an impressive article has insisted on the absolute necessity of pulling apart an impaction. He gives ether, and when the patient is anesthetized unlocks the fragments.[1] This unlocking is best accomplished by abduction, the rim of the acetabulum acting as the fulcrum of the lever (Whitman). In treating extracapsular fracture use abduction. Some use the extension apparatus with sand-bags (see page 550) for three weeks and then apply a plaster dressing. Get the patient on crutches after the plaster has been

[1] "Lancet," Dec. 21, 1895.

in place for two weeks. Remove the plaster at the end of four weeks. Thomas's splint may be used instead of Jones's frame.

Fractures of the femoral neck in children and in young adults can scarcely be regarded as very unusual, and is certainly more often encountered than separation of the upper epiphysis, which is extremely rare in childhood. The accident results

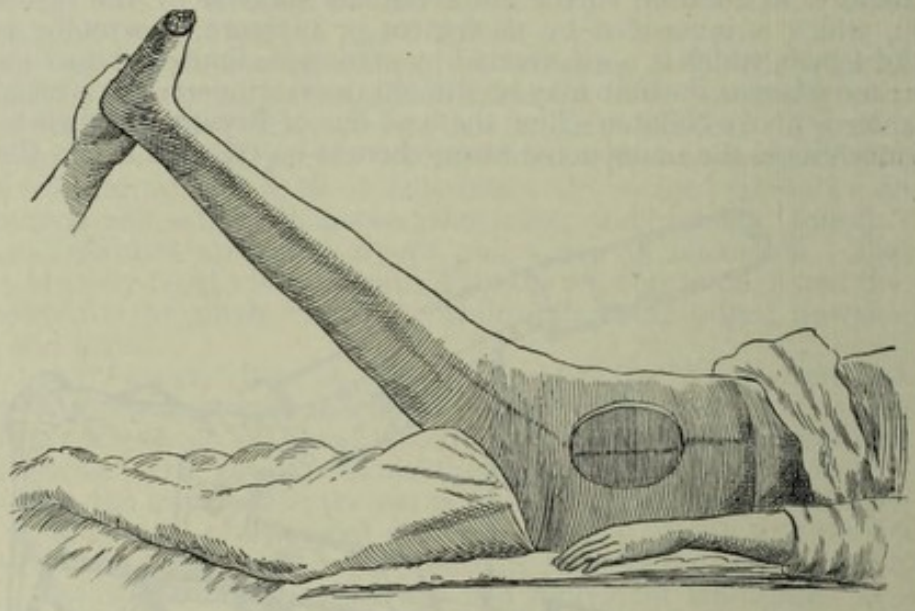


FIG. 425.—The long spica as applied for fracture of the neck of the femur in the adult; illustrating the advantage of an appliance which permits movement without danger of displacing the fragments; an opening has been made to lessen the constriction of the abdomen (Whitman).

from a fall rather than, as so often in an adult, from a twist, and it is the product of considerable violence rather than of slight force. In children such fractures may be impacted, and most of those which are unimpacted are of the greenstick variety. The disability is not nearly so great as in an adult; in fact, it is not unusual for the victim of such an injury to be able to hobble about a few days afterward. The symptoms are shortening, some eversion, impairment of joint movements, and a limp when the patient gets about. Fractures of the hip in children are often unrecognized and lead frequently to permanent impairment because of the development of coxa vara. The *x*-rays should be used in making the diagnosis.

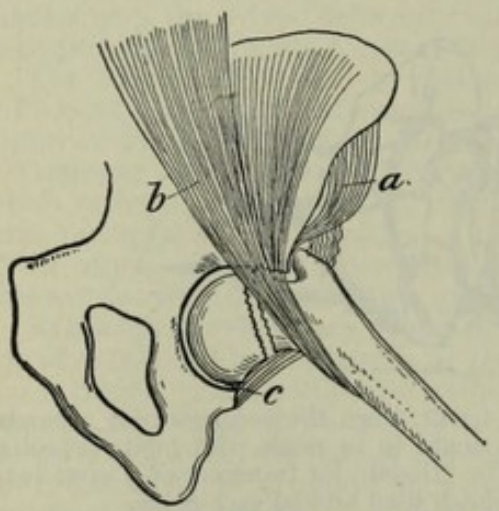


FIG. 426.—Reduction and fixation in abduction, showing security assured by direct bony contact of the neck and trochanter with the pelvis, also the effect of the attitude on muscular action: *a*, Abductor group; *b*, iliopsoas; *c*, capsule (Whitman).

A greenstick fracture may be treated with Thomas's splint, and after four weeks in bed "the child may be allowed up, wearing a traction hip-splint for several months until union is so firm that the danger from coxa vara is practically eliminated. A light plaster-of-Paris spica bandage from the calf to the axilla will maintain immobility after the splint is omitted" (Scudder on "The Treatment of Fractures"). An impacted fracture, after the impaction has been pulled apart, is treated exactly as a greenstick fracture. Royal Whitman's plan for treating a greenstick fracture is very satisfactory. This surgeon ("Med. Record," March 19, 1904) dresses these cases by placing the limb in extreme abduction and holding it so by means of a plaster-of-Paris spica (Figs. 425, 426). In a case of acute disability of the hip-joint in a child, following some time after fracture of the femoral neck, make a careful differentiation from tuberculous disease of the joint and apply a traction splint to support the body and give rest to the joint. If coxa vara becomes marked and causes great disability, osteotomy is justifiable.

Operative Treatment of Recent Fracture of the Femoral Neck.—I have practised this but once. The patient was a woman forty years of age and the result was excellent (see Fig. 414). The operation is not indicated in elderly subjects. It is not indicated at all if the fragments can be coaptated and retained by abduction. In a youth or a middle-aged person if retention in correct posture is impossible it is indicated. McGlannan sets forth the following contraindications to operation ("Surgery, Gynecology, and Obstetrics," March, 1916): Dilated heart, intermittent pulse, irregular pulse, very high blood-pressure, pulmonary congestion, marked renal insufficiency, evidences of a nervous breakdown, signs of uremia, alcoholism, or a drug habit.

Some advocate incision, suture of the torn capsule, and nailing. In my case I nailed through a very small skin incision and did not suture the capsule. It is held that suture of the capsule improves the circulation in the broken off head, but possible attainment of the object is not justification for the risk. The small cutaneous incision and nailing answers the purpose. It is not necessary to drill the trochanter as König did.

Before operating an *x*-ray picture is taken, while the fragments are brought into apposition by abduction or by extension and counterextension. From this picture



FIG. 427.—Comminuted fracture of upper third of femur.



FIG. 428.—Epiphyseal separation of head of the femur.

the angle of the neck is noted and the length of nail required is determined. A silver nail may be used. When ready to operate, the fragments are again brought into apposition by extension and counterextension or abduction. A small incision is made through the skin over the external aspect of the great trochanter, and the nail is driven through the trochanter and neck into the head. The wound is closed and dressed. The pelvis and extremity are then put up in plaster, a trap-door being cut over the seat of incision. The plaster dressing is retained for five or six weeks. Cure is obtained without shortening and with retention of joint mobility. This operation is also used for ununited fracture. Dr. G. G. Davis was the first to do a nailing operation for a recent intracapsular fracture of the femur. Albee prefers a peg of bone cut from the tibia, because he believes that nails of metal act as foreign bodies, retard callus formation, produce necrosis of adjacent bone, and loosen. One incision is made in front over the fracture. Another is made over the great trochanter. The bone-graft is shaped into a peg. The neck of the femur is drilled and the peg is inserted. The extremity is put in abduction and is so held in plaster for six weeks ("Annals of Surgery," 1915, lxii). A bone peg has such feeble osteogenetic power that it seems scarcely worth while to use it. If a fracture of the femoral neck is found to have united in a deformity which is crippling, subtrochanteric osteotomy is the treatment.

Separation of the upper epiphysis of the femoral head (Fig. 428) is a very rare result of accident; it occurs most often from disease. It is met with in youth, results in considerable permanent shortening, and perhaps in coxa vara. Royal Whitman points out its extreme rarity in childhood ("Annals of Surg.," Nov., 1922). It occurs particularly in adolescents. In childhood "the junction is protected by a thick covering of cartilage" (Whitman, Ibid.). The fracture may be complete from direct violence, but may be incomplete and progressive.

Symptoms and Treatment.—The *symptoms* of the complete form are like those of fracture of the neck, except that the crepitus is soft. In an incomplete separation there is a history of injury, the patient limps, and there is pain in the hip and knee during and after effort. During months the disability increases. There is external rotation and trivial shortening. Passive movements are limited in "flexion, abduction, and inward rotation" (Whitman, Ibid.). The *x*-ray picture is definite. The treatment is usually by abduction. If reduction is found to be impossible, open operation is called for.



FIG. 429.—Dr. Jones's case of fracture below the great trochanter and running into the joint (*x*-rayed by Sender).



FIG. 430.—Intertrochanteric fracture of the femur (skiagraphed by Dr. Manges).

Fractures of the Great Trochanter.—This is a very rare injury. There seem to be on record only 8 cases limited to the trochanter, but probably the diagnosis has been missed in some cases in which the fragment was held to the bone by periosteum. The line of fracture may run up into the neck (Fig. 429). This process may be (1) broken off without any other injury. In some cases it is completely broken off; in some it remains attached by periosteum and fibrous tissue. (2) The line of fracture may run through the trochanter and leave one portion of the trochanter attached to the head and neck and the other part attached to the shaft of the femur. The *cause* is violent direct force over and behind the great trochanter or a fall (Armstrong in "Annals of Surgery," Aug., 1907). Neck reported a case due to muscular action ("Zentralbl. für Chir.," 1903). The break may be intertrochanteric (Fig. 430).

Symptoms and Treatment.—The *symptoms* of form 1 resemble those of epiphyseal separation and, of course, there is no shortening. The symptoms of form 2 are similar to those of the extracapsular fracture. On rotating the femur the lower part of the trochanter moves with it, but not the upper. The lower fragment goes upward and backward and projects by the side of the sciatic notch. There are shortening, eversion, crepitus, and altered position of the trochanter. The *treatment* of the second form is like that in extracapsular fracture, and the first form is treated like separation of the epiphysis of the trochanter.

Separation of the epiphysis of the great trochanter is a rare accident. The *cause* is direct violence and the injury occurs in those under eighteen years of age. Poland in 1898 collected 12 cases.

Symptoms.—The trochanter, if completely separated, is found to have ascended and passed posteriorly; there is no shortening of the thigh; all the motions of the hip-joint can be obtained; if the thigh is flexed, abducted, and rotated externally, and the fragment is pushed downward and forward, crepitus may be obtained—soft in epiphyseal separation, hard in fracture. There is no shortening. If the process is not completely separated, diagnosis is impossible without the *x*-rays.

Treatment.—If the epiphysis is not completely separated, immobilize the limb in the position of abduction. If it is completely separated, incise the soft parts and either suture or nail the fragment in place.

Separation of the Epiphysis of the Small Trochanter.—This is a very rare lesion. Metcalf ("Jour. Amer. Med. Assoc.," 1915, lxiv) reported 2 cases and discussed the lesion. It may be due to direct or indirect force, but is usually caused by sudden and forcible contraction of the iliopsoas muscle. It causes severe local pain and tenderness. The patient cannot flex the hip. *Ludloff's sign* may be present. That sign consists of swelling and ecchymosis at the base of Scarpa's triangle. The case is treated by flexing and immobilizing the thigh.



FIG. 431.—Fracture through the upper third of femur (skiagraphed by Dr. Manges).

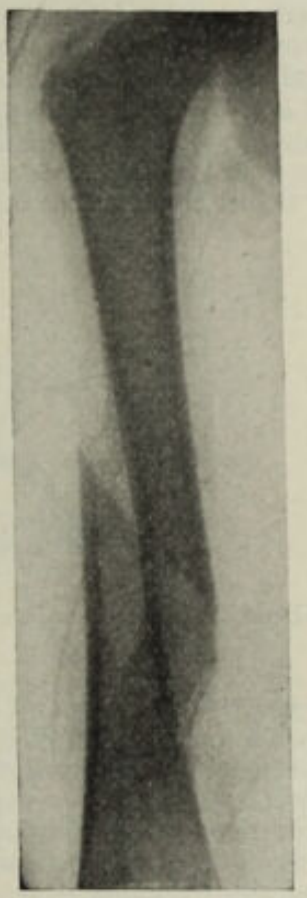


FIG. 432.—Dr. James A. Kelly's case of spiral fracture of femur in middle third (radiographed by Dr. Sender).

Fractures of the shaft of the femur may affect any portion of the shaft, but especially the middle third, and may occur at any age. Fracture of the upper third is a rare accident. Allis estimates that each year in Philadelphia there is 1 case of fracture of the upper third of the femur to every 100,000 inhabitants. Separation of the lower epiphysis occasionally occurs. The *cause* of fractures in the upper third is usually indirect force; fractures in the lower third are due to direct force; and in fractures of the middle third these two causes are about equally potential. Fracture from muscular action occasionally occurs. Oblique fracture is the usual variety. In many cases the soft parts are badly lacerated and sometimes a great vessel is torn.

Symptoms.—The chief symptom in fracture of the shaft of the femur is great displacement, except when impaction occurs, when the break is due to direct force, or when the injury is in a child. In a child the line of fracture is often transverse and the periosteum may be untorn. Greenstick fractures occur in children. As a

rule, in fracture of the shaft of the femur the lower fragment is drawn upward and the upper end of the lower fragment is found posterior and somewhat to the inside of the lower end of the upper fragment, and the lower fragment also undergoes external rotation (the drawing up is due to the rectus and hamstrings; the passing inward is due to the adductor muscles; the rotation outward arises from the weight of the limb). If a fracture of the lower two-thirds of the shaft is produced by direct force, there is usually but little deformity, because the line of fracture is nearly transverse. If produced by indirect force, there is often great deformity, the line of fracture being oblique. In fracture of the lower third of the shaft the gastrocnemius pulls upon the condyles and tilts the lower fragment, so that its upper end projects into the popliteal space and may damage the vessels. In fracture of the upper third the upper fragment is apt to be thrown strongly forward and outward (Fig. 431). Some attribute this to the action of the psoas, iliacus, and external rotator muscles, but Allis thinks it is due chiefly to the lower fragment pushing the upper fragment into this position, a part of the tendon of the gluteus maximus acting as a hinge for the fragments.[1] In rare cases the angular deformity is backward. In fracture of the shaft of the femur there is complete loss of function, the thigh and leg are slightly flexed and usually everted. In unusual cases the leg and lower fragment are inverted. There are shortening to the extent of 2 or 3 inches, pain on movement, preternatural mobility, crepitus and obvious deformity, and the ends of the fragments can be felt by the surgeon. In impaction there is alteration of the axis of the limb and some shortening. Always feel for the pulse below the fracture to learn if the artery has been damaged.

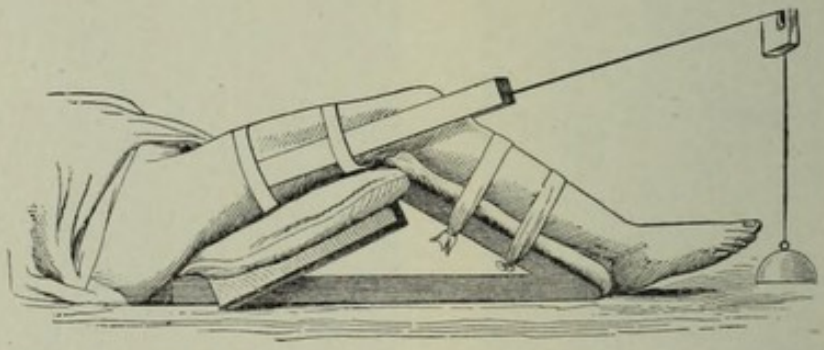


FIG. 433.—Dressing of fracture of the femur in the upper third with extension upon a double inclined plane (Agnew).

Treatment.—In setting and dressing a fracture of the thigh ether should be given and the parts must be handled with great care to prevent a sharp end of bone from tearing the soft parts and puncturing the skin. In fracture of the shaft of the femur, if impaction exists, the fragments must be pulled apart, when the case should be treated exactly as is a non-impacted fracture. After a fracture of the shaft of the femur some amount of permanent shortening is almost inevitable. In *fracture of the upper third* in an adult conservative treatment is usually unsatisfactory, and there is permanent shortening from angular union or from overlapping. In youths under fifteen a good result is obtained in over 90 per cent. of cases. Horizontal extension fails to correct the displacement of the upper fragment in fracture of the upper third. The double inclined plane (Fig. 433) will not correct the tilting of the upper fragment while shortening exists. Agnew used a double inclined plane and corrected shortening by the use of extension in the axis of the partly flexed thigh (Fig. 433). This plan is one of the most serviceable of those usually employed, but it, too, fails to correct the displacement completely. If, notwithstanding position and extension, the upper fragment projects, it should be pushed into place and be retained if possible by short splints bound upon the thigh. In many cases a Thomas knee-splint is the best apparatus. In fracture of the upper third with marked projection of the upper fragment the abduction frame may prove satisfactory. Extension should be continued for four weeks, a plaster-of-Paris bandage being used for four weeks more, the patient being then allowed to go about on crutches. Some surgeons, in fracture of the upper third, apply a plaster-of-Paris bandage to the leg, thigh, and pelvis, extension being made from the foot while the dressing is being applied. This method does not give good results because such extension will not correct the tilting of the upper fragment. The an-

[1] "Fracture in the Upper Third of the Femur Exclusive of the Neck," by Oscar H. Allis, "Medical News," Nov. 21, 1891.

terior splint of Nathan R. Smith is used by some in treating fractures of the upper third of the femur (Fig. 434). It is bent to the desired shape, fastened to the anterior surfaces of the leg and thigh, and hung to a gallows, the limb being suspended at the desired height. This splint is open to the same objection as the double inclined plane. Suspension, adjustment by weights, and traction by Blake's splint or a like apparatus is used by many (Figs. 323, 419–421). In fact, in many fractures of the upper third of the shaft of the femur no apparatus will maintain reduction. In such cases it is advisable to incise, separate the muscles from between the fragments, and fasten the ends of the bone fragments together with bone plates. This radical treatment has certain dangers of its own, but it is the plan which promises best to secure a thoroughly good limb. In *fracture of the middle third* or *upper part of the lower third* of the shaft of the femur the Thomas knee-splint is an excellent instrument. The extension apparatus and sand-bags will usually secure a satisfactory result (Fig. 348, 14). The strips of adhesive plaster are carried to just below the seat of fracture, and the turns of the roller bandage should be taken to a little above this point. Extension should be continued for four weeks, when the plaster-of-Paris bandage ought to be applied. The plaster is kept in place for four weeks. Many surgeons use Hodgen's splint in treating fractures of the thigh. The limb is suspended in a cradle and extension is obtained by strapping the foot to the cross-bar of the frame and pulling upon the frame by cords (Fig. 435). Hodgen's apparatus as applied by Brown, of Birmingham, Ala., is one of the most satisfactory methods of treatment in fracture below the upper third. The extremity can be raised or lowered at will without disturbing the approximation of the fragments, extension to the required degree can be obtained, and the patient can be moved in bed. I consider this apparatus one of the most comfortable appliances which can be worn and excellent results are obtained by its use. Blake's splint is even more comfortable and useful (Fig. 323). In fracture of the middle third or upper part of the lower third of the shaft if the line of fracture is transverse and there is little deformity, as is seen often after a fracture by direct force, and often in children, immobilization in an immovable dressing may be all that is required, but if shortening exists, extension must be used. If extension is used, continue it for four weeks and then substitute a plaster-of-Paris dressing for four weeks. The amount of weight required is pointed out by Dawbarn—1 pound for each year up to twenty.[1] In *fracture near the knee-joint* (*lower part of the lower third* of the femur) it may be impossible to effect reduction by horizontal traction. In such a case have an assistant make traction, and while it is being made gradually bring the leg to a right angle. Place the limb in a double inclined plane (see Fig. 348, 2). A McIntyre splint (Fig. 436) is a useful form of double inclined plane. After four weeks of the use of a double inclined plane apply a plaster-of-Paris dressing, which is to be worn for four weeks. Useful appliances for fracture of the femur are shown in Figs. 419–421, 424.

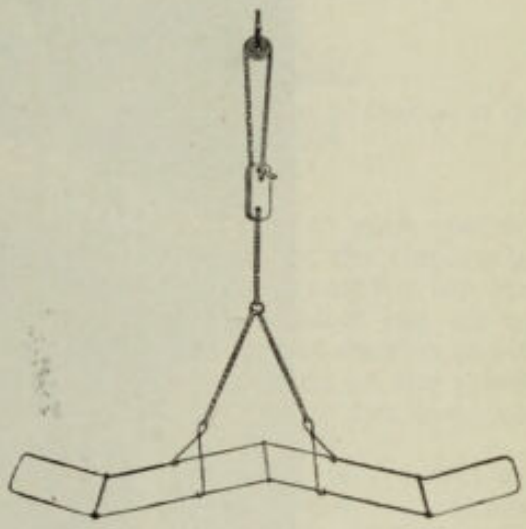


FIG. 434.—Smith's anterior splint.

Fractures of the Shaft of the Femur in Children.—In children under three years of age the extension apparatus will not satisfactorily immobilize the fragments. A fracture of the thigh in a child is reduced by extension and counterextension; a well-padded splint reaching from the axilla to below the sole of the foot may be applied to the outer side of the limb and body. This splint is held in place by bandages which are overlaid by plaster-of-Paris. It is worn for four weeks, when it is removed and a plaster bandage, applied so as to include the entire limb, is worn for four weeks.

The abduction frame (Fig. 437) is a very useful plan of treatment.

Bryant's extension (Fig. 438) is very satisfactory in treating a young child. I use this plan of overhead traction in preference to any other method. Both the injured limb and the sound limb should be flexed to a right angle with the pelvis, fixed by light splints, and fastened to a bar above the bed. The weight of the body produces counterextension and the child can be easily cleaned.[2]

[1] "Annals of Surgery," Oct., 1897. [2] Thomas Bryant's "Practice of Surgery."

Another plan is that of Theodore Dunham.[1] The child is placed upon a table, and the knee and hip are partly flexed. After first applying flannel rollers, plaster-of-

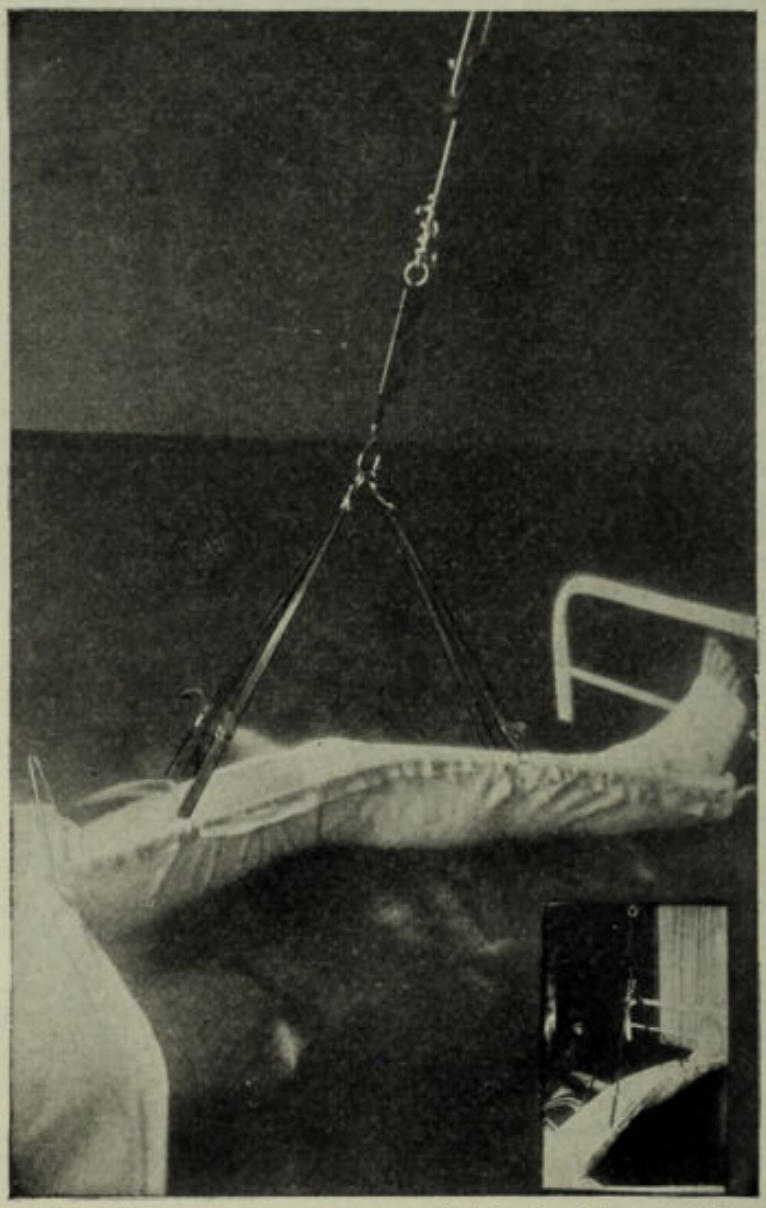


FIG. 435.—Hodgen's apparatus as applied by Dr. George S. Brown.

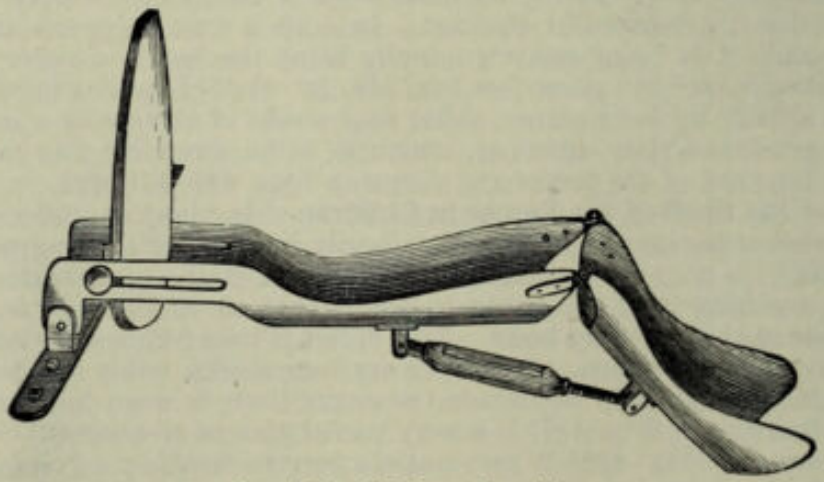


FIG. 436.—McIntyre's splint.

Paris bandages are applied from the roots of the toes to the spine of the tibia, and as a spica about the upper part of the thigh and pelvis. Two pieces of iron, suitably

[1] "Phila. Med. Jour.," April 23, 1898.

bent, are used to anchor the two plaster bandages together. One end of one iron is attached to the plaster over the groin and one end of the other iron is attached to the plaster over the front of the leg. The free ends of the irons overlap. At the points over the joints and the front of the leg where the irons are to rest masses of plaster are placed. The iron is sunk into the plaster and supported at each spot by several turns of a plaster bandage. While the irons are being adjusted the thigh is so held as to prevent bending or rotation, and the hip and knees are semiflexed. When the plaster has set an assistant makes extension on the leg and another assistant makes counterextension by pressing on the pelvis. Any shortening is thus reduced and the two irons are lashed together by strong cord (Fig. 439).



FIG. 437.—Jones's abduction frame, showing continued traction and counterextension (courtesy of Sir Robert Jones, Liverpool, England).

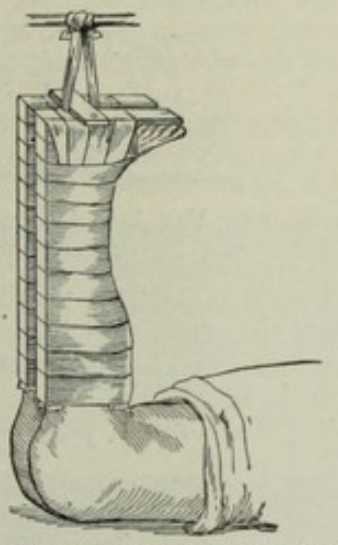


FIG. 438.—Bryant's extension for fracture of the thigh in a child.

Van Arsdale's triangular splint is a very useful appliance. It is made of binders' board. A. Ernest Gallant[1] describes its preparation and application as follows: Measure the length of the sound thigh from the middle of the groin to the end of the femur.

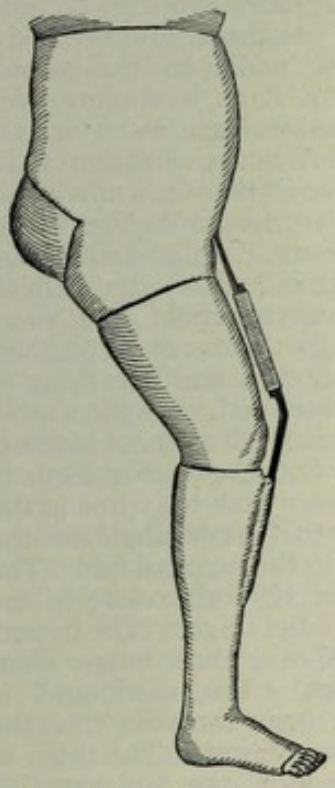


FIG. 439.—Dunham's apparatus for treating fractures of the thigh in infants and children.

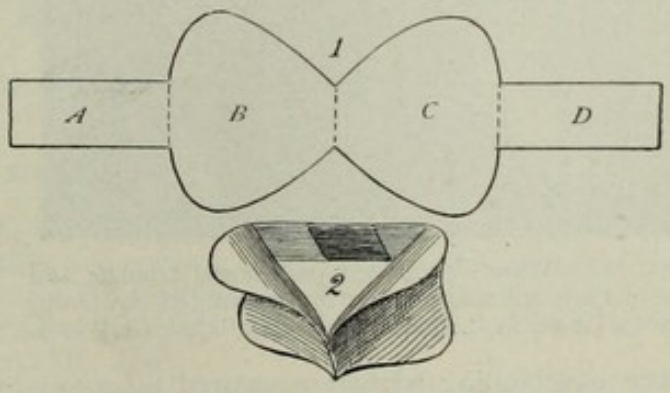


FIG. 440.—1, Diagram showing outline of Van Arsdale's splint; the end band to be folded on the dotted lines; each section to equal the length of the child's thigh. 2, Diagram, splint folded, fastened by rubber plaster, flanges bent to embrace the thigh and abdomen, ready for adjustment (Gallant).

Draw upon cardboard an outline of a double spade (playing-card spade—Fig. 440).

[1] "Jour. Amer. Med. Assoc.," Dec. 18, 1897.

Each of the 4 sections (*A*, *B*, *C*, *D*) must be equal to the length of the child's thigh, the flanged portions being equal to the widest part of the thigh. The figure is then cut out. The cardboard is moistened on one side and folded on the dotted line, section *A* being lapped over *D*, so as to form a triangle. It is fastened together by adhesive plaster. The thigh is flexed and the triangle is applied so that one flanged portion embraces the thigh and the other flanged portion rests upon the abdomen (Fig. 441). The



FIG. 441.—Showing Van Arsdale's triangular splint in position. Note the wide space between the dressings and the excretory passages (Gallant).

triangle is fixed in position by bandages, figure-of-8 turns being made around the knee and around the thigh and body. Plaster or starch bandages are then applied to fix the splint firmly. The leg should be bandaged from the toe to the knee to prevent swelling (Fig. 441). This splint is worn for three weeks. A child wearing this splint can sit on a chair, nurse, play on the floor and crawl about, may sleep on either side, and the dressing is not soiled by the evacuations.

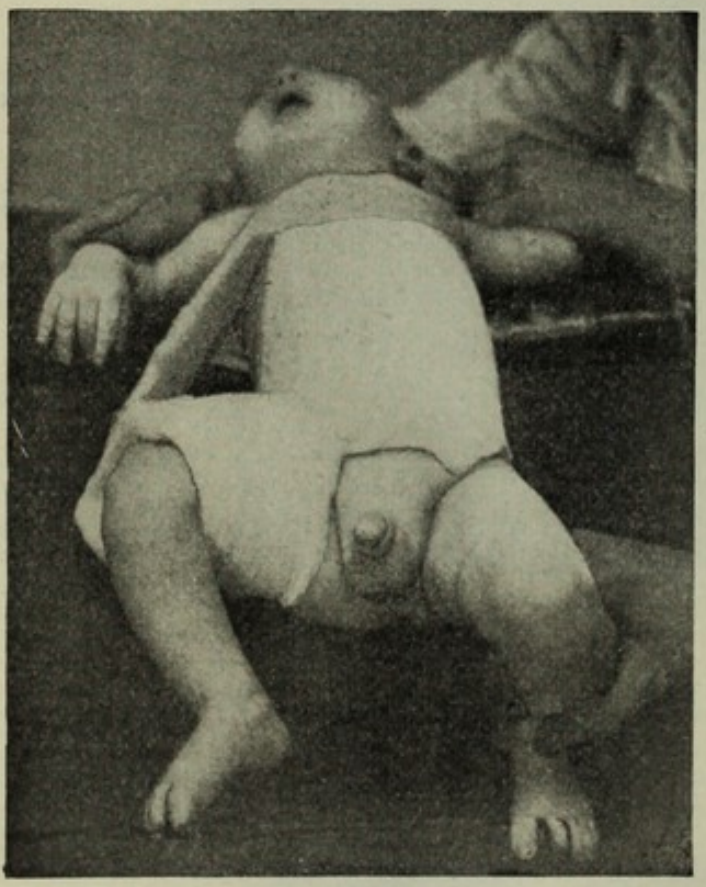


FIG. 442.—Ware's combined pasteboard triangle and plaster-of-Paris spica apparatus for fracture of the femur in infancy (Ware in "Annals of Surgery," August, 1905).

If a thigh is fractured during parturition, or during the first few weeks of life, *Wyeth's dressing* may be very serviceable. It is applied as follows: The leg is flexed on the thigh and the thigh on the abdomen. A flannel bandage is applied so as to include the leg, the thigh, and the body from the axilla to the pelvis. Plaster of Paris is applied over this; the dressing is worn for four weeks. A better dressing than the above is *Ware's*, a modification of *Van Arsdale's splint* ("Annals of Surg.," Aug., 1905—Fig. 442). It is lighter, the patient can be moved about with ease, the child's toilet can be carried out efficiently, and breathing is not embarrassed. A right-angled triangle is made of bookbinders' board. The length of one side is the distance from the trunk at the level of the lower angle of the scapula to the inguinal fold. The length of the other side is the length of the thigh. The hypotenuse is, of course, longer than the sides. The cardboard is marked, bent into the triangle, and the overlapping edges are secured by means of adhesive plaster. The thigh is flexed and abducted, the inner surface of the splint is padded, the apparatus is applied and retained by a muslin spica about the trunk and thigh. Several turns of a dextrin bandage are applied over this to give strength. The leg hangs free. The dressing is worn for three or four weeks. Figure 442 shows this dressing applied for fracture of the right femur, and Fig. 443 shows it applied when both bones are broken.

Fractures Just Above the Condyles of the Femur.—The *line* of fracture above the condyles is well above the epiphyseal line. The popliteal artery is in danger from the

fragments. The *cause* of the break, as a rule, is direct violence. Indirect force (falls upon the feet) is sometimes responsible. The knee-joint may be opened. The fracture is sometimes compound.

Symptoms.—The upper end of the lower fragment is drawn upward and backward because of the action of the rectus, hamstrings, gastrocnemius, and popliteus. The upper fragment passes inward, and the deformity is very manifest. There are pain, tenderness, shortening, crepitus, and mobility. The ends of the fragments can be felt by the surgeon. If the force has been very great, a T-fracture results. In T-fracture the knee is broadened and crepitus is obtained by moving the condyles, one front and the other back. The popliteal vessels may be torn. Always feel for the pulse below the fracture.

Treatment.—In treating fracture above the condyles, reduce the deformity by horizontal extension. If this fails, make traction at the same time, gradually bringing the leg to a right angle with the thigh. Place the limb on a double inclined plane for five weeks, then begin passive motion once every other day, reapplying the splint after the movements are completed. At the end of eight weeks after the accident remove the dressings, and, if the knee-joint be stiff, use for some time massage, passive motion, hot air, hot and cold douches, ichthyol inunctions, etc. Bryant treats this fracture in extension, cutting the tendo achillis, if necessary, to amend deformity. It is occasionally necessary to plate the fragments. Some few cases demand amputation because of injury to the structures in the popliteal space.

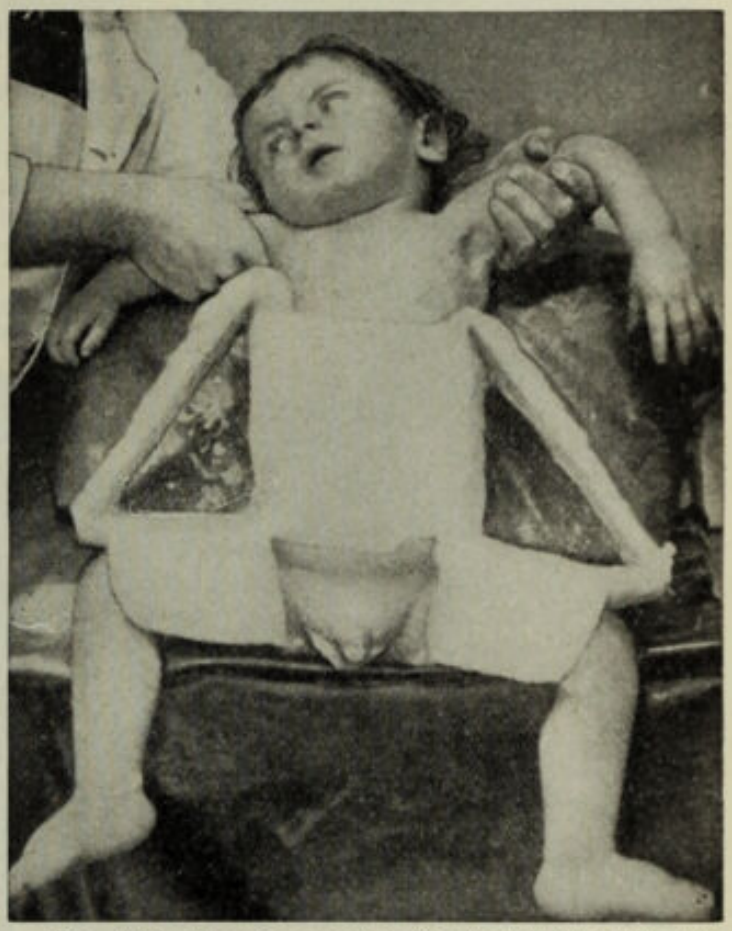


FIG. 443.—Ware's apparatus for treatment of fracture of both femora (Ware in "Annals of Surgery," August, 1905).

Fracture Separating Either Condyle.—The *cause* is direct force.

Symptoms and Treatment.—The broken piece is drawn upward, the leg bends toward the injury, crepitus exists, the knee is much broadened, there is no shortening, and considerable swelling is sure to arise. In treating a fracture separating either condyle, use a double inclined plane as directed above. If there is great displacement, the condyle should be nailed in place.

Longitudinal fractures run upward from the knee-joint. The *cause* is a fall upon the feet or the knees.

Symptoms and Treatment.—The *symptoms* of longitudinal fracture are often obscure. The femur is broadened when the knee is flexed. The split may be detected between the condyles. The *treatment* is the straight position in plaster for eight weeks.

Separation of the lower epiphysis occurs only before the twenty-first year. It is not a very rare accident in children (Fig. 444).

The *symptoms* in separation of the lower epiphysis are like those of transverse fracture, but crepitus is moist. The lower fragment is tilted, so that the articular surface looks forward. The lower end of the upper fragment projects into the popliteal space. There is danger to the structures in the popliteal space. The growth of bone may be stunted. Feel for the pulse in the leg or foot.

Treatment.—Reduction may be effected in some cases by horizontal extension. Occasionally this is impossible.[1] In such a case adopt the plan of Hutchinson and

[1] See the case reported by Jonathan Hutchinson, Jr., and Howard L. Barnard, "Lancet," May 13, 1899.

Barnard, make extension, and while it is being made gradually place the leg at a right angle to the thigh. This is effected by an assistant making traction on the leg, while the surgeon clasps his hands beneath the lower part of the thigh and draws upward. The treatment for separation of the lower epiphysis is the use of a double inclined plane as above directed. In some cases replacement is impossible without incision. In a case of my own amputation was performed because of laceration of the popliteal vessels.

Fracture of the patella is a very common accident. The *cause* is direct force (often producing vertical, star-shaped, or oblique lines of fracture, but not uncommonly transverse) or muscular action (producing a transverse line of fracture).

Transverse Fracture of the Patella.—The knee-cap is more often broken by muscular action than is any other bone. When the knee is partly flexed the middle third of the patella rests upon the condyles of the femur and the upper third of the knee-cap projects above them: when in this position a contraction of the quadriceps may cause

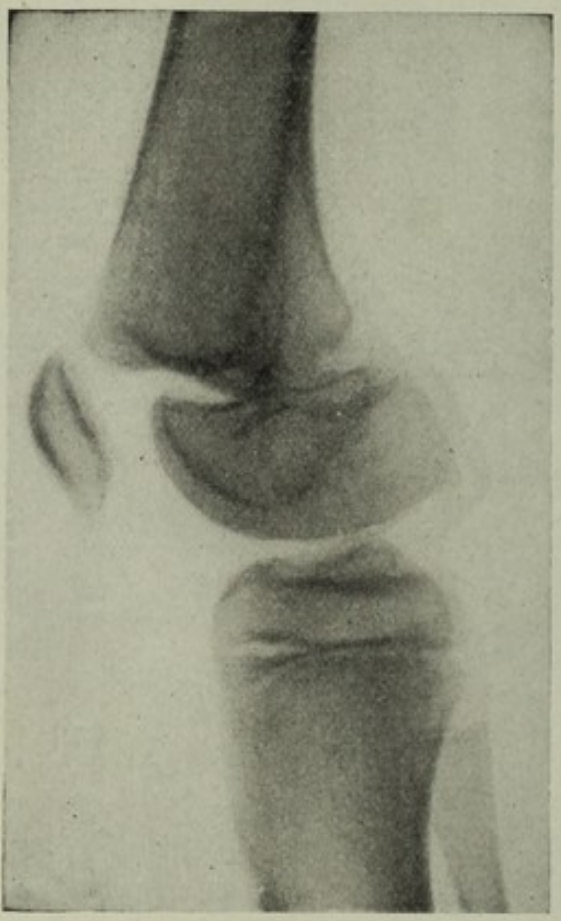


FIG. 444.—Dr. Senseman's case of fracture of lower epiphysis of the femur in a boy seven years of age.

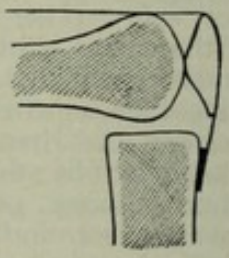


FIG. 445.—Mechanism of fracture of the patella by muscular action (after Treves).



FIG. 446.—Fracture of the patella.

easily a fracture near the center of the bone (Fig. 445). The accident may be due to sudden flexion of the knee when the quadriceps is contracting. The most usual cause is a fall or an attempt of the patient to save himself from a fall backward. Both patellæ may be broken at once. In fracture of the patella the joint, and often the prepatellar bursa, are opened. Fractures by muscular action and some fractures from direct force are transverse. The injury is more common in males than in females, and is extremely rare in the very young and the old. It is usually an injury of active manhood and middle life, but I have seen a woman of eighty-six with fracture of the patella.

Symptoms.—When the accident happens there is often an audible crack. As a rule, the patient will not try to use the limb, although it is possible for him to stand, to walk backward, and to move slowly forward when the extremity is kept straight. After the accident there is rapid and enormous swelling, due to the effusion first of blood and then of synovia and inflammatory products into and around the joint. The patient is absolutely unable to raise the limb from the bed. The fragments are movable and usually widely separated (Figs. 446, 447, and 448), this separation being

distinctly manifest to the touch unless swelling is great. The separation is accentuated by flexion of the leg. The separation may be to the extent of 1 inch or even more. In cases in which the lateral fibrous expansions and periosteum are but slightly torn, there may be trivial separation or no separation. Separation is due in part "to the retraction of the quadriceps and the tension of the fascia lata, and in part to distention of the joint by blood and exudate.[1] If fragments are not approximated and union does not occur, the separation becomes gradually greater because of the progressive shortening of the muscle and the retraction of the ligamentum patellæ (Stimson). In some cases an anterior angular displacement occurs because of the intra-articular distention. It may be produced by the pressure of bandages or strips of plaster when the fragments have been brought together. Crepitus is detected if the upper fragment can be pushed down until it touches the lower piece; but if swelling is great, or if fibrous tissue is interposed between the bones, crepitus cannot be elicited. It is not necessary to obtain crepitus in order to make the diagnosis; the condition is usually obvious without this sign. The anterior fibroperiosteal layer is torn, and the tear does not correspond exactly with the line of fracture. A portion of this torn fibroperiosteal layer may, as Macewan pointed out,



FIG. 447.—Fracture of patella (Dr. W. J. Taylor).

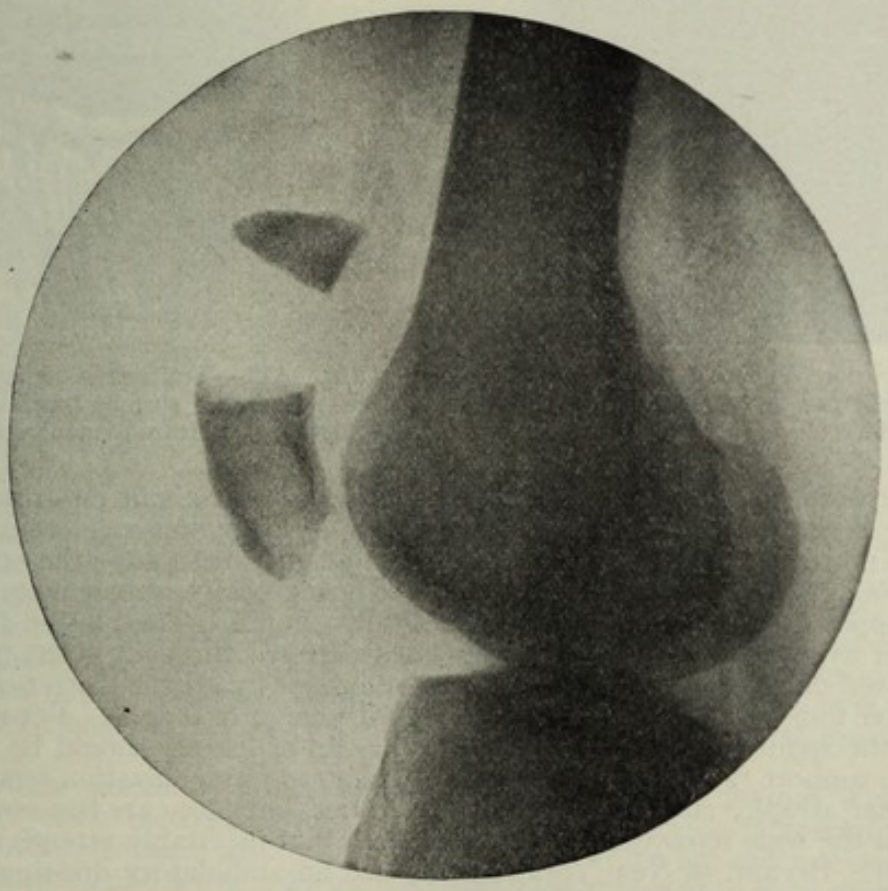


FIG. 448.—Fracture of the patella, showing wide separation of the fragments (author's case).

drop between the fragments and prevent union (Fig. 450). The lateral expansions of the capsule are usually extensively torn. If union occurs after a transverse frac-

[1] Stimson's "Treatise on Fractures and Dislocations."

ture, it will probably be ligamentous, and if the patient gets about too soon, even apparently well-united fragments will by degrees stretch far asunder.

Treatment of Transverse Fractures of the Patella.—*The Conservative Plan.*—If the swelling is so great as to prevent approximation of the fragments, reduce it by bandaging for a day or two, by using ice-bags, or by aspirating the joint. As a rule, the blood does not coagulate for several days. After it coagulates it cannot be withdrawn by aspiration, but only by incision. When the swelling diminishes, bring the two fragments into apposition, pull them together by adhesive plaster, and put on a well-padded posterior splint. Carry a piece of adhesive plaster over the upper end of the upper fragment, draw the bone down, and fasten the plaster to the splint behind and below the level of the joint. Carry another piece of plaster over the lower end of the lower fragment, draw the bone up, and fasten the plaster to the splint behind and above the joint. Carry a third piece over the junction of the fragments to prevent tilting. Agnew's splint enables us to accomplish satisfactorily this approximation (Fig. 348, 11, 12). A bandage holds the splint in place, and may be carried around the knee by figure-of-8 turns. The heel is sometimes raised upon a pillow so as to extend the leg and to semiflex the thigh, but this is not essential. Remove and reapply the dressing every few days, as it inevitably becomes loose. At the end of three weeks remove the splint permanently and apply a plaster-of-Paris dressing from just above



FIG. 449.—Dr. William L. Rodman's case of transverse fracture of the patella (skiagraphed by Dr. Pfahler).



FIG. 450.—Transverse fracture of the patella; fractured surface partially covered by irregular flaps of torn aponeurosis (Hoffa).

the ankle to the middle of the thigh, and get the patient about on crutches. Have the plaster cut so that it may be easily removed. Employ massage of muscles at this time. Do not begin passive motions until six to eight weeks after the accident. Up to eight weeks there is danger of refracture. During passive movements the surgeon fixes the upper end of the upper fragment by his thumb. The plaster dressing is to be worn for five weeks. After eight weeks of treatment the joint is left free at night, but kept fixed during the day by pasteboard splints or by a light plaster-of-Paris bandage. After four weeks more he gets about with canes or a cane. For months after removing the splints and plaster a lacing knee-cap of leather should be worn in the daytime to support the joint. The plan of prolonged immobilization renders more or less muscular atrophy and joint stiffness certainties, but these are less serious impediments than the wide separation of the fragments that inevitably attends an early use of the joint. Bryant, of New York, has devised an ambulatory dressing.

Operative Treatment.—Malgaigne's hooks are obsolete.

It is said that John Rhea Barton wired an ununited fracture of the patella in 1843. In 1877 Hector Cameron wired an ununited fracture of the patella, and a few months later Lord Lister operated on a fracture of the knee-cap two weeks after the accident. The question of the advisability of suturing a recent fracture has been very much dis-

puted. The ordinary non-operative plans of treatment do not endanger life and generally give a fairly good functional result, although the joint remains insecure on extension, there is imperfect extension, the patient is apt to fall, and a fall may refracture the bone. The operative method will usually succeed, generally obtains osseous union or at least firm and short fibrous union, and is capable of obtaining a better functional result and of obtaining it more rapidly. There is some slight danger of infection, and if infection should occur, the results may be most disastrous. Some cases obviously cannot be treated by the conservative method with any chance of success; cases, for instance, in which a flap of fibroperiosteum intervenes between the fragments, or cases in which from some other cause the bones cannot be approximated. Such cases should, of course, be operated upon. But in the great majority of cases a fairly good result will follow conservative treatment, and conservative treatment should be trusted unless the case is in the hands of a surgeon and in a place where every antiseptic precaution can be taken. We agree with Stimson when he says that operative methods can be used with confidence when surrounded by every protection; he habitually uses them, but he never teaches them as proper routine practice, and strongly advises against their use except by those who have had experience in operating, who have formed the habit of taking precautions, and who have the aid of skilled assistants.[1] Operation should only be performed on healthy persons of suitable age, when the separation is over ½ inch or when there is much laceration or interposition of the capsule.[2] If a patient is still able to extend the limb and the lateral expansions of the quadriceps have not been widely torn, a useful limb will be obtained by conservative treatment even if the bone fragments separate, and operation is not demanded. A working man needs the operation more than a gentleman of leisure because he is in more vital need of a sound knee-joint. A young or middle-aged person is more active than an elderly person, hence, in him operation is more strongly indicated than in an elderly man.

Barker advocated operation with punctures, but without incision and by aid of a strong special needle for silver wire. The wire is carried under and in front of the bones and is then twisted. The operation was successful, but is seldom practised today.[3]

There are objections to Barker's operation: It does not allow us to remove blood-clots from the joint; if a bit of tissue intervenes between the fragments, it cannot be removed; and a foreign body is left permanently in the joint.[4] If an operation is thought advisable, we deem it best to do an open operation. An open operation may be performed within a very few hours of the injury. If it is not done then it should be postponed for five days or longer. In the period between the first day and the fifth tissue resistance is lowest and the parts are most prone to infection. By the tenth or eleventh day it will be found more difficult to separate the tissue and hemorrhage may be profuse.

To perform the open operation make a semilunar cut open downward, free the joint from blood-clots by irrigation with hot salt solution, remove all tissue from between the fragments, suture the periosteal capsule at the sides with kangaroo-tendon and lateral tears in the capsule with catgut. Do not use a drain. Put the leg in full extension and fix with plaster. Two troubles are to be feared, viz., refracture and stiffness. After removal of the stitches the patient gets about on crutches. In three weeks begin massage and passive movements, removing the dressing daily to permit them. A month after the operation the dressing is worn only in the daytime. The splint is discarded at the end of the third month.[5] Among other operative procedures we may mention the following: encircling the fragments by a silk suture (the circumferential suture), which, however, may impair bone nutrition and retard union; drilling the bones subcutaneously and passing wire through the drill-holes in the form of a figure of 8 (Ceci); passing subcutaneously a ligature around and over the fragments (Butcher); and incising and approximating of the fragments by fixation hooks or metal pins.

Fracture of the patella by direct force are vertical, stellate, oblique, V shaped, or transverse; are often incomplete and occasionally compound or comminuted (Fig. 451). Ransohoff maintains that fractures from direct force are more common than from muscular action and are usually transverse and associated with some comminution ("Jour. Amer. Med. Assoc.," Oct. 13, 1906).

[1] "Annals of Surgery," August, 1898. [2] Powers in "Annals of Surgery," July, 1898.
[3] See the objections of Sir William Stokes to Barker's method in "Brit. Med. Jour.," Dec. 3, 1898.
[4] "Brit. Med. Jour.," April 11, 1896.
[5] Stimson, "Annals of Surgery," August, 1898.

Compound fracture of the patella is very rarely seen in Philadelphia hospitals. The records of the Boston City Hospital (an institution in which multitudes of fractures are treated) show only 8 compound fractures of this bone in forty-two years (Scannell in "Boston Med. and Surg. Jour.," Nov. 15, 1906).



FIG. 451.—Comminuted fracture of patella.

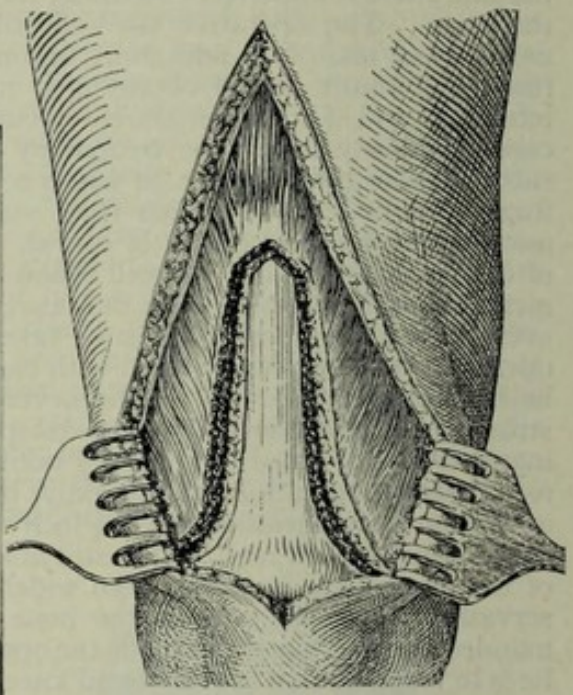


FIG. 452.—Incision detaching central section of quadriceps (Dr. G. E. Bennett in "Annals of Surgery").

Symptoms of Simple Fracture.—Fractures of the patella by direct force are followed by discoloration, swelling, great difficulty in movement, and much pain. There

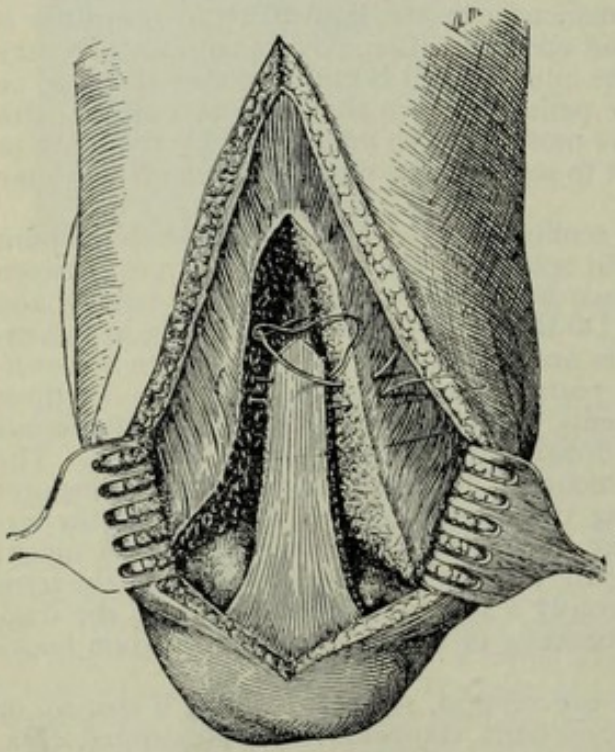


FIG. 453.—Flexing knee, pulling dissected portion downward (Dr. G. E. Bennett in "Annals of Surgery").

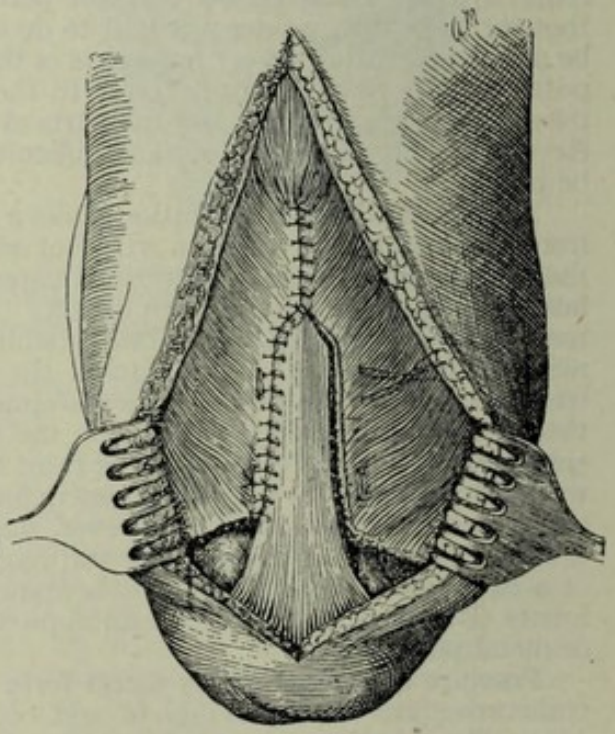


FIG. 454.—Suturing (Dr. G. E. Bennett in "Annals of Surgery").

may or may not be crepitus. The degree of separation of the fragments depends upon the direction of the line of fracture and the extent of bone involved. Bony union is apt to occur after such a fracture when there has not been wide separation.

Treatment.—A fracture resulting from direct force may often be treated by a posterior splint and the application of a bandage. If there is any separation, the fragments should be approximated by adhesive strips, bandages, and compresses. At the end of three weeks remove the posterior splint, apply a plaster-of-Paris splint, and get the patient about on crutches. The danger in these cases is ankylosis rather than non-union; hence, in the fourth week cut the plaster splint down the front and begin passive motion of the knee-joint. At the end of six weeks cease wearing the dressing in the daytime, and at the end of three months discard it entirely. In those cases in which an oblique fracture or a transverse fracture with wide separation arises from direct force, treat as advised for transverse fracture from muscular action. The question of operation is practically the same as for transverse fracture from muscular action. In every compound fracture of the patella, if amputation can be avoided, incise the soft parts freely and irrigate the joint with hot saline fluid. Remove hopelessly loosened fragments. Those not completely separated may in some cases be sutured into place. Drain for twenty-four or forty-eight hours.

Ununited and Badly United Fracture of the Patella.—There is usually a band of union, but it may be very thin and the fragments may be far asunder. It is commonly taught that the degree of functional impairment depends directly on the amount of separation. This is not strictly true. There may be great separation and but little impairment of function, the fragments being firmly united by a dense fibrous band. There may be little separation and yet lameness, stiffness of the joint, and imperfect power of extension. The reason for this has been pointed out by Bruns, of Tübingen.[1] He says there may be complete failure of union, even when the separation is trivial, and failure of union produces impaired function. If separation is considerable, the fragments are apt to tilt and tissue is often interposed between them. Functional difficulty is more often met with when the fragments are far apart than when they are near together, because non-union is more common. As a matter of fact in most cases of non-union John B. Murphy said a man could get along very well "without his patella" ("Surgical Clinics," vol. i, No. 3, page 326 and vol. iv, No. 4, page 771). In non-union the quadriceps is still able to act upon the tibia by means of the fascia lata, ligaments at the sides of the joint, or bands from the vasti to the lower fragment. Besides non-union, functional impairment may be due to anchoring of the upper fragment to the femur. The upper fragment may be anchored to the femur by the interposition of the fibrous investment of the knee-cap, which covers the fractured surface of the upper fragment and may grow fast to the capsule of the joint (Bruns).

The *treatment* of ununited and badly united fracture is discussed on page 493. If there is much impairment of function, remove soft parts from between the fragments, saw off a thin slice from the end of each fragment, and wire the bones together. In order to permit them to come together it may be necessary to do Bennett's operation.

Fractures of the Leg.—In leg fractures both bones or only one bone may be broken.

Fractures of the tibia are divided into: (1) Fractures of the upper end; (2) separation of the upper epiphysis; (3) fractures of the shaft; (4) fractures of the lower end, and (5) separation of the lower epiphysis.

Fractures of the upper end of the tibia are uncommon. They may be transverse, oblique, or vertical, running into the joint. The *cause* is direct violence.

Symptoms.—In fracture of the upper end of the tibia there is contusion of the soft parts. In a *transverse* fracture there are mobility and crepitus, but there is little displacement. In *oblique* fracture crepitus and mobility are marked, the axis of the limb is altered, and the fragments may be displaced. In fractures entering the joint there is great swelling of the knee-joint. *Comminuted* fractures exhibit marked signs, union is readily obtained, but if the joint has been damaged, stiffness is sure to ensue.

Treatment.—Reduce displacement by extension and manipulation. The special apparatus used for treatment depends on the case. In some cases extension is required, in some a posterior splint is applied and the limb is suspended from a gallows, in some a double inclined plane is employed, and in some a plaster-of-Paris splint is used.

The double inclined plane in the form of McIntyre's splint is frequently employed, or a double inclined plane in the form of a fracture-box may be preferred. The Balkan splint secures traction and is very useful (Fig. 400). The extremity should be immobilized for four weeks, when passive motion should be begun. Passive motion is to be made daily, the dressing being reapplied after each séance. In five or six weeks the dressings are removed and the patient allowed to go about on crutches. The crutches

[1] "Beiträge zur klinischen Chirurgie," "Mittheilungen aus der chirurg. Klinik zu Tübingen," Bd. iii, Heft 2, 1888.

are soon abandoned for a cane, and later all support is dispensed with. If a fracture extends into the knee-joint and the ill-adjusted fragments block the articulation, the joint should be opened and the fragments placed and fixed in proper position.

Separation of the tubercle of the tibia is due to violent contraction of the quadriceps, and occurs only in those under twenty years of age. The fragment is drawn up and can be felt, and the patient is unable to use the limb. In a case in which the tibial spine has been torn off, it may be nailed in place, or the limb should be placed on a posterior straight splint and the fragment should be pulled down into place by adhesive strips and bandages. The splint should be worn for five weeks.

Avulsion of the Spine of the Tibia.—This is a very rare accident. There are but very few cases on record, and in only one of them (Pringle's) was the diagnosis made during life, and it was made in that case by exploratory incision. The tibial spine is torn off by the anterior crucial ligament. The causative force is probably flexion, abduction, and internal rotation of the leg (J. Hogarth Pringle, "Annals of Surg.," August, 1907). After the accident the leg at the knee is in extreme abduction. Exploratory incision may be necessary for diagnosis. The treatment is to split the patella and to suture or nail the bone fragment in place.

Separation of the Upper Epiphysis of the Tibia.—This is an injury of extreme rarity. It does not seem to occur after the sixteenth year. It is caused by a twist or crush, or by violent abduction or adduction of the leg. It may lead to lessened growth of the limb. I have seen 2 cases. One in a boy of twelve who was knocked down by a trolley car. One in a boy of fifteen who was riding on the back of a truck while another truck ran into it. In both cases amputation was performed; in one case because of hemorrhage from the popliteal vessels, in the other because of gangrene. The *treatment* is as for a fracture of the upper end of the bone.

Fractures of the Shaft of the Tibia.—The *causes* of these fractures are direct force, indirect force, or torsion. A fracture in the upper part of the bone is usually transverse; in the lower part it is usually oblique (T. Pickering Pick).

Symptoms.—In transverse fracture of the shaft of the tibia there is no deformity, and the support of the fibula may even permit of walking; there is fixed pain; there may or may not be inequality of the fragments felt by the finger; and there are pain, tenderness, crepitus, mobility, and often linear ecchymosis. In oblique fractures there usually exist crepitus, a little mobility, and distinct deformity. The deformity depends on the direction of the line of fracture, and, as this line is usually from above downward, inward, and a little forward, the lower fragment usually passes behind the upper fragment and rotates inward.

Treatment.—In treating fractures of the shaft of the tibia effect reduction by making extension from the foot and counterextension from the knee, the knee-joint being in partial flexion. If there is much swelling put the limb in a fracture-box (Figs. 455, 456, and Fig. 348, 1), swing the box from a gallows, and apply an ice-bag for twenty-four hours. A silicate of sodium or a plaster-of-Paris dressing is applied when the swelling subsides, or the dressing may be used at once instead of a fracture-box if swelling is slight. As soon as the limb is immobilized in a silicate or plaster dressing the patient gets about on crutches. The dressing is removed after five weeks, and the patient goes about for one week on crutches, lightly using the foot, and then for a time walks with the aid of a cane. At the end of eight or nine weeks the cane may often be dispensed with, the amount of use of the leg being daily augmented. The Thomas arm splint is an efficient emergency apparatus for fracture of the tibia (Fig. 418).

Fractures of the Lower End of the Tibia: Fracture of the Inner Malleolus.—The *cause* of fracture of the inner malleolus is direct force or traction upon the internal lateral ligament.

Symptoms and Treatment.—The *symptoms* of fracture of the inner malleolus are pain, tenderness, some downward displacement, depression above the ends of the fragments, mobility, and crepitus. The *treatment* is to push the fragments into place and use side-splints or a fracture-box for two weeks, when a plaster of Paris or a silicate dressing may be substituted and the patient ordered to use crutches. Remove the plaster four or five weeks after it is applied, and direct the patient gradually to bear his weight upon the leg, as outlined above.

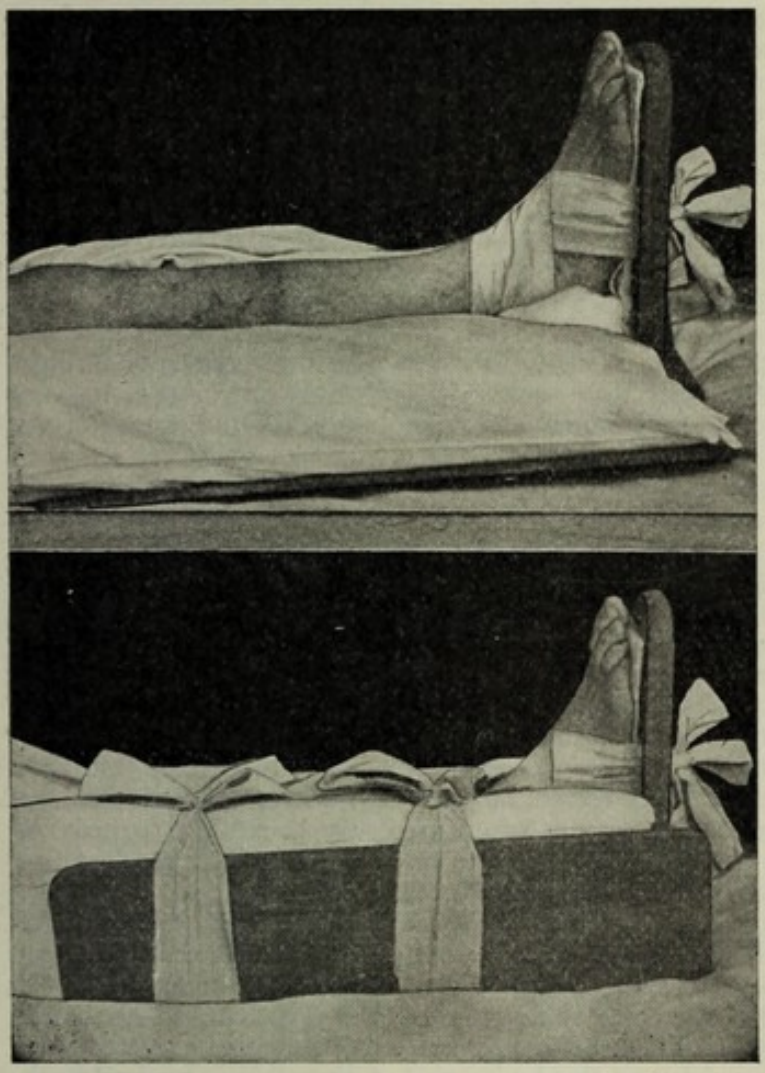
Separation of the lower epiphysis of the tibia is a rare accident, but is commoner than separation of the upper epiphysis. The *treatment* is a fixed dressing for six weeks.

Fracture of the fibula alone is commoner by far than is fracture of the tibia alone. Fractures in the upper two-thirds, which are rare, are usually due to direct force. Fractures in the lower third are frequent, and arise from indirect force.

Fractures of the Upper Two-thirds of the Fibula.—In these fractures the *cause* is direct force.

Symptoms.—In fracture of the upper two-thirds of the fibula the patient is frequently able to walk. The bone is deeply situated, and displacement cannot often be detected. There is a fixed pain, which is intensified by movement and by pressure. Pressure upon the lower fragment does not move the upper fragment. Crepitus is sometimes obtained, and linear ecchymosis is apt to appear. The bone is normally elastic, hence slight mobility is of no value diagnostically.

Treatment.—In treating a fracture of the upper two-thirds of the fibula apply a plaster of Paris or a silicate bandage and direct that it be worn for five weeks. Weight is not to be put upon the foot for six weeks after accident.



FIGS. 455, 456.—Fracture-box in fractures of the bones of the leg.

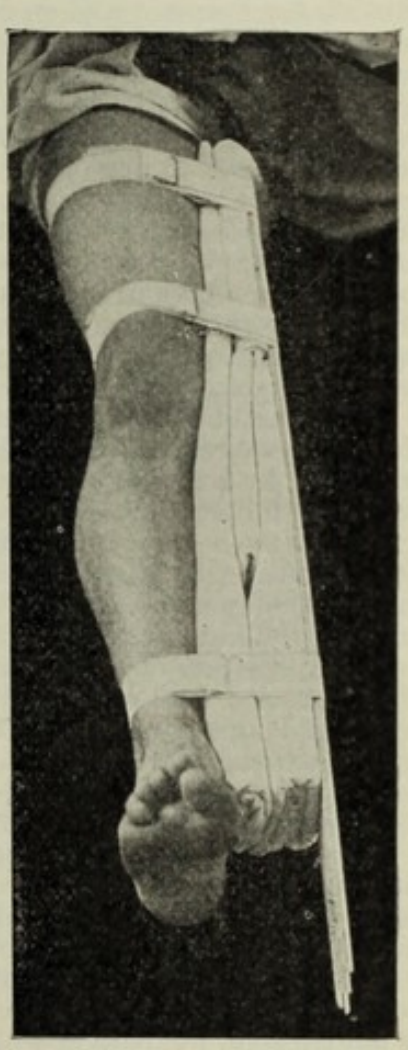


FIG. 457.—Pott's fracture. Dupuytren's splint. Note length of splint; position of straps; arrangement of padding; space between foot and splint (Scudder).

Fractures of the Lower Third of the Fibula.—In these fractures the *cause* is usually indirect force, especially twists of the foot. Forcible inversion of the foot pulls upon the external lateral ligament and the external malleolus, forces the fibula outward, and tends to break it, the lower fragment being displaced outward. Forcible eversion pulls the internal lateral ligament from the inner malleolus (often breaks the malleolus) and fractures the fibula above the ankle, the bone being displaced inward.

Pott's Fracture.—This fracture was described in 1779 by Percival Pott (Chirurgical Works). He described a fracture of the lower fifth of the fibula with outward dislocation of the foot and tearing off of the internal lateral ligament from the internal malleolus. Different conditions about the ankle are now comprised under the name "Pott's fracture." In a typical and complete case we mean by the term "Pott's fracture" a fracture of the lower fifth of the fibula produced by external rotation and

sudden abduction of the foot. Stimson points out that the production of Pott's fracture is often aided by the weight of the body. The lesions which arise depend upon whether the chief force is eversion or abduction. "If eversion is the sole or main movement, the force is exerted through the internal lateral ligament and breaks the internal malleolus squarely off at its base; then it presses the external malleolus outward, rupturing the tibiofibular ligament, and breaks the fibula close above the malleolus. Sometimes instead of pure rupture of the tibiofibular ligament there is avulsion of the portion of the tibia to which it is attached."[1] Stimson further points out that if abduction is the preponderating force there is an oblique fracture of the anterior portion of the internal malleolus or more frequently rupture of the anterior portion of the internal lateral ligament. There are, as in the former case, rupture of the tibiofibular ligament and an oblique fracture of the fibula from 2 to 3 inches above the external malleolus. It is evident that the degree of injury produced by eversion and abduction depends on the point at which the force is arrested. It may be arrested after the inner malleolus has been separated or the anterior fibers of the deltoid ligament torn, and in this case the tibiofibular articulation remains intact and the fibula is not broken. It may cease after separating the tibiofibular articulation, and in this case too the fibula escapes. It may be continued until the fibula breaks. In this fracture the astragalus passes outward, somewhat backward and also upward, the later deviation being due to separation of the tibiofibular articulation. The chief trouble in reduction and treatment is this common partial outward and backward dislocation of the foot. In rare cases the partial dislocation is forward. If there is posterior dislocation, the anterior capsule is torn. If there is anterior dislocation, the posterior capsule is torn.

The line of the fracture of the fibula is seldom transverse, but is usually oblique and somewhat spiral from below upward and backward. Vessels and nerves may be injured. In a compound fracture it is the internal malleolus or the lower end of the tibia which protrudes.

Symptoms.—There is soon decided swelling. Blebs may form. Pain is usually severe. In many cases there is eversion, in others it has disappeared when the surgeon sees the case. There is tenderness over the fibular break, over the internal malleolus, and in front of the inferior tibiofibular ligament (Stimson).

On correction of the deformity crepitus can be elicited between the fragments of the fibula and the broken malleolus and tibia. A most significant sign is great lateral mobility of the ankle-joint. There may be anteroposterior mobility. The foot is displaced outward and usually a little backward and upward. If there is posterior dislocation, the foot is shortened and the lower end of the tibia is readily palpable. If there is anterior dislocation, the foot is lengthened and the astragalus is freely palpable.

The inner malleolus or the tibia from which it was torn is extremely prominent. Stimson points out that there are three points where pressure is certain to provoke pain: in front of the tibiofibular ligament, at the base or anterior border of the inner malleolus, and over the seat of fracture through the fibula.

Treatment.—Thorough reduction is of the greatest importance. If thorough reduction is effected, a good result will probably be obtained; but if thorough reduction is not effected, the patient will be permanently crippled to a greater or less extent. In order to effect reduction it may be necessary to anesthetize the patient. In the usual cases with posterior displacement of the astragalus the patient's knee is flexed, the heel is pulled strongly forward and inward, and the lower end of the tibia is pushed backward. This corrects the posterior ankle dislocation, and then the valgus must be overcorrected (Jones). In the rare cases with anterior displacement of the astragalus, the foot is pushed backward and the tibia is pulled forward. Inversion of the ankle is imperative.

Some surgeons at once after reduction apply a plaster-of-Paris bandage. This treatment is objectionable because the deformity may be partially reproduced after the application of the dressing, the surgeon being unable to see it and unable to correct it.

If there seems to be no strong tendency to a recurrence of deformity, a fracture-box can be used. After reducing displacement in such a case, place the limb in a fracture-box containing a soft pillow. A bird's-nest pad of cotton or oakum is made for the heel (see Figs. 455, 456). A fillet around the ankle fastens the foot to the foot-piece of the box; a pad of oakum rests between the foot-piece and the sole. A compress is placed below the outer malleolus and another one above the inner malleolus. Close the sides of the box and tie them together with a bandage, and swing the box on a

[1] "A Practical Treatise on Fractures and Dislocations," by Lewis A. Stimson.

gallows. Every day let down the sides of the box and rub the leg, the ankle, and the foot with alcohol. In one week apply a plaster-of-Paris bandage and let the patient get about on crutches in two weeks after the accident. Cut down the plaster in three weeks after its application. After cutting down the plaster begin active motion and massage. Begin weight bearing in one month. Let patient go about with crutches for one week and with a cane for a week longer.

I am accustomed to dress most cases of Pott's fracture with a *Dupuytren splint.* This is a straight splint (Figs. 348, 9, 457) which reaches from above the head of the tibia to below the sole of the foot. This splint is padded, and a pyramidal pad with the base down is laid upon the inner surface of the leg, above the inner malleolus, the splint being put upon the inner surface of the leg, over the pad. The splint is fastened as shown in Figs. 348, 9, 457. If the short splint shown in Fig. 348 is used (it only goes to the head of the tibia), the leg is semiflexed upon the thigh and is laid upon its outer surface upon a pillow. After ten days of Dupuytren's splint, apply the plaster-of-Paris bandage, which is to be worn as above directed. Bryant treats Pott's fracture with a posterior splint, two lateral splints, and a swing. Stimson uses a posterior and lateral splint of plaster of Paris. This splint does not slip, as may Dupuytren's dressing, and does not hide the seat of fracture from view, as does complete encasement with plaster of Paris. It is a most useful dressing. When the patient begins to walk the callus may bend. If it does, eversion will be produced. In order to prevent this make the patient walk for a number of weeks upon a shoe heel raised on the inside in order to induce the position of varus. A very heavy man should also wear for several weeks an iron brace on the outside. I have given above the conservative treatment of Pott's fracture. I have come to the conclusion that operation should be the rule in this injury and not the exception. The fracture is often followed by pain, swelling, and disability. Pain and disability are so largely due to malunion or fibrous union of the broken malleolus, and it is so easy to fix the fragment in place by nails or sutures, that the conclusion seems obvious that in proper subjects operation should be performed. As Heath and Selby show, in an important article ("Annals of Surg.," Jan., 1908), operation also allows us to return the tibialis posticus to its normal position, and thus flat-foot is prevented. The plan suggested by Heath and Selby ("Annals of Surgery," Jan., 1908) is excellent. The fragment may be sutured in place by silver wire or chromic gut. If the tendon of the posterior tibial is displaced, the torn annular ligament is sutured so as to hold the tendon in place, a drain of rubber tissue is carried down to the bone, and the soft parts are sutured. The parts are dressed and a fixation apparatus is applied. The drain is removed in twenty-four hours. In eight weeks the patient should be walking freely (see cases reported by Heath and Selby, Ibid.). Pott's fracture may be *compound*, a portion of the inner malleolus or of the tibia above it projecting through the wound. If it is necessary to introduce through-and-through drainage, the foot must be placed and kept at a right angle to the leg. If a compound fracture exists, the malleolus must be nailed in place or sutured by silver wire or chromic gut. In a reported case the wire was passed through the joint and around the fragment, and the result was good.[1] Nailing seems a better plan.

Fracture of both bones of the leg (Figs. 458–462) is a very common injury, is often compound, and is not unusually comminuted. Fractures by direct force, such as blows or kicks, are commonest in the upper half of the leg. Fractures by indirect force, as by falls, are commonest in the lower half of the leg. In fractures from indirect force the tibia breaks first, and then the fibula breaks at a higher level. The point of greatest liability to fracture from indirect force is the junction of the lower and middle thirds. Fractures of the leg are usually oblique, but they may be transverse if arising from direct force. Spiral, torsion, or V-shaped fractures and longitudinal breaks sometimes occur. In oblique fractures, as a rule, the line of fracture runs from behind, downward, inward, and a little forward.

Symptoms.—Fracture of both bones of the leg is easy of recognition. The fibular fracture is detected as before described. By running the finger along the crest of the tibia displacement will be found, except in transverse fractures, when it may not occur. The common displacement is for the lower fragment to ascend and pass behind the lower end of the upper fragment and to rotate a little outward, and for the upper fragment to project in front. The ascent of the lower fragment is due to the action of the gastrocnemius and soleus muscles. If the line of fracture is in a direction the reverse of that which is usual, the lower fragment ascends in front of the lower end of

[1] "Rev. de Chir.," vol. viii, 1888.

the upper fragment. In fracture of both bones of the leg there are marked mobility and crepitus, severe pain, and inability to walk. In fractures from direct force there is more or less damage to the soft parts. A fracture of the shaft of the tibia near the ankle is distinguished from a dislocation by the fact that the deformity is easily reduced, but tends to recur in the fracture, and, further, that in a fracture the relations of the malleoli to the tarsus are unaltered, whereas in a dislocation they are altered.

Treatment.—If the fracture is near the ankle-joint, the action of the tendo achillis may maintain deformity, and in such cases the tendon should be divided. All fractures of the lower third are difficult to reduce and often require extension by the pulley. In very few will perfect apposition of the fragments be brought about, and the best we can usually attain is good alignment (Jones). In treating a simple fracture of the lower two-thirds of the bones reduce by extension and counterextension, and use a fracture-box (see Figs. 455, 456). The compresses used in Pott's fracture are not

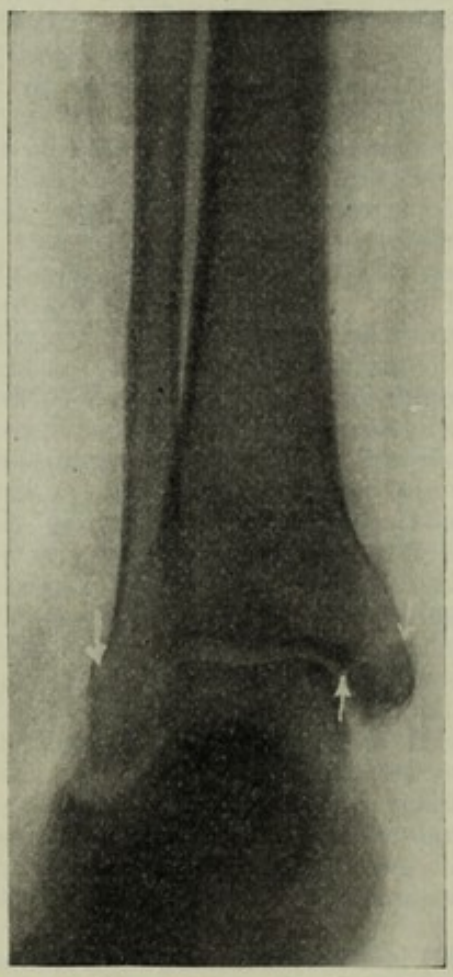


FIG. 458.—Pott's fracture with practically no displacement (Misericordia Hospital case; skiagraphed by Dr. Pfahler).

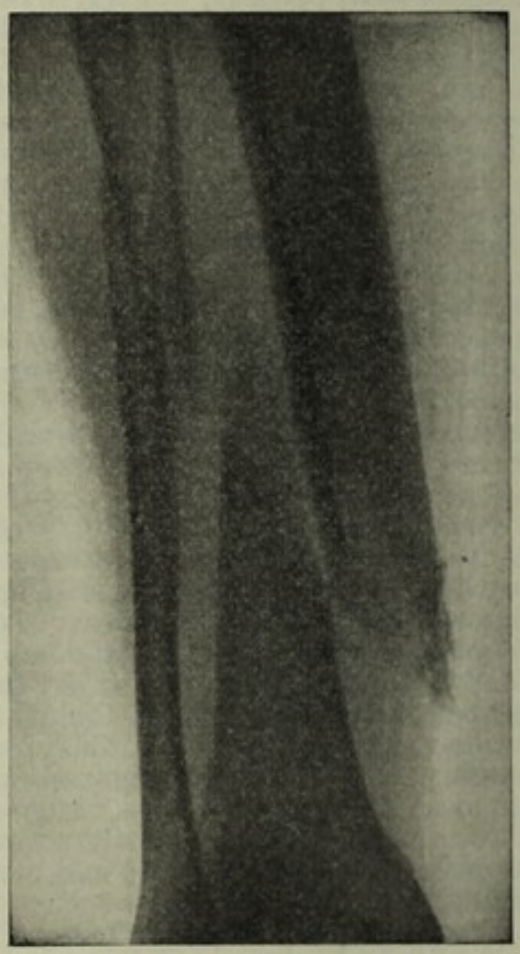


FIG. 459.—Fracture of both bones of leg. Bad position.

required. If the soft parts are bruised, use evaporating lotions for a day; if they are abraded, apply antiseptic dressings. The fracture-box should be swung upon a gallows. After three weeks apply a plaster-of-Paris or silicate of sodium dressing and let the patient sit up in a chair during one week; at the end of this time the patient may get about on crutches. At the end of six weeks after the accident remove the plaster, and let the sufferer go about on crutches for two weeks and with a cane for two weeks more. Brinton was accustomed to dress a fracture of both bones of the leg for two weeks in a fracture-box, for two weeks in side-splints made of metal, and for two weeks in an immovable dressing, allowing the patient to get about on crutches as soon as the plaster was put on. Instead of the fracture-box we may use a posterior splint, two lateral splints, and a swing. The Thomas bed-splint is a very useful dressing. So is the Balkan frame with traction (Fig. 400). Nathan R. Smith's anterior splint is used by some in the treatment of fractures of the leg. Some surgeons apply plaster of Paris in the form of an ambulatory dressing. In this dressing a solid apparatus

reaches to the lower third of the thigh and below the sole of the foot. When the patient walks the weight is transmitted to the thigh. In fractures of the upper third of the leg the McIntyre splint or the double inclined plane is used. If the fracture is *compound*, asepticize thoroughly and drain for a time. Apply a plaster bandage, and cut trap-doors over the drainage opening. In some cases through-and-through drainage is used (see Fig. 317); or dress with the bracketed splint and plaster of Paris (see Fig. 318). Remove the drainage, as a rule, in about forty-eight hours; but the patient's temperature is the guide, not the time of retention.

In many fractures of the lower third operation is indicated to accomplish reduction and fixation.

Fractures of the bones of the foot are rather rare accidents, although not so unusual as we once thought, for the *x*-ray has taught us that a considerable number of supposed sprains are, in reality, fractures. Owing to the number of the bones and to the elasticity of their connections the force of blows and falls is spread and dissipated. The bones most often broken

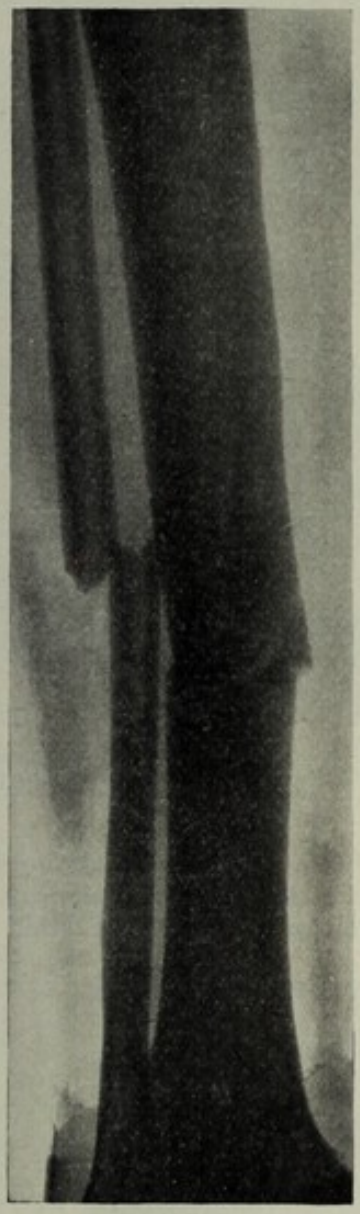


FIG. 460.—Dr. Jopson's case of fracture of both bones of the leg at the junction of the middle and lower thirds (Medico-Chirurgical Hospital case; skiagraphed by Dr. Pfahler).



FIG. 461.—Fracture of both bones in the lower third of leg (skiagraphed by Dr. Manges).

are the astragalus and the os calcis. Fractures from direct force are often compound. The *cause* of fracture of either the scaphoid, the cuboid, or one of the cuneiform bones is direct force. Simple fractures of the os calcis and astragalus may arise from crushes or twists of the foot, but result, as a rule, from falls. The calcaneum may be broken by a direct blow. A fractured os calcis is usually much crushed (Fig. 464). In rare instances the os calcis has been broken by contraction of the great calf muscles. Forcible dorsal flexion of the foot may fracture the neck of the astragalus (Eisendrath). Compound fractures may result from gunshot wounds, crushes, and falls.

Symptoms.—The history of the nature of the accident is of great importance. In fracture of the os calcis there are severe pain, tenderness, swelling, crepitus, mobility,

often an apparent widening of the bone, and not unusually a loss of the longitudinal arch of the foot (Pick). The widening can be detected under the outer malleolus. Lateral motion in the calcaneo-astragaloid joint is interfered with (Cotton in "Annals of Surgery," 1916, lxiv). In some cases the posterior fragment is drawn up by the calf

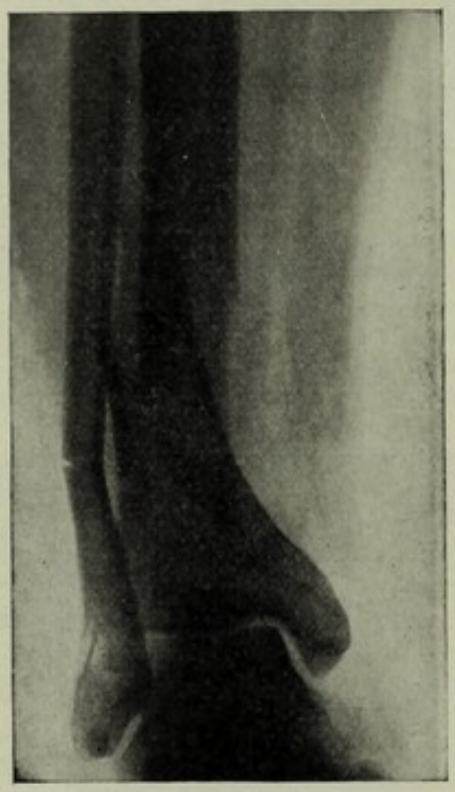


FIG. 462.—Fractures of both bones of leg in lower third (Medico-Chirurgical Hospital case; skiagraphed by Dr. Pfahler).



FIG. 463.—Fracture of the astragalus (Misericordia Hospital case; skiagraphed by Dr. Pfahler).

muscles, and in other cases there is no deformity. In fracture of the astragalus (Fig. 463) displacement may occur which resembles that of a dislocation. Crepitus may or may not be detected. It can be elicited, as a rule, by rotating the foot while the heel

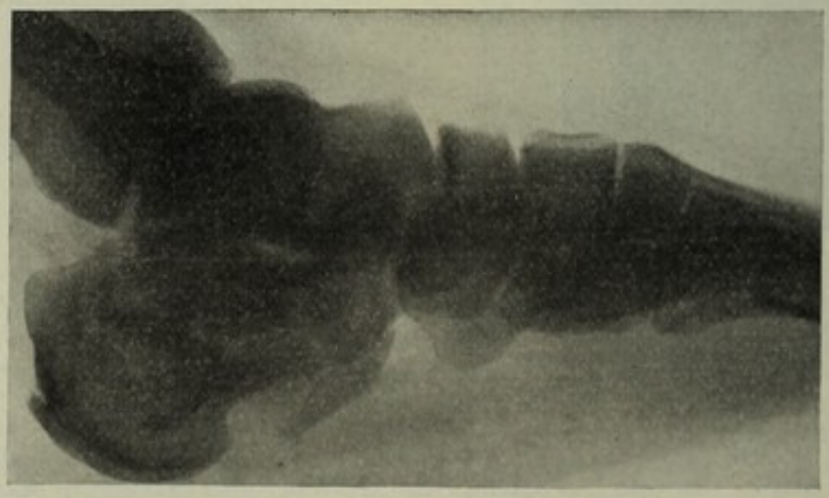


FIG. 464.—Comminuted fracture of the os calcis (Misericordia Hospital case; skiagraphed by Dr. Pfahler).

is firmly held. If crepitus cannot be detected we are not certain that a fracture is present, even though the patient may be unable to stand and there are swelling and pain on pressure. The malleoli may seem on a lower level than normal if the astragalus and os calcis have been crushed. Sometimes the foot is shortened and perhaps

the fragments have been dislocated (Eisendrath in "Annals of Surg.," March, 1905). The *x*-rays will make the diagnosis certain. Fractures of the other bones of the tarsus are difficult of detection except by the *x*-rays. There may or may not be crepitus, which, if it exists, is difficult to localize; there is pain on standing and on pressure, and there is bruising of the soft parts.

Treatment.—In simple fracture of the os calcis and astragalus without displacement the usual plan is to place the foot at a right angle to the leg and apply a plaster cast. This is cut down the front so that it may be removed easily. On the third or fourth day follow Eisendrath's advice and begin massage to reduce swelling and prevent muscular atrophy (Ibid.). The cast is worn for eight weeks, when the patient may begin to put weight upon the extremity. The results are often poor. If a flat-foot has resulted from the accident, a support must be worn. If there is displacement in a simple fracture of the os calcis or astragalus it is wisest to operate. Perfect correction is not possible otherwise, and no apparatus is satisfactory. The fragments are restored after incision and may be sutured, nailed or wired in place, or fixed together with a bone peg. A fragment may require removal or the badly splintered bone itself may have to come away. If the tendo achillis is torn loose, it should be sutured to the os calcis. In fracture of the os calcis alone Cotton anesthetizes the patient, pulls down the heel, and by lateral pressure and the use of a pad and mallet creates an impaction ("Annals of Surgery," lxiv). Another plan is to cut the Achilles tendon, and while the heel and ball of the foot are being held with a pull toward each other to create the arch, plaster of Paris is applied as high as the knee (Lounsbury in "Surgery, Gynecology, and Obstetrics," 1916, xxii). Fractures of the other bones of the tarsus are almost always compound, and the injury may require drainage and immovable dressing, excision of bones, or even amputation. If they are not compound, they may be treated by a plaster-of-Paris dressing or may require incision and fixation or removal.



FIG. 465.—Fracture of metatarsal bones.

Fractures of the metatarsal bones (Fig. 465) are almost invariably due to direct force and are almost always compound. Robert Jones has published skiagraphs of a fracture of the fifth metatarsal bone from indirect force. Crepitus may be absent because of impaction or fixation by interosseous ligaments. Jones says such a fracture may be produced by the pressure of the body weight on an inverted foot the heel of which is raised ("Annals of Surgery," June, 1902). When only one bone is broken, displacement is slight, there is severe pain on motion and pressure, and crepitus can generally be obtained. Pain is produced by flexing the toes, putting weight upon the toes, as in walking, and by inverting or everting the foot. Fracture of the third metatarsal is apt to destroy the arch of the foot. A simple fracture of a metatarsal bone is treated by an immovable dressing for four weeks. Fractures from crushes usually demand excision or even amputation.

Fractures of the phalanges of the toes are due to direct force and are often compound. They may require immediate amputation.

Treatment.—In a compound fracture where amputation is unnecessary, drain with strands of catgut for forty-eight hours and dress antiseptically, at the end of this time apply over the bichlorid gauze a gutta-percha or a pasteboard splint extending from beyond the end of the toe to well up upon the sole of the foot, and fix the splint in place with a spiral bandage of the toe and instep. The splint is to be worn for four weeks. In a simple fracture fasten the injured toe to an adjacent toe or toes by a plaster-of-Paris bandage and wear the dressing for three weeks.

DISEASES OF THE JOINTS

Synovitis is a primary inflammation of the synovial membrane alone. If other structures besides the synovial membrane are involved the condition is known as "arthritis." Two forms of simple synovitis exist, namely, *acute* and *chronic*. Some surgeons speak also of *subacute* cases.

Acute Simple Synovitis.—The *causes* of acute simple synovitis are contusions, sprains, twists, and overuse. The causative influence of exposure to cold or damp

has been much debated. It seems probable that in some cases cold produces vasomotor paresis of the vessels of the synovial membrane, a condition which may be followed by inflammation. Traumatic cases without infection are the usual cases met with in civil life. Infection may be the cause. In some cases infection arises from a distant focus, obvious or concealed (teeth, tonsils, sinuses, intestine, prostate, appendix, respiratory tract, boils, etc.). In synovitis the synovial membrane is red and swollen, and the joint contains an excess of turbid fibrinous fluid. If the inflammation advances, arthritis arises and sometimes blood is effused.

Symptoms.—A prominent symptom of acute synovitis is pain, which is increased by motion of the joint, by pressure upon the articulation, and by a dependent position of the limb. The pain is worse at night. Pressure upon the edge of the cartilage does not cause pain, but friction of the synovial membrane at once develops it. The patient places the limb in the position which gives the greatest ease, and the part becomes more or less fixed in this position because the muscles about the joint are rigid. A fluctuating swelling is noted in a superficial joint, most marked between the ligaments, which swelling bulges out the synovial area and hides or obscures the articular heads of the bones. The swelling is due early to excessive secretion of synovia, and later to effusion of liquor sanguinis. Bulging takes place at points where the capsule is thin, and at such points fluctuation may be detected. Fluctuation in the elbow is sought for posteriorly. Fluctuation in the knee is sought for on either side in front. A large effusion in the knee floats the patella up from the condyles (*floating patella*). A small effusion in the knee can be detected by Fiske's plan, which is as follows: Tell the standing patient to bend forward at the hips, resting each hand on the front of the corresponding thigh. The anterior structures of the joint are thus relaxed, and, by tapping the patella, even a small effusion can be discovered. Bulging cannot be distinctly recognized in the hip or shoulder unless effusion is great. The skin over the joint is rarely reddened, but feels hot to the hand of the observer (over superficial joints, but not over the shoulder and hip); the joint is partly flexed; fever exists, varying in degree with the size of the joint and the acuteness of the attack. If infection occurs fever is a striking feature. Suppuration rarely follows simple synovitis, but it may do so, the area of synovitis being a point of least resistance to organisms carried by the blood or lymph. If suppuration takes place, rigors occur, there is a septic temperature, and the joint soon gives evidences of containing pus. These evidences are violent pain, increased tenderness, dusky discoloration if the joint be superficial, greater muscular spasm, periarticular edema, and constitutional symptoms of sepsis. Traumatic synovitis without infection tends toward cure without suppuration if the patient is healthy, and after it ankylosis is rare.

Treatment.—In acute traumatic synovitis the method of McWilliams is very valuable ("Annals of Surg.," Dec., 1922). This consists in repeated aspirations with active motions, even walking without splints. Aspiration is to be done promptly. It relieves pain and prevents stretching of the ligaments. Cure is obtained in half the time required by immobilization.

Always be on the lookout for symptoms of infection and sources of infection.

Violent infection causes suppuration. Incision is necessary at once. It was formerly the custom to irrigate, drain, and immobilize. Williams and others show that such treatment is bound to be followed by stiffness, and advocate active motions. Suppose a man with pus in the knee. Make lateral incisions, insert no drains, begin active motions as soon as the effects of the ether have passed away (every two hours, day and night), begin to walk in forty-eight hours. Active muscle contraction squeezes out pus and drains the joint. Fever ceases and recovery without stiffness usually follows. Look for foci of infection and remove them if possible. If there is any evidence of beginning infection, follow Murphy's advice, that is, aspirate the joint and inject a mixture of formalin in glycerin (2 per cent.). As a rule this treatment will rapidly bring about a cure. The mixture of formalin and glycerin should have been made at least twenty-four hours before use. A rubber bandage is often useful toward the termination of a case of acute synovitis.

Chronic synovitis follows acute synovitis or it may be chronic from the start. Many cases called chronic synovitis are, in truth, tuberculous disease. Others are metastatic and due to focal infection. The synovial membrane looks nearly natural, but is edematous, and the joint contains an excess of fluid. If the quantity of fluid is large, the disease is called *hydrops articuli*, or *dropsy*. A large amount of fluid in the knee-joint "floats" the patella upward. Tuberculous infection may occur in very prolonged cases. In prolonged tuberculous synovitis the synovial membrane may

thicken in some places, soften in others; it is often adherent, and the villous processes hypertrophy. If the membrane becomes extensively softened (*pulpy degeneration*), the softened areas bulge and caseation eventually occurs. In the knee-joint a traumatic synovitis is sometimes linked with *inflammation of the semilunar cartilages*. Roux tells us that this inflammation may be produced by a squeeze, a twist, or a direct force, but a squeeze is the common cause. Hyperextension of the knee may squeeze the cartilage, and so may attempting to rise from a stooping posture.[1] If this injury has taken place, the disability will be prolonged.

Symptoms.—In chronic synovitis pain may be absent or may be present only during exercise or from pressure, and be slight even then. There may be seizures of pain; there is some limitation of movement; passive motion may develop creaking or joint crepitus; fluctuation is apparent and there is atrophy in the muscle about the joint. The atrophy of the muscles associated with an inflamed joint is a reflex atrophy and is named after Charcot. The aspirating needle will give exit to a viscid straw-colored or bloody fluid unless the material is gelatinous.

Treatment.—Chronic cases of traumatic synovitis without infection may be treated by repeated aspirations and active motions (unless there are joint mice or damaged membranes). In other cases rest and pressure are needed. Try to find and remove any focus of infection. Pressure may be obtained by the application of Martin's rubber bandage. A plaster-of-Paris dressing is probably the best way to combine rest and compression. Massage, douches, frictions, passive movements, and flying blisters should be used. Painting the joint with iodin and spreading over it blue ointment, and rubbing in ointment of ichthyol (50 per cent. with lanolin) may do good. Counter-irritation by the actual cautery is a valuable expedient. The Bier treatment (see page 166) is often of benefit. Injections of dilute carbolic acid in the parts about the joint rapidly relieve the pain (see page 601). Some surgeons advise aspiration, washing out with salt solution, injecting a 5 per cent. solution of carbolic acid or formalin-glycerin (2 per cent.), and immobilizing. Incision and drainage constitute a radical but proper plan in cases in which simpler methods have failed. If pulpy degeneration exists, perform an excision or an erasion. If pus forms, incise at once. Internally, treat any existing diathesis and give nutritious food, tonics, and stimulants. Chronic synovitis is often greatly benefited by the use of an electric heater.

Arthritis.—By this term is meant not only inflammation of a synovial membrane but also of other structures composing and surrounding a joint. It may follow traumatic synovitis; it may be due to pus organisms, to tubercle bacilli, to infectious diseases (gonorrhea and typhoid fever), to rheumatism, to gout, to syphilis, and to lesions of the spinal cord. Arthritis may be either acute or chronic.

Poncet's Tuberculous Arthritis (*Tuberculous Articular Rheumatism*).—It was pointed out by Grocco in the early 80's that tuberculous patients may develop joint disease without tubercles, cold abscesses, or destruction of the joint. Poncet, of Lyons, has written extensively on this subject. He maintains that joint inflammation is often the first evidence of extra-articular tuberculosis or of a distant latent lesion of tuberculosis. The joint inflammation is due to toxins, the joint fluid does not contain bacilli, and tubercles do not develop in the joint structures.

Such a joint may eventually develop into a true tuberculous joint with bacilli and tubercles. In many cases the joint recovers, with some stiffness or perhaps even ankylosis. The process may be acute, subacute, or chronic. One joint only may suffer. Several or most of the joints may be simultaneously involved. It is most apt to arise after an operation on tuberculous glands or bone. Fever exists in Poncet's arthritis. Matas ("Southern Med. Jour.," Oct., 1911) thus described tuberculous rheumatism:

"It may be a flitting arthralgia, a mere soreness, a dropsical synovitis, or it may persist as a hypertrophic or atrophic arthritis. It may present itself as a progressive polyarthritis deformans or as a dry senile arthritis (morbus coxarius senilis). The acute as well as the chronic form of this type of rheumatism may end in ankylosis. Many cases of spinal rigidity, spondylosis, scoliosis, painful flat-foot, genu valgum, coxa vara, and even certain cases of dry otitis media with ankylosis of the ossicles of the ear, and, in fact, all the osteo-articular affections of childhood and adolescence associated with defective osteogenesis, may owe their origin to the disturbing influence of a latent or obscure tuberculous toxemia.

"The most benign of the tuberculous rheumatic affections is a simple arthralgia—a sore or painful joint. There is pain without any objective signs, and yet this is

[1] "Gaz. des Hôp.," No. 125, 1895.

often the precursor of a manifest visceral tuberculosis. The acute and subacute forms of the disease are usually confused at the bedside with the manifestation of ordinary acute rheumatism. Nevertheless, the clinical picture of acute tuberculous rheumatism is distinctly graver; there are fever, rapid pulse, profuse sweats, and frequent attacks of dyspnea. This is brought about by associate general infections involving the serous cavities, the pleura, peritoneum, pericardium, and the meninges, but in the majority the evolution of the disease is slow and more benign. The joint symptoms appear in successive stages separated by intervals of rest more or less long, and are distributed over various joints, ending ultimately in ankylosis. The disease is more often chronic, and many patients either recover altogether or remain permanently crippled or deformed; others die of marasmus or complications from associate visceral disease. Therapeutically, this form of rheumatism is not relieved by any of the usual antirheumatic remedies, and is improved or cured solely by treatment which aims at the cure of the tuberculous infection."

Tuberculous Arthritis (*White Swelling*, so christened by Richard Wiseman; *Strumous Joint; Pulpy Degeneration*).—*Pathology and Symptoms.*—The predisposing causes of tuberculous arthritis may be strains, blows, twists, or cold (see page 156). The real cause is the tubercle bacillus. A single joint is attacked. Other joints may subsequently become involved so that several suffer simultaneously, but it is rare that the process is active in more than one joint at the same time. During the course of tuberculous disease of a joint (except of the shoulder-joint) phthisis is not common, although it may develop after the joint gets well. The same is true of tuberculous glands. During the existence of phthisis or tuberculous glands, tuberculous arthritis does not frequently arise. The primary infection with tubercle bacilli is usually in the bone, though it may be in the synovial membrane, the joint capsule, or the structures about the joint. The frequency of the bony origin of tuberculous arthritis is shown by John B. Murphy's statement that in 128 cases of tuberculosis of the knee it was demonstrated in all but 2 that the condition originated in the bone ("Jour. Amer. Med. Assoc.," May 20–27, June 3, 1905). If the primary infective focus is in the bone, a portion of the cartilage undergoes destruction and the joint is opened, or a sinus forms and perforates the synovial membrane. When tuberculous inflammation attacks the synovial membrane granulation tissue is formed, and the capsule and periarticular structures soon become involved in the process; the parts thicken and soften from caseation, and they may be covered with tubercles, though but little fluid is usually effused into the joint. Some few cases present large joint effusions, but in most cases fluctuation is absent. Capsular thickening may or may not be manifest. Soon after tuberculous arthritis begins the joint becomes rigid, irritation having induced muscular spasm. This reflex rigidity fixes the joint more or less completely, and atrophy of the rigid muscles soon begins. There is usually some pain in tuberculous arthritis; it is seldom marked except on motion or when the epiphysis is involved, and it may be referred to a distant part. For instance, in hip-joint disease the pain is often referred to the inner side of the knee, and in Pott's disease of the spine the pain may be referred to the abdomen. A cardinal symptom of tuberculous disease of a joint is localized tenderness. In other types of infection the tenderness is wide-spread. Attempts at motion demonstrate the limitation of movement due to muscular rigidity and also produce pain. A child that suffers from a tuberculous joint is apt to be restless in sleep, moaning and tossing, and waking at times crying out in terror (*night-cries* and *night-terrors*). In the ordinary form of tuberculous arthritis there occurs what is known as *gelatiniform degeneration;* the granulation tissue is formed in large amount as fungous growths; the structures are markedly edematous and softened; the relaxed ligaments yield under pressure; the natural contour of the joint is lost and it becomes spindle shaped; all the structures, articular and periarticular, are glued into one mass; the skin about the joint is white, thick, and adherent, and in it one or more large veins are seen; fluctuation or pseudo-fluctuation is noted when caseation has occurred; pain is not often severe, but it can usually be elicited by certain motions or by firm pressure, but the pain will always be severe when the epiphysis is involved; the temperature of the part is seldom elevated; deformity results from destruction of bone, cartilage, and ligament, from muscular spasm, and from the habitual assumption of certain attitudes to secure relief from pain. There is soon impairment of joint motions. When the products of a tuberculous arthritis caseate the thick liquid seeks exit by forming sinuses, and from them caseous pus flows. If a sinus becomes infected with pyogenic cocci, and the joint itself becomes their prey, acute suppuration arises in the joint, and constitutional involvement is pronounced and perilous to life.

In *pannous synovitis* a large effusion is formed, there is but little granulation tissue, though the tubercles are present in large numbers, and the ligaments and structures about the joint are slightly or not at all implicated.

Diagnosis and Prognosis.—Tuberculous chronic synovitis produces great swelling and distinct thickening of the capsule with obliteration of the outlines of the joint, no severe pain, and no tendency to early subluxation. Tuberculous arthritis rarely causes distinct fluctuation, does not thicken the capsule, causes reflex muscular spasm, rigidity of the joint, muscular atrophy, severe pain on movement, and eventually subluxation (Shaffer). In syphilitic arthritis there is usually some fluctuation, distinct enlargement of the joint, limitation of motion, no reflex spasm, trivial atrophy, but distinct pain on motion (James K. Young, "Therapeutic Gazette," June 15, 1902). Acute rheumatism attacks more than one joint, is usually symmetric, is very rare in children under five, and produces high fever. The *x*-rays aid in the diagnosis of tuberculous arthritis and enable us to tell the extent of bone involvement.

The diagnosis of a tuberculous joint is often difficult, and sometimes impossible, and the prognosis is always grave. In only a very few cases, even when recognized early, is a cure obtained without some impairment of joint function. The best that can usually be accomplished is a cure with more or less ankylosis, fibrous or bony; and often ankylosis becomes complete. Long after the disease is apparently cured, it may break forth anew. Tuberculous lesions may arise in a distant organ or general tuberculosis may occur. Caseation is apt to produce severe constitutional disorder. Infection by pus organisms gives rise to grave danger of septicemia. Death is not unusual from exhaustion, from septicemia, from disseminated tuberculosis, from tuberculosis of an important organ, or from amyloid disease.

Treatment.—No serum or vaccine is of any proved value. Ridlon says: "Tuberculin in harmless doses is useless; administered in larger doses it is both dangerous and harmful." It seems to do harm in articular cases with fever, in very late cases, and in very early cases. Conservative treatment is especially successful in children. According to Hoffa, in 75 per cent. of cases in children non-operative treatment will produce cure ("Die Bekampfung der Knochen- u. Gelenktuberculose in Kindesalter Tuberculosis," iv, 1, 1905). The conservative treatment consists in open-air life, if possible in a sanatorium, the following of the plans outlined under Tuberculosis, heliotherapy, immobilization and extension of the joint, and injections of iodoform emulsion or formalin-glycerin (2 per cent.). Even when tuberculous pus forms, the same treatment may be followed unless there is violent pain or elevated temperature which does not quickly abate, in which case operation must be performed. Cases treated early by conservative methods may get well with a movable joint, but in most cases there is a stiff joint when the disease is arrested. Constitutionally, the treatment is directed against the tuberculous diathesis. The patient should be placed under good hygienic conditions. A change of climate is often of the greatest importance. Many cases do well at the seaside; others require high altitudes, and all should live in the open air. The value of sunlight is set forth on pages 163 and 164. It causes local hyperemia which is bactericidal, stimulates oxidation and metabolism, and produces lymphocytosis of the peripheral blood after one hour's exposure (Taylor in "Internat. Abstract of Surgery," July, 1915). Personally I have only used local exposure, beginning with a few minutes and reaching three or four hours a day, taking care that the skin is not hurt and avoiding burning by using talcum powder freely for the first week (Taylor, Ibid.). A hat should be worn and, if necessary, goggles. Electric light has been used instead of sunlight. The Finsen light, too, is of service. The Roentgen rays may prove of great value in synovial tuberculosis and in very chronic sinuses. Treatment by tuberculin is considered on page 165. Locally, rest is of the first importance, and fixation is maintained for many weeks. Rest is best secured by immobilization and traction, and traction is applied or maintained by splints, by plaster-of-Paris bandages, or by extension appliances. The hot-air apparatus may be of some benefit. If it is employed, it should be used daily, the limb being immobilized during the remainder of the twenty-four hours. Fixation must be maintained as long as pain exists or muscular spasm is present. Fixation must be abandoned gradually, and mobility is to be slowly regained. During restoration to mobility, if pain arises, the part must be immobilized temporarily. Movements should never be violent, prolonged, or repeated at too close intervals. Forcible breaking up of an ankylosis is never advisable in the knee, ankle, or hip; it is seldom advisable in the wrist, elbow, or shoulder. Such an attempt may be followed by a fresh outbreak of the disease. Osteotomy or resection will more safely correct a faulty and disabling deformity. In a tuberculous joint

injection of formalin-glycerin, as advised by Murphy, is a valuable procedure. Several or a number of injections may be made. The joint is aspirated and the mixture introduced. About 4 drams are used in the knee, about 2 drams in the ankle. After injection extension is applied. The mixture used must be at least twenty-four hours old. In tuberculous joints intra-articular injections of iodoform are often of the greatest value. This drug strongly stimulates the formation of fibrous tissue. If sufficient fibrous tissue is formed the tuberculous foci will be firmly encapsuled and the case will be cured. Iodoform is particularly called for when no bone disease is shown by the *x*-ray or discovered by incision. The joint is incised, adhesions are gently broken up, the capsule is sutured except for a small space, the nozzle of a syringe is inserted and a mattress-suture draws the capsule tightly about the nozzle (Brackett's plan). The emulsion is injected under tension and then the capsule is closed tightly. In a large joint a 4 per cent. emulsion is used; in a small joint a 10 per cent. emulsion. The part must not bear weight for six months. Bier's plan of inducing passive hyperemia is often of great service (see pages 44–47). Aspiration or incision can be used for fluid accumulations. Caseous masses are often let alone, or an aspirator is used and the joint drained, washed out with saline solution, and injected with an emulsion of iodoform and glycerin (10 per cent.). From 1 to 2 drams are injected into the joint of a child, from 2 to 5 drams into the joint of an adult. Even surface lesions are not curetted. Bier's treatment should be associated with immobilization and systemic treatment. It is more serviceable in tuberculosis of the small joints than in disease of the large articulations. There are certain contraindications to Bier's treatment, viz.: serious pulmonary involvement, extensive amyloid degeneration, and the existence of such an unfavorable position of the parts that cure by ankylosis would mean a less useful limb than cure by resection (Bier at Internat. Surg. Congress of 1905). One advantage of this treatment is that we can employ active and passive motion early, except, according to Bier, when the foot or knee is diseased. Even in very serious cases cure may be obtained without any limitation of activity, and as the patient can get about it is not necessary to restrain him long in a hospital. Bier advocates his suction apparatus to empty sinuses. The enthusiasm for Bier's hyperemia has largely waned. It finds its best field in elbow and wrist cases (Taylor in "Internat. Abstract of Surgery," July, 1915). Personally I believe that fixation should be the basis of treatment in most cases, and that passive hyperemia, compression, counterirritation, heliotherapy, radiotherapy, and intra-articular injections may be used as additions to fixation. Injections of balsam of Peru or of iodoform emulsion about the joint once a week are efficient in some prolonged cases, but are not to be used early. It is not wise to attempt to correct faulty position until the focus is well.

Fistulæ are frequently treated by the method of Beck, of Chicago, that is, by the injection of a paste containing bismuth. In early cases a bismuth-vaselin paste is used, in late cases a bismuth-wax-paraffin paste.

Beck described his method in the "Illinois Med. Jour.," April, 1908. The vaselin paste is composed of 30 parts of subnitrate of bismuth and 60 parts of vaselin, mixed and well stirred while boiling. The paste for later cases is composed of 30 parts of subnitrate of bismuth, 5 parts of white wax, 5 parts of soft paraffin, and 60 parts of vaselin, mixed while boiling. One per cent. formalin is often added to these pastes. The paste is injected before an *x*-ray picture is taken, and the picture shows all the ramifications of the fistula. The paste is left in for treatment. If a sequestrum exists it should be removed before the paste is injected. It is not essential, but is advisable, to dry the fistula before injecting.

The paste is sterilized before using. It is sucked up into the syringe while still liquid and is cooled to the requisite temperature and hardened to the proper consistency by running cold water over the syringe. It is injected very slowly and the injection is continued until a sense of pressure annoys the patient. Then the syringe is laid aside, a bit of gauze is held for a time over the outlet of the fistula to keep the paste from running out, and an ice-bag is put over the region to harden quickly the injected material. There is no pain from such an injection. Beck employs the first paste until pus disappears and then uses the second.

The value of this paste is that it distends and fills the abscess cavity and sinus, and affords a trestle or frame for granulations to grow upon. A considerable amount of the paste may run out of the fistula during the first twenty-four hours. In shallow sinuses it all runs out. In deep and tortuous fistulæ much of it remains for weeks and is slowly absorbed. In empyema and bone cavities it is slowly absorbed. Beck holds that the paste is bactericidal, astringent, and non-toxic. Cases of pigmentation of the

lips, gums and cheeks, and cases of ulceration in the mouth from absorption of bismuth have been recorded, and at least 8 deaths are on record (Reich in "Beiträge zur klinischen Chirurgie," Nov., 1909). Beck limits the first dose to 100 gm., but increases the amount later. Because of possible danger of poisoning Blanchard uses a paste of white wax and vaselin without bismuth. Not over 4 oz. of bismuth paste should be injected. As Bell points out, if a large quantity is injected an opening must be left. This precaution may prevent poisoning. Some think the poisoning is due to bismuth, others believe it is due to arsenic held as an impurity. David and Kauffman ("Illinois Med. Jour.," Oct., 1909) point out that there may be acute cases of poisoning which are liable to be fatal, and chronic cases which tend to recovery. In an acute case of bismuth poisoning there is pigmentation of the gums, ulcerative stomatitis, dyspnea, delirium, and albuminuria. David and Kauffman regard pigmentation of the gums, lips, or cheeks as an indication of toxic action and a sign to discontinue the drug. The use of bismuth paste is undoubtedly a valuable method. I have seen sinuses heal under it after they had resisted various other plans of treatment. It may be used in sinuses, cold abscesses, empyemata, tuberculous joints, and other conditions. Ridlon and others have obtained with plain vaselin results as good as have been obtained by the use of Beck's paste.

If these means fail, if the patient gets worse, if there is persistent fever or violent pain, if sequestra exist, if there is mixed infection, or if the condition of the sufferer renders dangerous the prolonged conservative course, operate, removing the entire diseased area by erasion, by excision, or possibly by amputation. If the *x*-ray picture shows extensive sequestrum formation, operation is indicated. If amyloid degeneration exists, conservative treatment is contraindicated and so is resection. Amputation, must be done. Always remember that an incomplete operation or a partial removal, unless it consists of simple drainage, is worse than no operation, as it opens the portals to systemic infection, and may be responsible for the development of general tuberculosis, septicemia, or pyemia. Simple drainage, as previously stated, is seldom advisable. Garré is of the opinion that the hip, wrist, and shoulder do best by conservative treatment; the knee, elbow, and ankle, by operative treatment (John W. Churchman in "Amer. Medicine," April, 1906). Many mobilizing operations have been done for stiff joints and in many cases the results have been imperfect and disappointing. Certain it is that no tuberculous joint should be subjected to this operation until the disease is soundly cured.

It is small advantage to substitute a movable and painful for a stiff and painless joint. The results of arthrodesis are far better in cases of traumatic ankylosis.

Tuberculosis of Special Joints; Tuberculosis of the Vertebræ (see page 808). —**Tuberculosis of the Sacro-iliac Joint** (*Sacro-iliac Disease*).—This is an uncommon affection, and is especially rare before the age of fifteen. The disease may begin in the joint, may arise in adjacent bone, or may result from a cold abscess burrowing into the joint. In some cases it is associated with extensive disease of the pelvic bones. The disease, if undetected, may lead to dissemination of tubercle, to abscess, or even to death.

Symptoms are often obscure. The disease is frequently confounded with vertebral caries, hip-joint disease, or sciatica. The patient limps on walking, the joint has a feeling of insecurity, especially on ascending stairs or carrying a weight, but can stand on either leg. There is pain in the sacro-iliac joint, about the hip, and down the back of the thigh, and occasionally also along the front of the thigh. Pain may be complained of about the knee. Pain may be increased by a jar, a misstep, perhaps by coughing or sneezing (Howard Marsh on "Diseases of the Joints and Spine"). Tenderness is manifest on pressure over the joint and on pushing the ilia together; there may be fulness over the sacro-iliac joint, but the hip is not flexed unless iliac abscess exists.[1] The thigh is usually extended. There may be apparent lengthening. Muscular wasting, especially of the gluteal region, is apparent. Frequently a diagnosis of sciatica is made. I have known appendicitis mistaken for sacro-iliac disease. Sometimes a diagnosis of hip-joint disease is made, sometimes of lumbar caries.

Treatment.—Rest in bed for months, using also a felt case for the pelvis. Counter-irritation by blisters and the actual cautery. In some cases injection of formalin-glycerin or of iodoform; in others, incision and curetting. I have operated on 9 cases, with 1 death. In 1 case in the Jefferson Medical College Hospital the abscess was pointing in both the back and groin. Both areas were incised, the diseased bone was removed, and the boy ultimately recovered. In another case the abscess pointed in

[1] See A. G. Miller, "Edinburgh Med. Jour.," May, 1895.

the groin. The treatment was as previously set forth, and the patient, a woman, recovered. The best way to reach the joint is to chisel or bore through the ilium above the great sacrosciatic foramen.

Tuberculosis of the Hip-joint (*Hip Disease; Morbus Coxarius; Morbus Coxæ; Hip-joint Disease*).—The primary lesion may be in the synovial membrane, but it is usually in the bone. It may begin in the acetabulum; it may begin in the femur. In 95 per cent. of cases it begins in the head of the femur. If it begins in the femur, it usually arises on "the distal side of the epiphyseal cartilage" (Senn). Sometimes primary tuberculosis arises in the trochanter major, and never involves the joint. When the synovial membrane becomes involved at any point, spread throughout the joint is rapid. In many cases the articular cartilages are attacked, and in some cases the epiphyseal cartilage is destroyed. It is commonest in children, but it may arise in adults and even occasionally in those of advanced years; 62 per cent. of cases arise in children under ten years of age and 80 per cent. of cases occur before the twentieth year (Bryant). Traumatism and cold may be predisposing causes. The disease strongly tends to caseation and the formation of sequestra.

Symptoms.—It has been usual to divide the disease into three stages: (1) The stage of microbic deposition and multiplication, the products of the bacilli causing irritation and new growth; (2) the stage of progression, with formation of masses of granulation tissue and effusion into the joint, and (3) the stage of caseation, with destruction of the joint and often of the structures about it. Bradford and Lovett[1] protest against this. They say: "It has been customary to divide hip-disease into stages, and to ascribe to these stages certain definite symptoms. Neither from a clinical nor a pathologic point of view is it desirable to attempt such a division." As H. Augustus Wilson says: "Tuberculous bone and joint disease should be considered as the primary invasion or incipiency, and all other symptoms should be regarded as results and not as an integral and necessary part of the trouble."

The symptoms of incipient coxalgia are slight and may be overlooked entirely. In a child there are night-terrors, on getting about in the morning the child shows no lameness, but a limp develops during the day, and the little one soon grows tired while playing and lies down to rest. There is a slight limp; some muscle spasm may be noted, and pain may be complained of at night in the hip, in the front of the thigh, or at the inside of the knee. Tapping the sole of the foot, the thigh and leg being extended, may develop pain, just as it will develop pain in any inflammatory involvement of the joint, but the employment of this method is objectionable. It may injure a joint already damaged by the tuberculous process, and it gives no information which cannot be obtained by a safer mode of investigation. After all, pain on tapping the sole of the foot means only what muscular rigidity means, and muscular rigidity is always present and is easily demonstrable by careful manipulation. The diagnosis of incipient coxalgia is more or less problematic.

As the disease progresses more positive symptoms are observed. The limp grows worse; the hip is broadened by an effusion into the joint, and fluctuation may possibly be detected; the thigh muscles atrophy; the extremity is pushed forward, abducted, and everted. The position is described as flexion, abduction, and outward rotation (Fig. 466). This position may not be obvious; in fact, the limb may be extended by the side of the companion extremity. When it is, there is a forward curve of the lumbar spine (lordosis) and a lateral curve of the lumbar spine, which raises the pelvis on the sound side and depresses it on the diseased side. These lumbar curves serve to bring the femur toward the middle line, give the extremity the appearance of being lengthened, enable the sufferer to walk (Fig. 466), and cause him to rest his weight on the sound limb. Apparent lengthening means abduction. In some few cases adduction exists rather than abduction. The abduction, which is usual, releases tension of the fascia lata, and thus abolishes pressure upon the joint through lessening of pressure upon the great trochanter, and also relaxes the outer portion of the Y-ligament and the ligamentum teres. The flexion relaxes the anterior portion of the capsule and the psoas muscle and prevents pressure of its tendon upon the front of the joint. Outward rotation relaxes the inner portion of the Y-ligament and the posterior portion of the capsule. Pain exists, often sudden or starting, and is located in the joint, on the front of the thigh, and to the inner side of the knee in the course of the obturator nerve; the pain is aggravated at night, and full extension and complete abduction are not possible. The gluteal muscles waste, and the gluteal crease is on a lower level than is that of the sound side. The gluteal crease may be nearly or quite effaced be-

[1] "Orthopedic Surgery."

cause of hypertrophy of the subcutaneous layer (Alexandroff), or from slight flexion of the leg (McClellan). As the disease progresses adductor spasm causes adduction, and the limb is flexed, adducted, and apparently shortened. This apparent shortening is accomplished by a lateral curvature of the spine, which keeps the limb from crossing its fellow and being useless. It does so by raising the hip of the diseased side and drawing the femur outward (Fig. 466). This causes apparent shortening (Howard Marsh in Treves' "Manual of Surgery"). The above symptoms arise chiefly from unconscious efforts to obtain ease from joint effusion, reflex irritation, and involuntary or spasmodic muscular contractions. There is an appearance of lengthening or shortening, but it is only apparent, not real. The real position is shown on Fig. 468, 4. The fluid effusion may be absorbed or may find its way externally by means of sinuses. The latter condition is known as *abscess of the hip*. The absorption of the exudate or the rupture of the capsule permits the contracting muscles to bring the head of the femur into firm contact with the acetabulum or its brim; the bones are worn away and destroyed, real shortening results, there is adduction, and flexion is increased as shortening becomes more marked.

In advanced cases of coxalgia the head of the femur passes upward and outward upon the rim of the acetabulum, the thigh is flexed and fixed, and attempts at extension when the patient is recumbent cause the pelvis to tilt forward and occasion a marked lumbar curve (lordosis—Fig. 468, 2), which is due to the pelvis moving with the femur as if ankylosed, and which disappears on flexion. In this condition adduction occurs because of the ascent and movement outward of the head of the bone.

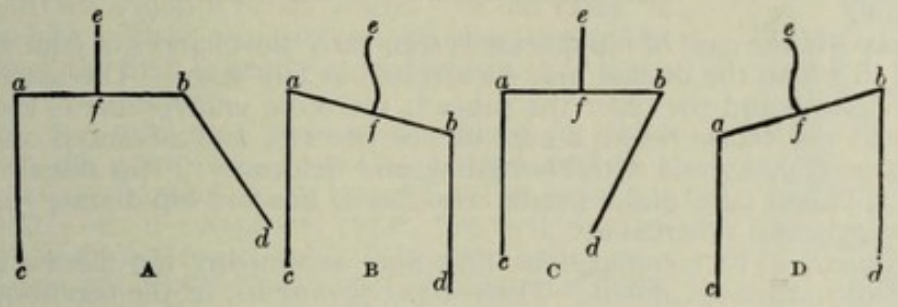


FIG. 466.—Positions in hip-joint disease. A: *e–f*, Lumbar spine; *b–d*, limb fixed in flexion and abduction, useless for walking. B: *e–f*, Lumbar spine. Patient corrects the condition in Figure A by curving the lumbar spine forward and rotating the pelvis on its transverse axis, thus making the femur point downward. The lumbar spine is curved laterally, the pelvis ascending on the sound side and descending on the affected side (apparent lengthening). C: *b–d*, Limb fixed in flexion and adduction. D: *e–f*, Curve of lumbar spine to correct condition in Figure C (apparent shortening). (After the plan of Howard Marsh and Treves.)

Shortening is marked. After a hip abscess finds an external outlet pyogenic infection is very apt to take place and suppuration arises, which is followed by that state which is designated as "hectic." If a cure follows advanced coxalgia, partial or complete ankylosis takes place; if death ensues, it may be due to septicemia, tuberculosis of the viscera, exhaustion, or amyloid degeneration.

Diagnosis is very easy in well-established cases of hip disease, but very difficult when the disease is incipient. Always make a systematic and thorough examination. Undress the patient and place him recumbent, with his legs extended upon a table or a hard mattress. Note if the heels are level and if the iliac spines are on the same level (a depressed spine on the affected side means abducted extremity, the degree of which is determined by carrying the limb out until the spines are horizontal; elevation of the iliac spine on the affected side means adduction, the amount of which is determined by adducting the limb until the spines are horizontal, Fig. 466). The amount of flexion is ascertained by lifting the knee until the curved spine has become straight. Try all the movements belonging to the joint, to detect any limitations; observe if bringing down the knee produces lordosis; look for swelling and for muscular wasting; feel if the head of the bone is enlarged; determine if motion produces pain or if pressure develops tenderness; and always carefully elicit the history of the attack, of the person, and of the family.

Hip disease may be confounded with spinal caries in which a psoas or a lumbar abscess has formed, with sacro-iliac disease, with infantile paralysis, with congenital dislocation of hip, with lordosis from rickets, with gluteal abscess, and with bursitis of the gluteal bursæ. In hip disease there is always some lameness; pain may be severe,

may be trivial, or may be absent entirely, and may be in the hip or be referred to the front of the thigh or the inner side of the knee. Always remember that the pain is not characteristic, and that pain in the same localities may arise from aneurysm of the femoral or iliac arteries, from abscess in Scarpa's triangle, from caries of the lumbar vertebræ, from sacro-iliac disease, and from cancer of the rectum. Altered position of the limb, limitation of movement in the hip-joint, muscular wasting, and swelling soon arise in hip-joint disease.

In disease of the sacro-iliac joint examination shows that the movements of the hip-joint are unlimited and produce no pain, and that pain is developed by pressure over the sacro-iliac articulation and by pressing the ilia together. In infantile paralysis there is no pain, but there is paralysis with great muscular atrophy, which comes on with considerable rapidity. In spinal caries with psoas abscess the evidences of disease of the vertebræ are clear and a collection of fluid is located in the groin external to the femoral vessels. The tuberculous pus of hip abscess generally gathers under the tensor vaginæ femoris muscle, but it may reach Scarpa's triangle by passing through the cotyloid notch or through the bursa under the psoas muscle; it may even appear under the glutei. Matter from a caseating acetabulum may reach the interior of the pelvis and appear above Poupart's ligament.

In gluteal bursitis the symptoms last for many months, and do not remit as the symptoms of early hip disease are apt to do. The pain is but moderate, and is aggravated by exercise, but passes away on going to bed, and is felt back of the hip and back of the knee. There is a certain amount of limitation of motion and there is a positive limp, which arises early. In marked cases fluctuation can be detected in the upper gluteal region.[1]

Prognosis.—If the case of hip disease is seen early the chances of cure are excellent in children, in whom the disease may be arrested at any stage. The longer the duration of the disease and the older the subject, the more unfavorable is the prognosis. Many months will elapse before a cure can be effected, and advanced cases only get well by means of ankylosis with shortening and deformity. Hip disease may recur years after apparent cure, and a person who has or has had hip disease runs a chance of developing visceral tuberculosis.

Complications.—The complications that may accompany hip disease are the following: *Abscess*, as above noted. *Tuberculous meningitis*, or the condition known as "acute hydrocephalus" or "water on the brain," may arise during the progress of the case or after apparent cure, and is apt to ensue upon incomplete operations. It is almost inevitably fatal. *Phthisis pulmonalis* is a rare complication, but a not uncommon sequence, perhaps arising, sooner or later, after the hip disease has been cured. *Amyloid, lardaceous*, or *waxy degeneration of viscera* (see page 171) follows upon profuse and long-continued suppuration and is apt to arise in the liver, spleen, kidneys, or intestinal mucous membrane. Tuberculosis is not the only cause of amyloid degeneration, syphilis being responsible for at least 30 per cent. of all cases. In amyloid disease of the liver the organ is much enlarged, smooth, painless, and of increased consistency; there is no jaundice, the spleen is apt to be enlarged, and albuminuria is the rule. In amyloid kidney large amounts of pale urine of low specific gravity are voided; albumin is usually present in large amount, but may be absent; globulin may often be found, as may also hyaline, fatty, or granular casts; the patient is anemic and dropsy usually exists. Test the hyaline casts with iodin for amyloid material. Amyloid changes are usually slow in onset, but they may be rapid; they are commoner in men than in women, and are most frequently encountered in individuals between the ages of ten and thirty. Slight amyloid change may be arrested, but an extensive degeneration brings about a fatal result.

Treatment.—In most of these cases conservative treatment is advisable. Antituberculous treatment is used in all cases. In incipient hip disease the treatment usually advocated is rest. The patient is placed upon a solid mattress and extension is applied. In children under ten years of age a weight of from 3 to 5 pounds is used; in individuals between ten and twenty a weight of from 5 to 8 pounds is used. A long splint is often applied to the sound side to keep the patient recumbent and horizontal. A cradle is employed to hold up the bedclothing. The extension is applied in the long axis of the limb, the extremity being placed in the line of the deformity due to disease and being properly supported. Lordosis means that there is flexion of the thigh, and when lordosis exists the limb is to be raised until the lumbar spine flattens out on the

[1] See E. G. Brackett's important paper on "Gluteal Bursitis" in the "Transactions of the American Orthopedic Association," vol. x.

bed and extension is to be applied (Fig. 468, 5). If the anterior superior spine of the ilium is depressed on the affected side and there is apparent lengthening abduction exists. The limb is to be moved until the anterior superior spines of the ilia are on a horizontal level and then extension is to be applied (Fig. 468, 6).

If the anterior superior spine is elevated and there is apparent shortening, adduction exists. The limb should be moved inward across its fellow until the spines of the ilia are on the same horizontal level, and the extension is to be applied (Fig. 468, 7). The object of extension is to overcome muscular spasm and so put the part in a condition of physiologic rest. Muscular spasm is a great factor in destroying structures. Spasm presses the parts together, and as a result of pressure plus bacterial action destruction occurs. The extension and traction tire out the muscles and cause spasm to cease. Extension will remove flexion in two weeks in a recent case and in the course of some months in an older case. As flexion is relieved the pillows are removed and the leg lowered, but extension is maintained in the long axis of the thigh. Abduction and adduction cannot be removed by simple extension in the axis of the limb.

Abduction demands no special treatment. In a movable joint it will disappear, and in an ankylosed joint it is an advantage, compensating by apparent lengthening for the shortening due to bone absorption or to stunted growth of the limb. Adduction requires an addition of several pounds to the extension weight, the use of a long splint on the sound limb, and the drawing up of the sound side by a rope and pulley toward the head of the bed. The weight used to pull the sound side toward the head of the bed is equal to that used to pull the diseased side to the foot of the bed. This expedient is used for a month or six weeks. In old cases, in which the weight will not bring about extension, the patient is anesthetized, the limb is gently straightened a very little, and the weight is reapplied.



FIG. 467.—Thomas' posterior splint.

Extension in a mild case must be continued for three months after the symptoms have disappeared, and in a severe case the period must be six months. The weight is gradually taken off; if symptoms recur, the weight is reapplied; if they do not recur, apply a traction splint or a plaster dressing, put a high-heeled boot on the sound limb, and send the patient out on crutches. In young children extension can be made while the child is in a wheeled carriage, thus enabling the patient to go out in the fresh air and sunlight. The general treatment is tonic and restorative. The joint is so deeply placed that external applications are useless. In the treatment of hip disease Thomas's splint (Fig. 467) is used by many, and it may be combined with weight extension; or Sayre's splint (Fig. 469) may be employed. Wyeth's apparatus (Fig. 470) is a favorite with many American surgeons.

If the limb is in good position, or has been brought into good position, either by weight extension or straightening under ether, plaster of Paris is a useful dressing. It is applied from the toes up, and includes the entire extremity and also the pelvis. A patient wearing plaster may get about on crutches when the sole of the foot of the sound extremity is raised by the wearing of a thick-soled shoe.

Treatment by Weight Bearing and Fixation by Hip Spica of Plaster of Paris (Lorenz's Method).—This plan is based upon the principle that ankylosis is to be secured in every instance. To keep the patient in bed is to keep him from the open air and sunlight, which are so necessary in tuberculosis. Such confinement favors muscular atrophy, leads to anemia, and lessens vital resistance. The hip is placed in 20 degrees of flexion, 20 degrees of abduction, and 5 degrees of external rotation, and is fixed by a short plaster spica of the hip. The patient walks and so antagonizes muscular spasm. The joint surfaces bear weight, which leads to a useful increase of blood-supply (curative hyperemia), but do not grind upon each other, hence the spread of the disease is not favored. That muscles increase in size is shown by the fact that the cast gets tight and must be changed from time to time. The open air life and exercise are of the greatest benefit to the patient and a gain in weight is the rule. Cases in a debilitated condition or those with discharging sinuses must not be treated by this plan "without the temporary use of crutches" (H. A. Wilson in "Southern Med. Jour.," Dec., 1908).

The plan is more suitable for incipient than for advanced cases. The average duration of treatment is claimed to be about ten months (H. A. Wilson, Ibid.). It is true that the method affords easier access to the open air than does the bed treatment, but why

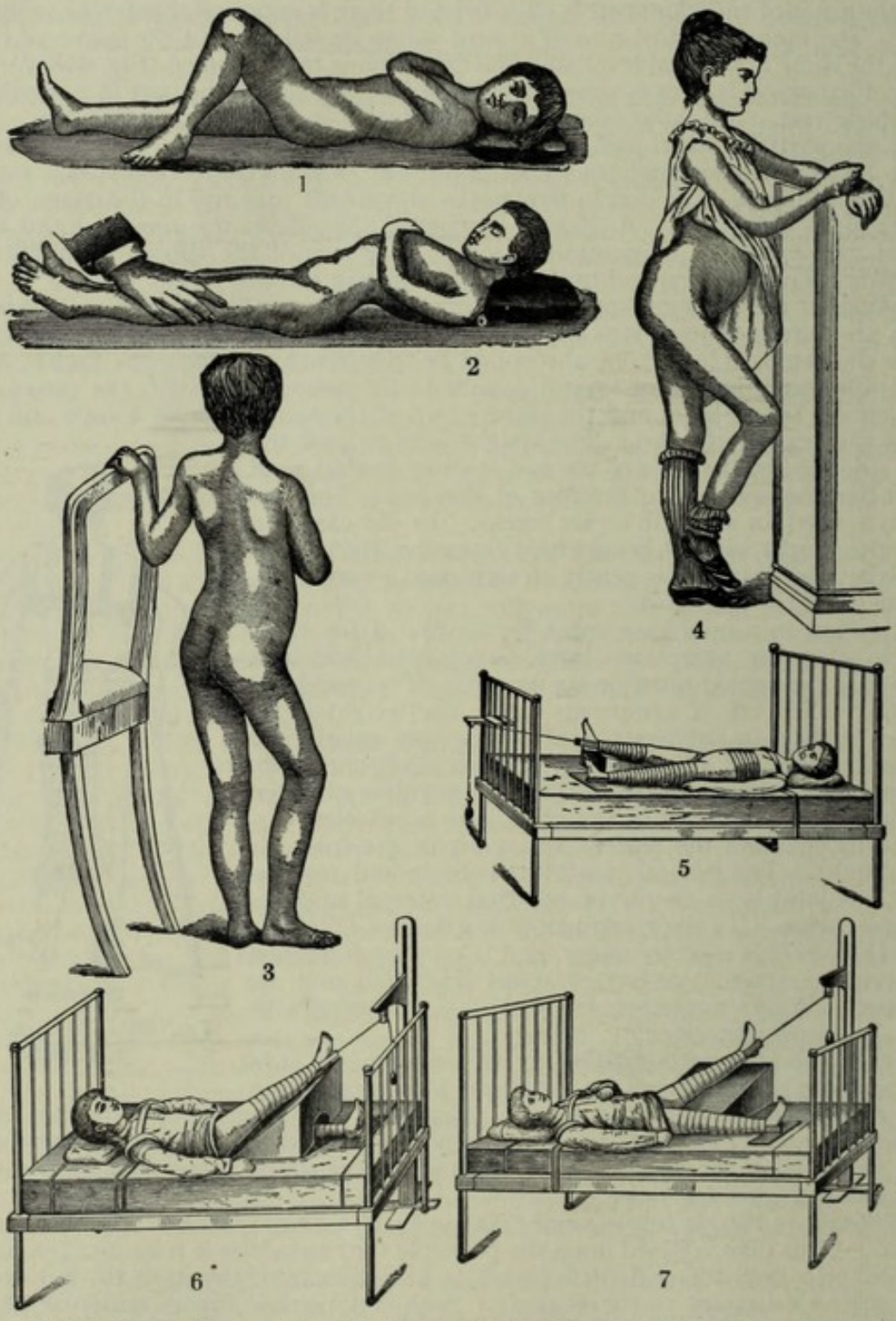


FIG. 468.—Hip-joint disease: 1, 2. Effects on the lumbar spine of flexing and extending the diseased leg in hip disease (Albert). 3, 4. Positions in coxalgia (Albert). 5. Extension in hip disease (Treves). 6. Extension of the limb in a flexed and adducted position (Treves). 7. Extension of the limb in a flexed and abducted joint (Treves).

should every patient be doomed to ankylosis when we know that in many cases joint function may be retained by treatment looking to that end?

Intra-articular Injections and Operation.—If in spite of treatment the condition does not improve or if it becomes worse, use intra-articular injections of formalin-glycerin or iodoform. Always try these injections before doing a resection unless the

x-rays show a large sequestrum. Sometimes they succeed, and if they do, resection is unnecessary. Asepticize the surface, carry a small aspirating needle into the joint, irrigate the joint with salt solution, and inject a sterile emulsion of iodoform and glycerin (see page 584). In one week, if reaction has ceased, repeat the injection. In another week again use the injection. It may be necessary to give from ten to twenty injections. The proper spot for puncture is thus determined: Draw a line from a point ½ inch outside of the middle of Poupart's ligament to the outer edge of the great trochanter. Puncture at the middle of the outer half of this line (De Vos). I have not attempted to remove the disease surgically early in any case and greatly doubt the wisdom of doing so. Huntington and some other surgeons advocate early operation in children instead of simply fixation, extension, and rest. Huntington ("Amer. Jour. Med. Sciences," July, 1905) recalls that when the lesion is in the head of the femur it tends to perforate into the joint, and he advises trephining at the lower border and outer aspect of the great trochanter and tunneling the neck and head of the femur with a curet. Bradford objects to this method in most cases on the ground that unless the disease is localized and the cavity is well walled off, and unless injury to the localizing barrier is avoided, the operation may be responsible for dissemination of the bacteria.

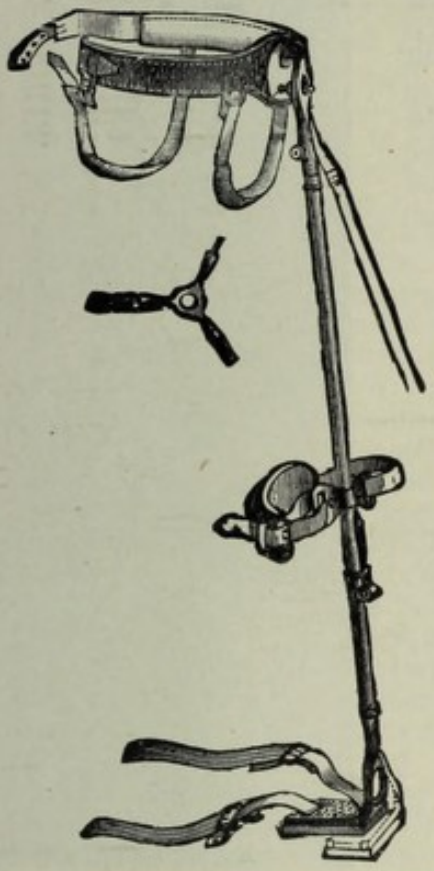


FIG. 469.—Sayre's long splint.



FIG. 470.—Wyeth's combination method.

If an abscess forms, incise with the most thorough antiseptic care, let the fluid drain away, irrigate the cavity with salt solution, remove any sequestra, inject with iodoform emulsion, sew up without drainage, and dress antiseptically. In some cases the sequestrum is extra-articular. In many cases no sequestrum is found. If this method fails, drainage must be employed. The old plan of not operating until rupture was seen to be inevitable would be wrong today. To open early and antiseptically often means rapid healing, the prevention of burrowing, a lessened danger of visceral infection, and an earlier cure. In contrast to what happens when a very large cold abscess is opened, hectic fever will rarely arise when a tuberculous joint is opened and drained with aseptic care.

Excision of the hip is to be performed when there is a large sequestrum or severe fistulæ (Garré, "Deutsch. med. Woch.," 1905, Nos. 47 and 48); when the head of the femur is detached and lies loose in the joint; when profuse suppuration continues for a long time, and other methods fail to arrest it; when amyloid disease is threatening; or when very faulty position is inevitable without operation. Excision is an operation of considerable danger, and the older the person, the greater the danger. Schede

advocates arthrectomy in some cases as a substitute for resection. Senn tells us that opinion as to resection has greatly changed of late, and it is now taught that the operation is advisable in all cases where fixation, extension, intra-articular and parenchymatous injections have failed to arrest the disease (Senn on "Tuberculosis of Bones and Joints"). Resection of the hip does not give a very satisfactory functional result. When there is extensive disease of the femur, when excision has been tried and has failed, when the patient has not the recuperative power to withstand the long siege of illness following excision, or when there is amyloid disease, amputate.[1] Amputation of the hip-joint for tuberculous disease is very successful as a life-saving procedure.

Knee-joint Disease (*White Swelling*).—After the hip, the knee is, of all joints, the commonest site of tuberculous disease. Knee-joint disease can begin as a synovitis, but oftener begins as tuberculous inflammation of the femoral or the tibial epiphysis. Tuberculous disease rarely attacks the bone on the diaphyseal side of the epiphyseal line; a single focus only exists, as a rule, and a sequestrum is seldom formed. In very rare instances the patella or the semilunar cartilage is primarily attacked. It may begin at any age, but is most common in children and young adults. If an acute synovitis ushers in the case there may be a large effusion into the knee-joint and partial flexion, but swelling is usually slight in knee-joint disease. Pulpy degeneration of the synovial membrane occurs; the joint enlarges; the ligaments soften; the skin becomes edematous, and muscular spasm exists. The leg becomes flexed;

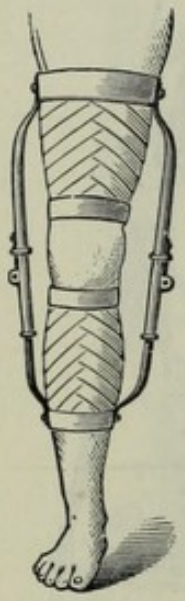


FIG. 471.—Sayre's knee splint applied.



FIG. 472.—Hutchinson's knee-joint splint.

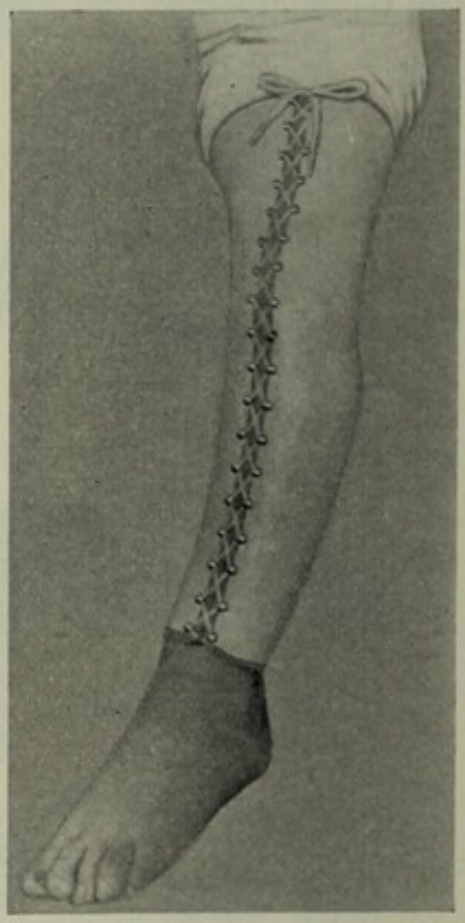


FIG. 473.—Davidson's celluloid support used after resection of the knee.

the tibia displaced backward and outward; the foot is everted; and lameness arises, due chiefly to deformity. Muscle atrophy is marked above and below the joint. Pain may be absent, is often slight, and is rarely severe. Local tenderness is very common. When the disease begins in the bone or an epiphysis there are pain, tenderness, lameness, swelling, inability to extend the limb completely, sudden spasmodic muscular contractions, and final involvement of the joint. When an abscess forms, it may destroy the joint very rapidly or it may break externally.

Treatment.—In treating knee-joint disease conservative treatment is usually tried, but often fails. A plan of doubtful value is to make a mixture of guaiacol and olive oil (1 : 4). Once a day the surface of the knee is exposed by removing dressings, is painted with this mixture, and the painted surface is covered with cotton-wool. Rest is of the first importance, and may be secured by the application of splints (Figs. 471, 472), the use of extension, or the employment of a plaster-of-Paris bandage. In any case the patient must be kept in bed for a few weeks; he may then be permitted to

[1] See the admirable article by Howard Marsh in Treves's "Manual of Surgery."

go out upon crutches, wearing a high-heeled shoe upon the foot of the sound limb. In cases in which treatment is begun early the disease may often be arrested in from eight to twelve months. If the symptoms do not abate after a number of weeks, or if the condition grows worse and caseation occurs, aspirate, irrigate, and inject iodoform emulsion or formalin-glycerin. Intra-articular injections are not unusually curative. Insert the needle in the angle between the outer edge of the patella and the ligament of the patella (De Vos). Repeat the injection in one week if reaction has abated, and continue as directed for the injection of the hip-joint. If this plan fails, incise the capsule, remove all fragments and tuberculous foci, irrigate with normal salt solution, inject iodoform emulsion, and sew up without drainage (Neuber's plan). A more severe case requires drainage. If these means fail, or if the case is too far advanced to permit of their use, open the joint and perform an excision or an erasion (see pages 655 and 660). Excision gives a satisfactory result in most cases, although it leaves a rigid knee and marked shortening. Garré considers any shortening over 5 cm. a bad result, and he got such a bad result in 75 per cent. of his 117 cases. In children shortening follows even conservative treatment, and the shortening which follows excision is due in part to removal of bone and in part to impairment of the nutritive power of the epiphyseal cartilage. In most cases in children conservative treatment should be tried. In most adult cases resection is indicated. Some cases demand amputation, which, if the patient's health is much impaired or if amyloid disease exists, is to be preferred to excision. Amputation is preferred to excision in very young children and aged people.

Ankle-joint disease may begin in the synovial membrane, in the tibial epiphysis, or in the tarsus. The origin is not infrequently synovial.

The *symptoms* are pain, swelling, lameness, limitation of joint movements, and atrophy of the calf muscles. Caseation often occurs and sinuses form.

Treatment.—Conservative treatment with injections of iodoform or of formalin-glycerin will cure many cases. Rest is obtained by means of splints or plaster-of-Paris bandages. Caution the patient to avoid standing upon the diseased extremity. In making an intra-articular injection insert the needle below the outer malleolus. When caseation occurs, it is advisable to open the joint, wash out with normal salt solution, inject iodoform emulsion, sew up the incision, and put up the ankle-joint in plaster. When there is considerable bone disease, when fistulæ exist, when adjacent joints or tendons are diseased, or when joint disorganization occurs, perform an excision or an erasion. Some cases demand amputation (Syme's amputation being preferred by some, amputation above the ankle being approved by many). Osteoplastic resection is sometimes advised (Wladimiroff-Mikulicz operation). Operative treatment is more satisfactory in children than in adults (Garré).

Shoulder-joint disease is not common; it is rare in children, but is less rare in adults; it may begin in the synovial membrane, but usually begins in the head of the humerus. The glenoid cavity is rarely attacked. Pain is slight, atrophy of the deltoid and other muscles is noted, the joint is stiff, and the scapula follows the motions of the humerus. Caries sicca is the usual cause of destruction. In many cases swelling is not obvious, the joint shrinking because of destruction of the head of the bone and contraction of the capsule (Senn). Abscess formation is unusual. If an abscess forms, it may open in the axilla, through the deltoid muscle, or at some far distant point. Shoulder-joint disease is frequently complicated by pulmonary tuberculosis.

Treatment.—A majority of cases recover by the use of conservative treatment, a stiff joint resulting. Put on a shoulder-cap, apply the second roller of Desault, and hang the hand in a sling. Maintain rest for a number of months. Arthur Gillette's plan is very efficient. It consists in placing in the axilla a wedge-shaped pad with the base up. The arm is allowed to hang. Aspiration and injection of iodoform emulsion or of formalin-glycerin are of great service in synovial tuberculosis. In making an intra-articular injection the needle is entered below the acromion, while the arm is held against the side and the forearm is at right angles to the arm and across the front of the chest (De Vos). If caseation occurs, open the joint, remove tuberculous foci, wash with hot saline fluid, inject iodoform emulsion, and close without drainage. In a decidedly severe case, drain. Caries sicca may occur. In rare instances dead bone will have to be gouged away. Excision is sometimes required, but the results are seldom satisfactory.

Elbow-joint disease may begin in the humerus or the ulna. The head of the radius is rarely the primary focus. In some cases the synovial membrane is first attacked. The disease is most frequent in young adults. The joint is swollen, its

movements are somewhat limited, muscular wasting is pronounced, and pain is generally slight. Tuberculous pus may form.

Treatment.—In treating early elbow-joint disease, especially in young children, conservative treatment is very successful. Rest is secured by means of an anterior angular splint (Fig. 474) and a triangular sling or a plaster-of-Paris dressing. Splints are to be worn for from four months to a year. Injections of iodoform emulsion or formalin-glycerin are usually employed. Insert the needle close to the outer side of the olecranon. In a cure by conservative methods a stiff joint will usually result. It may be necessary to perform resection because of extensive bone disease. Resection gives an excellent functional result.

Wrist-joint disease may arise at any age, and is sometimes met with in late middle life or even in old age. The joint presents a puffy swelling, loses its normal contour, and becomes spindle shaped. Hand movements are impaired, pronation and supination cannot be performed completely or satisfactorily, the joint is stiff and partly flexed, the grasp is enfeebled, pain may be severe or slight, the skin is sometimes, but seldom, hot, and muscular atrophy is marked. This form of tuberculosis may begin in the synovial membrane, in the bones, or in the tendon sheaths. The prognosis is better than in tuberculosis of any other joint. There is usually preservation of considerable function on recovery.

Treatment is usually conservative and very successful, giving, as a rule, a functionally useful joint and movable fingers. Garré recommends a trial of the method even when there are fistulæ and when there is necrosis of the carpus. Apply a celluloid cast. It is light, clean and solid; maintain strict rest for from four to six months. Aspiration and injection of iodoform emulsion or formalin-glycerin may be practised. Enter the needle at the dorsal edge of the radial styloid process, and again at the upper edge of the pisiform bone (De Vos). In some cases it is well to incise, wash with salt solution, inject iodoform emulsion, and close without drainage. Severe cases demand incision and drainage with the maintenance of rest. Resection is to be avoided if possible. It gives a bad functional result, the amount of bone removed leaving the tendons too long and contractures of muscles being common (Garré). It may be demanded because of extensive caries or sequestra formation. Amputation is occasionally necessary.

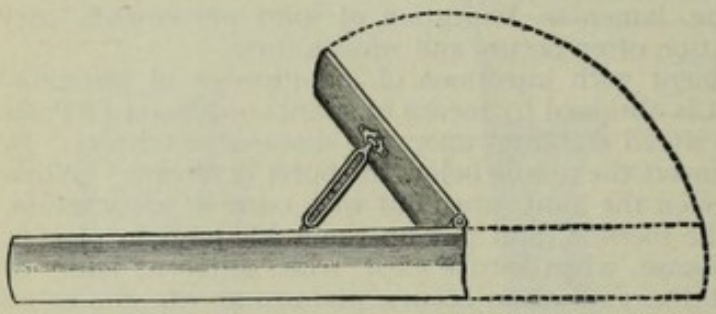


FIG. 474.—Stromeyer's anterior angular splint.

Non-tuberculous Arthritis.—Most of these cases, acute and chronic, are of infectious origin. Some of them are non-infectious. Among the non-infective forms are the joint lesions of locomotor ataxia and syringomyelia—constitutional conditions, as gout, purpura, hemophilia, and scurvy—functional derangements expressed by articular neuralgia or intermitting hydrops and traumatic states (Hoffa in "Zentralbl. f. Chir.," xxxiv, 1907; and Bloodgood in "Progressive Medicine," Dec. 1, 1907).

Osteochondritis Deformans Juvenilis (Quiet Hip Disease. Coxa Plana. Osteochondritis Deformans Coxæ. Legg's Disease. Perthes's Disease).—Legg, of Boston, discovered this condition in 1909 ("Boston Med. and Surg. Jour.," 1910, clxii). Perthes, of Tübingen, described it in 1910. (See Leonard V. Ely in "Annals of Surgery," Jan., 1919.) The lesion is not inflammatory (Waldenstroem in "Zentralb. f. Chir.," 1920, xlvii). In this disease there is atrophy and rarefaction of the head of the femur and if weight bearing is continued the head of the femur will become flattened and finally be almost destroyed. In many cases a diagnosis of tuberculous hip has been made. The cause is unknown. Legg considers trauma causal in 67 per cent. of cases ("Boston Med. and Surg. Jour.," Feb. 7, 1910). Taylor and Freider consider trauma a possible but very doubtful cause ("Amer. Jour. Orthop. Surg." vol. xiii, 1915). Kidner suggests infection of the tonsils as causal ("Amer. Jour. Orthop. Surg.," vol. xiv, 1916). Others regard the lesion as nutritional. The latter explanation gains much in probability from Blanchard's observation that there is also "decreased bone density and some atrophy of the pelvis of the diseased side in the acute cases" ("Jour. Amer. Med. Assoc.," Sept. 29, 1917). It is probably a nutritional disease of growing bone and muscle. The first symptom is a limp. There may be some pain running down the thigh.

Fever is absent. There are no night cries. There is some limitation of rotation, and atrophy of the hip and buttock. If the case is untreated shortening will occur. After about a year the head of the femur may be largely destroyed. The neck will be shortened and in a coxa vara or coxa valga position (Blanchard, Ibid.). There are 2 or 3 cm. of shortening. "Abduction is partly lost and movements of the hip in other directions are slightly limited" (Blanchard, Ibid.). In a year or more the disease ceases to progress and the bone begins to harden and to undergo repair. If weight bearing is prevented during the existence of the disease the head of the femur will never lose its rotundity and by the end of the second year will have become hard again. Even if the head of the femur has been destroyed, proper mechanical treatment for a year or two will cause almost complete regeneration. A limp remains after recovery due to ossification in deformity. In coxa vara the softening involves the neck chiefly; in coxa plana, the head.

The plan of letting these cases walk about without treatment is to be condemned. Treatment is highly successful. A plaster-of-Paris spica running from the foot nearly to the axilla is an excellent plan of treatment. It is associated with a high shoe on the sound side and crutches.

Some use the abduction splint as in tuberculosis of the hip and guard the patient from treading on the diseased limb (Sever in "Jour. Amer. Med. Assoc.," Sept. 29, 1917).

Traumatic Arthritis.—This may be due to a single injury (a sprain or a bruise) or to some continuing cause (genu valgum may cause arthritis of the knee; flat-foot may be responsible for arthritis of the knee or hip).

If a contusion or sprain causes relaxation of the capsule or of certain supporting tendons, the joint becomes loose and injures itself again and again during movement. It does the same thing when there are loose bodies or enlarged synovial fringes. Traumatic arthritis usually involves but one joint. Recent traumatic arthritis is treated by repeated aspirations and active motions (see Acute Simple Synovitis on page 580) in preference to heat, massage, and passive motions.

If a continuing cause is present it is to be removed. Distant causes may be removed by orthopedic apparatus or by operation. Causes within the joint may be sought for by arthrotomy, and when found they should be removed. For instance, in the knee, *inflamed synovial fringes* may be responsible for chronic inflammation. They get caught between the joint surfaces, are squeezed, and trip the victim. They should be removed. Lockwood ("Brit. Med. Jour.," July 3, 1909) points out that an overgrowth of fat may get between the tibia and femur and be squeezed. This surgeon calls attention to the fact that there are "adipose pads immediately above the articular surface of the femur, and on either side of the upper end of the patella" (Ibid.). He calls them the *pads of Malgaigne*, after the French surgeon who described them in 1859. If they are subject to repeated traumatism they should be removed.

Infective Arthritis.—In this condition the inflammation is due to bacteria. Various forms of bacteria may be responsible. A streptococcic arthritis begins in from one to five days after the primary infection, a typhoid joint many days or even weeks after. In some cases pus forms and pyogenic bacteria are demonstrable in fluid removed by aspiration. In other cases, perhaps exhibiting symptoms as acute, no pus forms and perhaps no bacteria are demonstrable in the fluid removed by aspiration. The non-purulent cases are due to toxins or to bacteria of attenuated virulence. Secondary infection may occur. In most cases the disease is polyarticular, but if a joint wound is causal the arthritis will be monarticular. The bacteria may reach a joint by way of a wound, from an adjacent focus of osteomyelitis, from a near or distant area of infection. Infection may be from the genito-urinary tract, the respiratory tract, the intestinal tract, the teeth, or by way of the tonsils. Bacteria not directly introduced into the joint reach it by way of the blood or lymph.

The disease may arise during the course of gonorrhea, scarlatina, or any infectious process. The source of the bacteria may be oral sepsis, infection of the tonsils or teeth, sinus infection, chronic appendicitis, prostatic inflammation, or some other focal infections. It may arise when no area of infection can be discovered. It may arise in the course of an acute infectious disease (such as erysipelas, cerebrospinal fever, bronchopneumonia, typhoid fever, pneumonia, influenza, mumps, dysentery, diphtheria, measles, scarlatina, variola), and may be due to pyogenic cocci, to the specific microorganism of an acute infectious disease, or to microbic products. Arthritis may accompany or follow empyema or gonorrhea. Infective arthritis may be followed by pneumonia. Rosenau claims that streptococci can be converted into pneumococci.

So, too, he asserts, pneumococci may be converted into streptococci ("Illinois Med. Jour.," 1914, xxv). Joint inflammation arising in the course of or as a sequel to an acute infectious disease may or may not suppurate.

Symptoms.—If no suppuration takes place, the *symptoms* of the attack resemble those of rheumatism; if suppuration occurs, the symptoms are the same as those of acute suppurative arthritis, with which disease this form of infective arthritis is identical. Suppuration rarely occurs. Ashby has well described the arthritis which sometimes follows *scarlatina*. It involves the wrists, finger-joints, tendons of the forearms, the knees, ankles, or spine. The joints are painful, but are rarely much swollen or discolored (Howard Marsh). We can distinguish infective arthritis from rheumatism by the fact that it does not migrate and is uninfluenced by antirheumatic remedies. Dislocation may follow the acute manifestations of infective arthritis. In the hip it may simulate congenital misplacement. In chronic cases cartilage, bursæ, and ligamentous insertions become involved. Because of the absence of blood-supply repair of cartilage is very slow, hence inflammation of cartilage means a prolonged case. Chronic cases are similar to, perhaps identical with, rheumatoid arthritis. In chronic cases many joints or nearly all joints may suffer from pain, swelling, and stiffness. The muscles, too, inflame and undergo fibrous changes. A joint swells, the ligaments stretch, the articulation becomes wobbly, the slightest motion causes violent pain, the adjacent muscles are weak and stiff. Such exacerbations occur again and again and may be accompanied by slight elevation of temperature. Sooner or later, if the disease progresses, the involved joints become dislocated and usually ankylosed in deformity. Tendon sheaths also suffer.

Treatment.—In every early case in which we suspect the condition, diagnostic aspiration is performed. If the fluid obtained contains bacteria Murphy's formalin and glycerin should be injected (2 per cent.). An injection is followed by the application of an extension apparatus. The mixture must be at least twenty-four hours old. In many cases this treatment is of the greatest value. If aspiration, injection, and extension fail, arthrotomy and irrigation are indicated. In all clinically severe cases and in some prolonged cases open and irrigate with normal salt solution. If the joint contains pus, free incision should be followed by the use of Dakin's fluid. Recent cases which are not very acute and are free from pus may be opened, and the capsule closed without drainage of the joint. The soft parts above the capsule are not sutured (Cotton in "Boston Med. and Surg. Jour.," 1915, clxxiii). Suppurative arthritis is treated as is directed in the following section. In a prolonged case seek for and remove every source of infection in appendix, gall-bladder, prostate, lymph-glands, teeth, tonsils, nasopharynx. Lyon's non-surgical drainage of the gall-bladder may enable us to recognize an infection otherwise undiscoverable. Arsenic and quinin may be of some service. Cabinet baths are indicated. Massage to muscles is very valuable when acute tenderness has abated. Hydrotherapy is indicated. Any violent movement or forcible massage may precipitate an attack. The toxins of erysipelas and Bacillus prodigiosus may do much good. The initial dose is ¼ minim at intervals of three or four days, and gradually advanced. The intention is to avoid a severe reaction and the treatment must be continued for many months (Torrey, Klein).

Pyogenic or Acute Suppurative Arthritis.—This condition is a form of infective arthritis and is usually due to the Staphylococcus pyogenes aureus or to the Streptococcus pyogenes, which finds entrance by means of a wound, by the spontaneous evacuation into a joint of the products of an osteomyelitis, by extension of suppurative inflammation through contiguous structures, by the blood-stream, or by the lymph. It is necessary to remember that causative bacteria may have entered the blood or lymph at a point near to or distant from the joint (tonsils, ethmoid cells, urethra, a focus of osteomyelitis, puerperal sepsis, etc.). When bacteria are in the blood the condition is called bacteremia. Of course, a wound into a joint may be the open gateway for infection. A traumatism may create a point of least resistance and bacteria may be derived from the blood or lymph. It is not very unusual for traumatic arthritis to eventuate in pyogenic arthritis. Particularly in youths and young children the symptoms of arthritis may overlie and hide a causative osteomyelitis. Sometimes gonorrhea is the cause and in rare cases septicemia is causal. In septicemia bacteria multiply in the blood. In pyogenic arthritis all the joint structures are involved and suppuration rapidly appears. Synovial membrane is converted into granulation tissue and cartilage is destroyed by pus. The greater the intensity of the inflammation, the larger the amount of granulation tissue, hence, ultimately, the greater the amount of scar tissue and the greater impairment of joint function.

The *symptoms* of acute suppurative arthritis are usually a chill followed by fever and a rapid pulse. There are severe pain, which is aggravated by motion and is worse at night; discoloration, heat, and edema of the skin, partial flexion of the joint, fluctuation, and marked constitutional symptoms of sepsis. The joint tends to rapid disorganization, and fatal septicemia is very apt to occur. In pyemic arthritis several joints become infected.

Treatment.—Remove areas of infection which might be causal. In every suspicious case immediately aspirate. If bacteria are found in the aspirated fluid, at once open the joint (*arthrotomy*) and irrigate it with salt solution. In early cases which are not very violent formalin-glycerin may be injected, the wound closed, and the joint immobilized or subjected to extension after the operation. In a late case or a violent case with pus treatment consists of incision and active motion at once (page 580). Many surgeons still prefer incision, drainage, perhaps Dakin's fluid, and immobilization. Always be sure whether or not arthritis is the result of osteomyelitis. If osteomyelitis exists the area of bone disease must also be operated upon. Arthritis due to staphylococci and streptococci is often secondary to bone suppuration. If a periosteal abscess exists the joint condition is almost certainly secondary. If osteomyelitis exists it requires prompt and radical treatment (see page 464). In advanced cases involving the knee Allen and Alden ("Surg., Gynecol., and Obstet.," July, 1909) open the joint by a transverse incision below the patella, disinfect with pure carbolic acid followed by alcohol, and pack with iodoform gauze. I would only regard this as justifiable in advanced and very severe cases, as it is sure to be followed by ankylosis. Although in late cases which recover after arthrotomy and irrigation there is always more or less ankylosis, many cases treated early recover without serious impairment of joint function. Early arthrotomy is of the utmost importance, and if the aspirated fluid contains bacteria we should never postpone operation or hold it in reserve while we employ Bier's hyperemic or any other conservative method. Radicalism is here the course which promises the greatest safety and the surest retention of joint function. If we decide that the best we can get will be ankylosis, and if that is what we seek, every care must be taken to place the joint at the angle which will be most useful. Sir Robert Jones advocates the following positions[1]:

Shoulder: Fixed in abduction of 50 degrees.
Elbow: Fixed at an angle of 110 degrees.
Wrist: Dorsiflexion.
Hip: Fixed in extension.
Knee: Fixed in extension.
Ankle: Fixed at a right angle.

Free drainage, immobilization, and antiseptization are imperative. It is thought best not to remove loose pieces (Osgood[2]). Resection or amputation may be required. In some cases ample or partial resection is indicated. In some amputation is necessary. Septic joints following gunshot fractures constitute a special group (page 607).

Typhoid Arthritis.—This disease is a form of infective arthritis. That the bacteria of typhoid may inflame the joints is proved, and it seems certain that they can cause suppuration, although their pyogenic power has been disputed. Some claim that mixed infection is the real cause of pus formation in a typhoid joint. The typhoid bacilli enter the bones in many typhoid cases and sometimes cause osteomyelitis. Joint disease is more common than bone disease. Bone cases are apt to occur in older, joint cases in younger, persons. One joint, two joints, or several joints may be involved. Typhoid disease of a joint begins when the fever is abating, and more than one joint may be involved. Typhoid joints may recover permanently, may become ankylosed, may dislocate, or the joint disease may lead to fatal sepsis. In most cases the joints recover. In slight cases the synovial membrane only is involved; in more severe cases capsule, cartilages, ligaments, and even bones are involved. Some few cases suppurate. Suppurative typhoid arthritis is identical in symptoms and progress with ordinary pyogenic arthritis. Typhoid arthritis proper may be monarticular or polyarticular, the monarticular form being the most common, and the hip-joint being the articulation most liable to be attacked. In most cases typhoid arthritis causes little pain. The swelling is marked, although in the hip it is concealed. Keen calls attention to the fact that in the 84 cases of typhoid arthritis which he collected spontaneous dislocation occurred in 43, nearly all in the hip.[3] Fluid from a typhoid joint

[1] See Lt.-Col. Osgood in "Amer. Jour. Orthop. Surgery," Oct., 1918.
[2] Ibid.
[3] Keen on "The Surgical Complications and Sequels of Typhoid Fever."

may be sterile (bacteria having died), may show mixed infection, or may give a pure culture of typhoid bacilli (A. G. Ellis in "Jour. of Infectious Diseases," April 1, 1909).

Treatment.—A mild case is treated as a simple synovitis. If diagnostic puncture obtains fluid free from bacteria, no more radical method than aspiration and irrigation is required. If the fluid contains bacteria, inject formalin-glycerin. If this fails, incision and drainage are demanded. In some cases an autogenous vaccine appears to be of service, in others it fails utterly.

Typhoid arthritis may be responsible for spontaneous dislocation. If, for instance, the hip becomes painful and the limb assumes an abnormal position, dislocation is threatened, weight extension should be used, and aspiration should be practised to relieve effusion (J. B. Murphy in "Surgery, Gynecology, and Obstetrics," Aug., 1916). If luxation has occurred Murphy insists on aspiration, but reduction should not be made until well into convalescence and then should be by the method Lorenz teaches for congenital dislocation. If a luxation is not found until advanced convalescence it should be reduced promptly by the Lorenz plan.

Gonorrheal Arthritis or Gonorrheal Rheumatism.—During the progress of gonorrhea the development of a painful joint does not of necessity prove the existence of gonorrheal rheumatism, for ordinary rheumatism is just as likely to arise when a man has clap as when he has not this malady. Furthermore, the term is inaccurate, as gonorrheal rheumatism is not rheumatism at all, but is an infective disorder of the joints or of the synovial membranes, the infective material being contained primarily in the urethral discharge. Gonorrheal arthritis is one of the forms of infective arthritis. Occasionally this form of arthritis arises from gonorrheal ophthalmia (Heiman's case); it sometimes, though rarely, arises during the height of a gonorrhea, but it is more frequently met with in chronic cases or when the intensity of the inflammation is abating in acute cases. Men suffer from gonorrheal arthritis far more frequently than do women, and the seizure is very apt to recur again and again. In some cases many joints are involved, but in most cases only a few joints suffer. Osler states that the knees and ankles are most apt to be involved in gonorrheal rheumatism, and that this form of arthritis is peculiar in often attacking joints that are usually exempt in acute rheumatism ("the sternoclavicular, the intervertebral, the temporomaxillary, and the sacro-iliac"). There are two forms of gonorrheal rheumatism—an acute and a chronic form. The poison reaches the joint by way of the blood. In severe cases gonococci or pus cocci may be found in the joint fluid; in mild cases no bacteria are found. Osler suggests that the non-suppurative cases are due to the action of toxins taken up from the area of primary infection, and that the suppurative cases are due to infection of the inflamed joint with pyogenic bacteria. Endocarditis may occur, and it is due to micro-organisms and not to toxins.

Changes In and About the Joint.—The inflammation of gonorrheal arthritis may be articular, but may be located around rather than in the joint, and especially in the tendon sheaths. Suppuration is unusual, but it may occur in joints and in tendon sheaths. Stained cover-glass preparations or cultures of the exudate may or may not show bacteria.

Symptoms.—The acute form attacks, as a rule, but a single joint, but may attack several joints. The joint trouble begins with great suddenness, and is often ushered in by chilly sensations or by a distinct chill. Moderate fever arises. The pain in the joint, severe from the first, soon becomes excruciating. Muscular rigidity is noted. If superficial joints suffer, the skin over them becomes red and hot, and periarticular edema soon presents itself. The fluid in the joint is in most cases serous, but may become purulent. If pus forms, the fever becomes very high and chills may occur.

A chronic condition may follow the acute, but the condition may be chronic from the start. The symptoms resemble those of the acute form, but are far milder, although acute exacerbations may occur. Muscular atrophy is noted. The joint fluid is usually serous.[1] In gonorrheal arthritis there may be transitory, intermittent, and wandering pain in and about the joint, without any other symptom; one or more joints may become swollen and painful, and moderate fever may develop. One joint, especially the knee, may swell to an enormous extent, pain, periarticular edema, redness, and fever being absent (hydrarthrosis or dropsy of the joint). Suppuration in this form of the disease seldom occurs. The tendons, the tendon sheaths, the bursæ, and the periosteum may inflame. Whether the joints are inflamed or not inflamed, the tendon sheaths about the wrist and ankle and the retrocalcaneal bursæ may suffer. In some cases numerous bursæ are involved. It is often difficult and is perhaps impossible to

[1] See Schuller in "Aertztl. Pract.," No. 17, 1896.

check gonorrheal arthritis. It may last for a long period, and tends to recur again and again. Iritis, periostitis, pleuritis, endocarditis, and pericarditis have been observed as complications.

The *diagnosis* between gonorrheal arthritis and acute rheumatism rests chiefly on the great chronicity, the lesser degree of fever, the excessive tendency to recurrence, and the absence of profuse acid sweats in gonorrheal arthritis; and on the shorter course, the higher fever, the profuse acid sweats, the lesser tendency to rapid recurrence, the greater proneness to symmetric involvement, and the great liability to cardiac and visceral complications in rheumatic fever. Furthermore, in gonorrheal arthritis a gonorrheal infection (urethral or ocular) certainly exists or recently existed; in ordinary rheumatism a urethral discharge may, of course, happen to be present. Gonorrheal arthritis is apt to affect certain joints which acute rheumatism seldom attacks. Gonorrheal rheumatism of the spine comes on suddenly, causes elevation of temperature, muscular rigidity and pain.

Treatment.—Because of the lingering character and dangerous nature of gonorrheal arthritis and because if unchecked it is liable to produce grave impairment of function, treatment should be prompt and radical, as advocated by Halsted many years ago. The joint should be aspirated and if the fluid obtained contains gonococci or any pyogenic bacteria, formalin-glycerin should be injected. If this fails, the joint should be opened and irrigated. If pus is absent and the case not very violent, the joint may be injected with formalin-glycerin and the wound can be closed without drainage. If pus is found by incision, treat as directed in the section on Pyogenic Arthritis. In cases free from pus Bier's treatment is of value (see page 44). Drug treatment is of little value in gonococcal arthritis. The salicylates, the alkalies, and salol are useless; iron, arsenic, and strychnin are possibly of some benefit. Quinin is thought to be helpful in some cases. Large doses (1 dram) of syrup of iodid of iron are given by some clinicians, associated with tonic doses of corrosive sublimate. Iodid of potassium seems to be of a certain amount of value. The inflamed joints are usually wrapped in cotton and bandaged, and every day a little blue ointment is rubbed into the skin about them. If the inflammation lingers, it is customary to use the hot-air oven, massage, and gentle passive motion, to apply blisters, or to counterirritate with the hot iron. The object in this stage is to absorb infiltrations and adhesions and thus lessen stiffness. Early passive motion allays reflex muscular contractures, combats atrophy, and prevents adhesion (see Bier and Baetzner in "Practitioner," June, 1912). It is thought by some competent clinicians that antigonococcic serum possesses distinct value, greatly alleviating pain and favoring the restoration of joint mobility. My experience with it is as yet too insignificant to justify me in expressing an opinion.

The value of vaccine treatment is estimated highly by some, but many have obtained no beneficial results.

Arthroplasty for ankylosis caused by gonorrheal rheumatism is usually followed by re-ankylosis, but sometimes by a flail-joint. Gonorrheal ankylosis gives a worse prognosis for this operation than ankylosis of another origin because of the amount of exudate in the tissue about the joint. Operation may be tried and even if it fails ankylosis in a more useful position may be obtained. Cases of anchoring of the patella give a very good prognosis after arthroplasty. Cases of ankylosis of the knee are very unfavorable. A painful partial ankylosis calls for resection and the creation of a firm, and hence painless ankylosis (see Okinczyc in "Jour. de Chir.," 1914, xiii).

Pneumococcus Arthritis.—This is a rare condition, although Bulkley has collected 172 cases from literature and added one of his own ("Annals of Surgery," 1914, lix): Examination of the blood may or may not discover pneumococci, and pneumococci may be found in the blood during pneumonia, when the joints are free from disease. The inflammation may attack any joint, but is most apt to arise in a joint weakened by previous injury or damaged by rheumatism or gout. In three-fourths of the cases but one joint suffers. In one-fourth of the cases the disease is polyarticular. Infants are most liable. Alcoholics are prone to suffer. In a great majority of cases the disease is associated with lobar pneumonia, but Cole's case proves that the lung may be free ("American Medicine," May 31, 1902). Seventy-five per cent. of cases are associated with pneumonia, about 93 per cent. of pneumonia cases following and 7 per cent. preceding the lung lesion (Bulkley, Ibid.). Bulkley points out that the most common date of occurrence is within two weeks after the onset of pneumonia. As a rule, a single large joint is attacked, and the knee is most liable to suffer. The synovial membrane alone may be involved or cartilages may suffer and bone may be attacked. The fluid

may be serous, but is usually purulent. I have seen 2 cases: in 1 case the knee only was involved; in the other, both knees, one elbow, and one shoulder were attacked. In Cole's series of 41 cases, 13 exhibited involvement of more than one joint. The inflamed joint is frequently completely destroyed. Pneumococcus arthritis develops, as a rule, soon after the crisis of pneumonia, but Herrick says it may arise as late as three weeks after the crisis.

The diagnosis is made by the history of pneumonia, the development of septic symptoms, and the signs of joint inflammation. It is confirmed by aspiration and examination of the fluid. Without a history of pneumonia diagnosis is impossible unless the joint fluid is examined. The disease is very fatal. In Herrick's series of cases over 65 per cent. were fatal ("Amer. Jour. Med. Sciences," July, 1902). In Cole's series of cases there were 28 deaths and 13 recoveries. Even if the patient recovers, the convalescence is prolonged and more or less ankylosis is to be expected.

Treatment.—A non-purulent effusion may be treated by aspiration if bacteria are not found in the fluid. If the aspirated fluid contains bacteria, formalin-glycerin is injected. If this fails, or if pus is present, the joint should be opened as in pyogenic arthritis.

Syphilitic Arthritis.—(See pages 272 and 276.)

Acute Rheumatic Arthritis; Rheumatic Fever or Acute Rheumatism.—Acute rheumatism is a self-limited febrile malady whose characteristic features are polyarthritis, profuse acid sweats, and a tendency to heart involvement. There is some evidence to indicate that acute rheumatism is a form of infective arthritis, the bacteria being deposited in the synovial tissues and later perhaps entering into the joint cavity. Arthritis of many joints has followed intravenous injection into animals of diplococci obtained from the throat of a man suffering from rheumatic angina (Poynton and Payne at Manchester meeting of the "Brit. Med. Assoc.," 1902). Rosenau in 14 out of 16 cases of acute rheumatism was able to isolate organisms from joint fluid, in 4 out of 7 cases from the blood and in 2 cases from the stools. These organisms were similar to those described by Payne and Poynton (Rosenau in "Illinois Med. Jour.," 1914, xxv). When the virulence of these bacteria is in different stages they produce different effects when injected into animals. In one stage of virulence they produce endocarditis, arthritis, and fever. In another stage they cause myositis. John O'Conor[1] believes that acute rheumatism is a condition "something similar to gonorrheal arthritis and pyemia, the germ or toxin gaining admission to the body through the tonsil or other microbic trap-door, and that the joint invasion is promptly followed by a form of infective arthritis accompanied with general toxemia; and, furthermore, the infected joints serve as incubators, where the poison is elaborated and passed into the circulation and thus conveyed to other articulations and to the heart." Some observers are inclined to regard rheumatic fever as a reaction to foreign proteins.

Symptoms of Acute Rheumatism.—In acute rheumatism the case begins with malaise and fever, and one or more joints become affected. The inflammation spreads from joint to joint, is apt to be symmetric, and when it arises in fresh joints, usually disappears quickly in those previously affected. The temperature is high, the skin sweats copiously, the joints are red, swollen, hot, and excruciatingly painful, and the structures about the joints are edematous. After a short time the inflammation subsides in one joint and passes into another, the joint first attacked regaining its functions. Suppuration does not take place. Anemia is pronounced, exhaustion is profound, the sweat is sour, the saliva is acid; the urine is acid, scanty, high colored, often contains albumin, and is deficient in chlorids. Cardiac disease is apt to be produced (endocarditis, pericarditis, or myocarditis). Nodules may form upon fibrous structures, hyperpyrexia is not unusual, and cerebral or pulmonary complications may occur.

The *treatment* of acute rheumatism comprises the use of alkalies, salicylates, etc. (See a book upon practice of medicine.) O'Conor is a believer in incising and draining the inflamed joints; and if the theory of an infective origin is correct, this treatment is rational. I have never ventured to do it, but would consider the advisability of doing so if the ordinary treatment proved futile. O'Conor operates early and believes that this is the real way to arrest the disease and prevent complications, but his views have not met with general acceptance.[2]

Chronic rheumatism sometimes follows repeated attacks of acute rheumatism, but oftener arises insidiously in people who have been exposed to cold and damp, who have suffered from poverty, hardship, and privation, or have had much worry. The capsule and tendon sheaths thicken, and there is usually but little effusion into the joint.

[1] "Lancet," Jan. 24, 1903. [2] Ibid.

but the articulation becomes stiff and painful. The joint cartilages are occasionally eroded. Muscular atrophy occurs.

Symptoms of Chronic Rheumatism.—In chronic rheumatism the affected joints are stiff and painful and are a little swollen, but not red. Dampness and cold aggravate the symptoms. One joint or many may be affected, but usually several are involved. Passive movements cause the joint to creak and develop crepitus in the tendon sheaths. The muscles are wasted. Anemia is usually pronounced. The smaller blood-vessels become surrounded by fibrous tissue which progressively contracts and lessens the blood-supply of the synovial structures. The joints may ankylose. There is no fever and no tendency to suppuration, and the disease is incurable.

Treatment.—In chronic rheumatism maintain the general health of the patient, give courses of iron, arsenic, and strychnin, and an occasional course of iodid of potassium or a salt of lithium, and, if possible, send him every winter to a warm climate. Turkish baths give considerable temporary relief. The waters and regimen of Carlsbad and Vichy are of positive though temporary benefit, and the sufferer may obtain relief at the hot springs of Virginia and Arkansas. The patient must avoid damp and must wear woolens. Frictions, the douche, massage, flying blisters, counterirritation with the hot iron, ichthyol ointment, and mercurial ointment are of benefit. Subjecting the diseased joint to a very high temperature by placing it daily in a hot-air apparatus often does great good. The pains of chronic rheumatism may be greatly benefited by the plan communicated to me by Dr. J. T. Rugh. He makes a mixture of 14 min. of glycerin, 14 min. of sterile water, and 1 gr. of crystallized carbolic acid. This is injected at two points, about the articulation and in the extracapsular structures. As soon as an injection has been made the area must be vigorously rubbed to diffuse the fluid and prevent sloughing. The joint must be kept at rest for three days. Injections can be repeated at intervals of five days. In partial ankylosis it is proper in some cases to give ether and break up the adhesions.

Gouty arthritis, which appears especially in the smaller joints (as the fingers and the metatarsophalangeal joints of the great toes), is due to a deposition of urate of sodium in the joint and in the periarticular structures. The irritant urate of sodium causes inflammation, inflammation leads to the formation of granulation tissue, granulation tissue is converted into fibrous tissue, and the fibrous tissue contracts and thus deforms the joint and limits its mobility. A great mass of urates clinging to a joint constitutes a *chalk-stone*.

Symptoms.—The premonitory symptoms may be observed for a day or so, but the acute seizure usually occurs early in the morning, the patient, as a rule, being aroused by excruciating pain in the metatarsophalangeal articulation of one of the great toes. The joint swells, and the skin over it feels hot to the touch and becomes red and shiny. There is often considerable fever. After a few hours the intensity of the seizure abates, only to recur again with renewed violence early the next morning, these remissions and recurrences taking place during six or eight days, until the attack subsides. In patients with *chronic gout* many joints are stiffened and deformed as a result of repeated attacks. Chalk-stones form, and the skin above them may ulcerate. Such patients are chronic dyspeptics, have high-tension pulses, their hearts are hypertrophied, and their urine contains albumin and casts.

The *treatment* of gouty arthritis belongs to the physician, and not to the surgeon, although to the latter the symptoms of the disease should be known, so that it may be diagnosticated from other maladies.

Chronic Osteo-arthritis (*Rheumatoid Arthritis; Arthritis Deformans; Rheumatic Gout*).—Perhaps this condition should be included under the heading "chronic arthritis," such a heading including all the forms of chronic non-suppurative arthritis. In this disease, which is not a combination of gout and rheumatism, the synovial membrane and cartilages are affected, the periarticular structures are involved, and masses of new bone may form. In some cases there is extensive bone destruction.

Osteo-arthritis has in certain cases, as John K. Mitchell long ago pointed out, a nervous origin. Perhaps the nervous predisposition may exist in all cases, infection being the exciting cause. It arises especially in persons who have been worried, driven, and harassed. There is apt to be muscular atrophy, trophic lesions of the hair and nails are likely to appear, and the symptoms are disposed to be symmetric. The causative lesion has not been determined. The condition is now generally regarded as of toxic origin. The suspected cause is streptococcic infection (Payne and Poynton, quoted by Rosenau, in "Illinois Med. Jour.," 1914, xxv). The foci of infection may lie in any part of the body, but are most fre-

quent in the teeth, tonsil, accessory sinuses of the nose and naso-pharynx, the prostate, the female pelvis, the appendix, the gall-bladder, the middle ear, the bronchial glands, the mesenteric glands, and the intestines, especially the large intestine. The disease is commoner in women than in men. The greatest liability exists between the ages of twenty and forty, but children may acquire the disease, and it may also be developed in people far beyond middle life. Apes in captivity may develop it. Arthritis deformans may attack the rich or the poor; it does not result from gout, nor does it often follow rheumatism; it is not caused by damp and cold, and only in rare cases does it arise after traumatism of a joint.

Osteo-arthritis differs from gout in the entire absence of urate deposit, and it differs from chronic rheumatism in the extensive alterations in the joint structures. The changes begin in the cartilage; the cartilage cells multiply, the intercellular substance degenerates, the pressure of the bones causes thinning, and at length the cartilage is entirely destroyed and the bone exposed. The exposed bone is altered in shape, is hardened, and is worn away in the center, the periphery increasing in thickness by ossific deposit, the center deepening by absorption (hypertrophic form). The margins are not only thickened, but are bulged and lengthened by deposit. The fringes of the synovial membrane hypertrophy and multiply, and some of them are apt to break off (*loose cartilages*). Muscular atrophy arises and contractures occur. It is usually taught that these are due to nerve influence. It seems probable that they are caused by myositis (Billings in "Illinois Med. Jour.," 1914, xxv). The capsule and the ligaments of the joints, as a rule, become fibrous and contract; but they may soften, relax, and permit of dislocation. The joint usually contains no effusion, but in some cases there is great effusion (*hydrarthrosis*). The tendons about the joint may become fibrous and contracted, they may ossify, they may be separated from the bone, or they may be destroyed entirely. Deformity is marked and motion is limited. The fingers, when involved, show nodules on the sides of the joints (Heberden's nodes). The vertebræ may be involved. Almost all the joints may suffer. Suppuration does not occur.

Symptoms.—Charcot divides osteo-arthritis into three forms, and gives their symptoms as follows:

1. *Heberden's nodes*, which are commoner in women than in men, usually begin between the ages of thirty and forty, and are especially common in neurotic subjects. The interphalangeal joints become the victims of attacks of moderate swelling and of some tenderness, and these attacks are not severe, but recur again and again. After a time small hard swellings (nodes) appear upon the sides of the dorsal surfaces of the second and third phalanges, remain permanently, and slowly increase in size. The joints become stiff and creak on movement, the cartilages are destroyed, and contractions and rigidity develop, the joints may partially dislocate; tendons adhere to their sheaths, trigger-finger being common for a time until adhesion is firm, but there is no fever and the larger joints are not involved. The malady is incurable.

2. *Progressive rheumatic gout*, which may be acute or chronic. The *acute* form begins as does rheumatic fever. There are moderate fever and swelling, without redness, of a number of joints, of bursæ, and of tendon sheaths; the joints are stiff and crepitate, and are apt to be symmetrically involved; muscular atrophy begins early and rapidly becomes decided; pain is slight. This acute form is apt to arise in young women after pregnancy, but is not unusual at the climacteric and in children. Anemia always exists. The case is apt to advance progressively until a number of joints are firmly locked, when it may become stationary. Another pregnancy will develop anew the acute symptoms. In the *chronic* form swelling and pain on movement are noted in certain joints. Smaller joints may be involved as well as larger ones. The involvement is apt to be symmetric. Attacks of swelling and pain alternate with periods of apparent quiescence, but the disease does not cease its advance. Articulation after articulation is attacked by the malady until almost all the joints are involved; deformity and stiffness become pronounced, and pain may or may not be severe. There is not persistent fever, though the temperature may rise a little during an exacerbation. Muscular atrophy is marked.

3. *Partial rheumatic gout* or *monarticular rheumatism* attacks one articulation, and it is most often met with in old men. It may fix itself on the vertebral column, on the knee, on the shoulder, on the elbow, or on the hip. The joint grates and becomes stiff, swollen, and deformed; the muscles atrophy; there is usually pain, but fever is absent.

Still's disease is a form of arthritis deformans in which the spleen enlarges greatly and in which the joint changes cause permanent disability early in the case.

Osteo-arthritis or **partial rheumatic gout of one joint** seldom occurs before the age of forty-five, but is occasionally, though very rarely, met with in persons under twenty-five. If the disease arises in an elderly person, it is often called *morbus coxæ senilis*. In some cases the hip-joint or some other joint only is attacked; in many cases other joints subsequently become diseased. Osteo-arthritis of the hip may follow an injury. Usually the disease is unconnected with traumatism, begins very gradually, and advances slowly. There is pain, often mistaken for sciatica, in and about the joint, and there is increasing stiffness. The pain and stiffness are worse when the patient first moves after resting. Lameness becomes noticeable, and grating can be detected in and about the joint. The symptoms become gradually worse, although at times they may seem to improve for brief periods. The lameness and the stiffness are greatly aggravated, and the pain becomes very severe, even when at rest. Shortening takes place, the great trochanter ascends above Nélaton's line, the limb is usually abducted, but in very rare cases is adducted, and finally ankylosis occurs.

Partial rheumatic gout of the vertebral articulations causing fixation is called *spondylitis deformans* (see page 812).

Treatment.—Osteo-arthritis cannot be cured, but in some cases it remains stationary for many years. I have seen one case apparently arrested by removal of a diseased appendix. Diseased tonsils and teeth should be removed. Billings ("Illinois Med. Jour.," 1914, xxv) has cultures grown from them and from the cultures obtains autogenous vaccines. It is claimed by some that Lane's operation of extirpation of the large intestine may arrest it. Bottomley ("Jour. Amer. Med. Assoc.," Sept. 9, 1916) believes that in all cases the operation has some beneficial influence, but that it is disappointing. If an intestinal cause is suspected the operation is justifiable, but if we are to obtain benefit it must be done early. In far advanced cases it can do material good. Bottomley thinks the risks and uncertainties should be set forth to the patient. The same surgeon prefers colectomy to ileosigmoidostomy in spite of the greater risk of the former procedure. As yet I would not feel justified in recommending a theoretic operation with the idea of directly benefiting osteo-arthritis. I would, however, remove, if possible, any *obvious* area of infection (appendix, female pelvic organs, gall-bladder, teeth, tonsils, in naso-pharynx, lymph-glands). Lyon's non-surgical drainage may enable us to demonstrate infected bile. The usual plan of medical procedure is to treat the anemia by iron, arsenic, nourishing food, and have the patient out in the fresh air as much as possible. Debility is met by the administration of strychnin and food. Hot baths of mineral water and cabinet baths do good. It is claimed that the hot-air apparatus is of service. Diathermy is recommended. Douches improve these cases, but electricity is useless. Counterirritants are usually regarded as useless. I am sure that blisters and the actual cautery are sometimes of benefit. Injection into a joint of 2 per cent. formalin in olive oil followed by immobilization for two to eight weeks may prove of service (Porter in "Amer. Jour. Orthopedic Surg.," 1915, xii). Massage retards the progress of the case, relieves the pain, aids in the absorption of effusion, and delays fixation. It is used upon muscles and joints, but only lightly, and never during an exacerbation. During an acute exacerbation the joint should be put at rest for a time and evaporating lotions applied for a few hours. In an exacerbation in disease of the hip the patient should be put to bed and have extension applied. The patient is, unfortunately, liable to develop the opium habit. If dropsy of a joint arises, try compression by Martin's bandage, and, if this fails, aspirate and wash out the joint with a 2 per cent. solution of carbolic acid. Some remarkable results have been obtained by Coley's fluid, it being used as a foreign protein (Pemberton, Torrey, Klein). Patients with rheumatic gout do best in a warm, dry climate. Cod-liver oil does good, as it improves nutrition and hence retards the progress of the disease and it contains valuable vitamins. In an early case do not be tempted to immobilize the joints beyond a day or two: fixation only hastens ankylosis. Howard Marsh[1] maintains that, as a rule, but little good comes from manipulation. He makes the following exceptions: when one joint only is affected; when the joint is very stiff but not very painful; when the patient is in good general health and is not beyond middle age. If ankylosis is inevitable the surgeon should endeavor to have it take place in the position of greatest usefulness. If only one joint is involved it may be proper to produce ankylosis by operation. When ankylosis occurs all symptoms subside. Albee describes an operation for osteo-arthritis of the hip-joint. He removes a thin layer from the top of the head of the femur and a corresponding amount of bone from the roof of the acetabulum.

[1] "Diseases of the Joints and Spine."

The two surfaces are held in contact until union occurs. In the knee-joint Hibbs bridges the front part of the joint with the denuded patella.

After ankylosis osteotomy may be advisable to correct deformity. In children the deformity can usually be corrected by manipulation. After ankylosis arthroplasty may be advisable, fascia, fat, muscle, or chromicized pig's bladder being interposed between the bony surfaces. The best results are in the elbow and hip. Knee cases are not satisfactory. Jones ("Brit. Med. Jour.," 1914, ii) says that arthroplasty is contraindicated in children, if there is active disease, in cases in which the muscles have been destroyed or if scar tissue about the joint would put the flaps in danger.

Osteochondritis Dissecans.—This disease of the knee was first described by Koenig in 1888. It is one of the causes of foreign bodies in a joint. It follows a single severe traumatism or many acts of slight traumatism, usually occupational, brought about by kneeling (Brackett and Hall in "Amer. Jour. of Orthopedic Surg.," Feb., 1917). If a violent traumatism causes it the symptoms of the disease begin after the acute symptoms of the injury clear up. The ordinary case which follows repeated and trivial traumatisms comes on gradually with weakness and slight disability but no pain. After a time the joint begins to catch or perhaps lock as it does in an ordinary case of joint-mice. The catching suggests the squeezing of a synovial fringe. The locking is not followed by anything like the customary amount of synovitis and disability which are apt to follow locking in the ordinary case of movable cartilage, and there is a rapid return to the usual functional level. The *x*-rays show an area of bone defect on the outer part of the internal condyle and perhaps movable bodies in the anterior chamber of the joint. There is no osteo-arthritis. Exploration through a median patella incision proves the absence of general arthritis and discloses irregular elevations of thinned and frayed cartilage to the outer side of the inner condyle near the attachment of the posterior crucial ligament, a depression in the condyle, and cartilage hanging or separated (Brackett and Hall, Ibid.). The nature of the lesion has been much disputed. Ludloff ("Archiv f. klin Chir.," 1908, Bd. lxxvii) says the exfoliation of the cartilage is due to trauma occluding a terminal artery. Brackett is convinced that traumatism is causal. A median patella incision permits free exposure of the anterior chamber of the joint and removal of a loose or a partially separated cartilage. This operation is followed by cure with little or no impairment of function.



FIG. 475.—Charcot's joint.

Trophic Joint Affections (*Arthropathies*).—It is well known that certain diseases and injuries of the brain, cord, and nerves may be responsible for arthritic changes (hemiplegia, injury of the cord, locomotor ataxia, neuritis).

From three to six weeks after an apoplexy the joints of the palsied side are apt to suffer from inflammation. The condition following apoplexy is one of synovitis. Any joint may suffer, but the hip seldom does. A well-known arthropathy is Charcot's joint (Figs. 475, 476).

Charcot's disease (*Tabetic Arthropathy; Charcot's Joint; Neuropathic Arthritis*).—This condition is an osteo-arthritis due to trophic disturbance, arising in a sufferer from locomotor ataxia, and is anatomically identical with osteo-arthritis, which was described on page 601. The knee is most apt to be attacked (Fig. 475), and the hip suffers more often than any joint but the knee (Fig. 476). The condition may develop in the shoulder, elbow, ankle, or wrist. The smaller joints sometimes, though seldom, are involved. More than one joint may suffer. Vertebral arthropathy has been observed. Ochsner ("Practical Medicine Series," vol. i, 1917) sets forth the joints selected by the disease in 947 cases: Knee, 394; hip, 210; shoulder, 128; foot, 89; ankle, 50; elbow, 39; hand, 16; jaw, 2; various, 19. The disease in most cases begins acutely, often as a sudden

effusion, which after a time may disappear. In most cases, however, the joint becomes rapidly disorganized. The swelling is usually very marked and is sometimes enormous. In the earliest stages it is due to periarticular edema and to articular effusion. Pain is slight or is absent, there is no constitutional involvement, and the condition is unconnected with injury. Some cases begin without this preliminary acute swelling, disorganization being manifest from the start. When disorganization has once begun, it continues inexorably. Bony masses form around the articular cavity, in the ligaments, and in the cartilages. The old bones and the cartilages are rapidly destroyed and absorbed; fracture is apt to occur; the joint creaks and grates; the softening and relaxation of the ligaments permit an extensive range of movement; great deformity ensues; dislocation is apt to occur; muscular atrophy is decided, and pus occasionally, though very rarely, forms. There is sometimes, but seldom, repair. Charcot's joint differs from rheumatoid arthritis in the usual acute onset and the painless course. The complete or nearly complete freedom from pain is one of the most striking features of the condition. In saying there is freedom from pain we mean freedom from pain in the joint, from the pain and tenderness in the regions in which we expect to find them in an inflamed

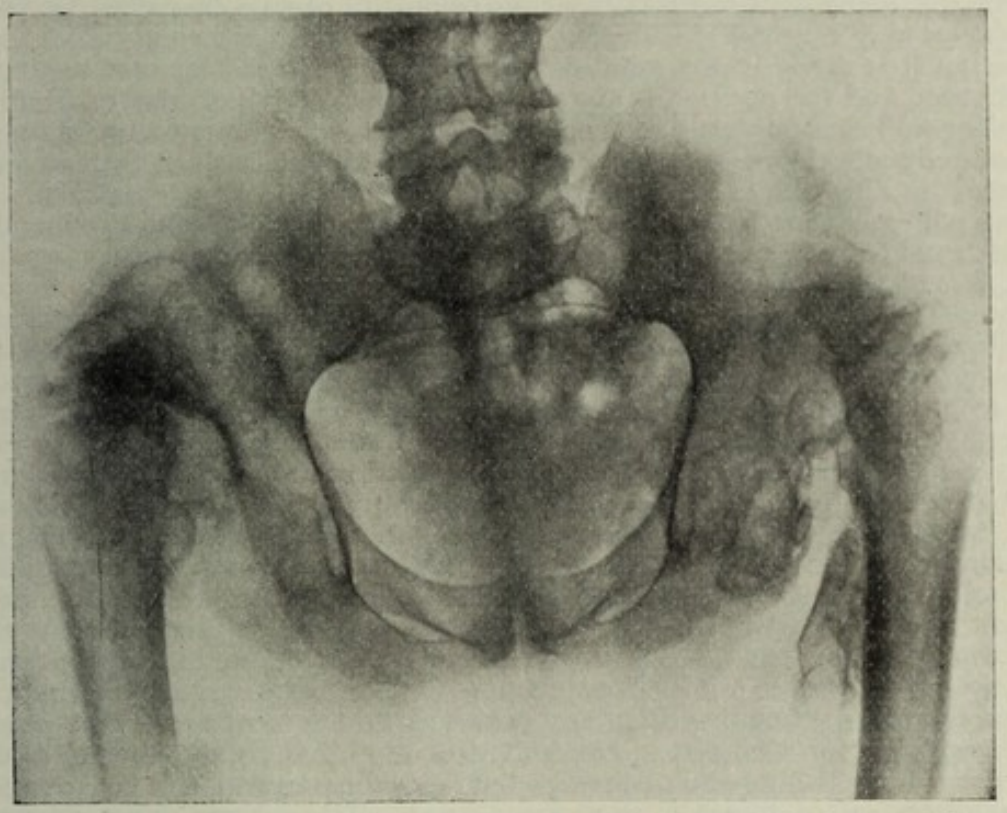


FIG. 476.—Charcot joint of each hip (U. S. Naval Hospital, League Island, Pa.; skiagraphed by Lieut. George U. Pillmore, Medical Corps, U. S. Navy).

joint. Usually these patients, though free from pain in the joint, suffer much from the lightning pains of locomotor ataxia. Gastric crises are not uncommon (Bramwell). The Wassermann reaction is usually positive. Charcot's joint is more common in female than in male tabetics. In saying that Charcot's joint is often of sudden origin, we mean that in a single night, as Charcot pointed out, swelling of a joint may arise. In a day or two the joint swelling becomes great, and if aspiration is performed, yellow serum is obtained. In a week or two the joint begins to creak on movement.

The *treatment* of Charcot's disease consists in the wearing of an apparatus to sustain the joint and save it from weight bearing. Resection is recommended by some, but most surgeons do not advise its performance. Southam advocates amputation for certain cases of Charcot's joint. He has performed the operation on 4 patients. He amputated twice for ankle-joint disease and twice for disease of the tarsus. In every case the stumps healed quickly and without suppuration. Southam was led to perform amputation on his first case by the report of Jonathan Hutchinson's case of amputation of the leg for perforating ulcer and disease of the bones of the foot in a tabetic.

Osteo-arthropathie Hypertrophiante Pneumique (*Marie's Disease*).—A condition associated with, and possibly springing from, pulmonary disease, and characterized by wide-spread enlargement of joints, clubbing of the finger-ends (Fig. 709), and the formation of a dorsolumbar kyphosis. The joints are painful, the skin undergoes pigmentation, and profuse perspiration is often present. The head entirely escapes in this disease, and this immunity marks a distinction from acromegaly. The disease is probably a toxemia caused by a focus of tissue destruction, especially if the focus be purulent, but it may be due to alteration of bodily metabolism (Gilman in "Edin. Med. Jour.," 1914, xii).

Hysteric joint (*Brodie's joint*) is a condition mostly encountered in young women. The disease occurs most commonly in the knee and the hip, and often follows a slight injury which acts as an autosuggestion, a latent hysteria being awakened into action and localized, though severity of the injury does not determine the severity of the symptoms. The disease may ensue upon synovitis or arthritis, or may arise without apparent cause. The patient complains of pain in and stiffness of the joint, resists passive motion strenuously, and claims that it causes much pain. There is occasionally some muscular atrophy from want of use, and the joint is a little swollen. The skin is hyperesthetic, and a light touch causes more complaint of pain than does deep pressure. The muscles may be rigid. The joint may be maintained either in flexion or in extension, but it is rarely in the exact degree of flexion assumed for ease in a true joint inflammation, and the position is apt to be changed from day to day or from hour to hour. The skin is usually pale and cool, but may be red and hot, because of hyperemia. A periodically developed heat may be observed, especially at night, accompanied apparently by much pain. The alleged pain in some cases is neuralgia, but in most cases is a pain hallucination. There is no effusion into the joint, and swelling does not exist, although occasionally there is slight periarticular edema. In some rare cases organic disease arises in a hysteric joint.

Hysteric phenomena are seldom isolated, but are associated with certain stigmata which may be latent. These stigmata, some of which may be absent, are concentric contraction of the visual fields, pharyngeal anesthesia, convulsions, hysterogenic zones, globus hystericus, clavicus hystericus, zones of anesthesia, especially hemianesthesia, and hyperesthetic areas. Such patients are predisposed by inheritance, and have had previously, as a rule, nervous troubles. Hysteric phenomena, be it remembered, lack regularity of evolution, and are produced, altered, or abolished by mental influences and physical sensations which are without effect in causing, modifying, or curing organic disease. The general health, as a rule, is good, but neurasthenia may coexist. In examining these patients the observer will note that the symptoms disappear when the attention is diverted; that they are out of all proportion to the local evidences of disease; that there is no sign of joint destruction, and that a light touch may cause more pain than does firm pressure. If the patient is anesthetized, perfect joint mobility will be found without any evidences during movements of joint changes.

The *treatment* for a hysteric joint comprises attention to the general health, the employment of nourishing and easily digested food, the prevention of constipation, and the administration of tonics if they are needed. The surgeon must dominate his patient's mind and make her realize that he is master of the case. He is to be an inexorable but just ruler—never a brutal or a cruel one. If possible, send the patient away from the harmful sympathies of her home and let her have the rest treatment of S. Weir Mitchell. Local remedies kept applied to the joint do harm, as a rule, by concentrating afresh the patient's attention upon the articulation, although the hot iron sometimes does good. Suggestion in the hypnotic state may be tried. The use of morphin should be avoided as being the worst of enemies. Never immobilize the joint, and always use massage, passive motions, and frictions.

Neuralgia of a joint as an independent, isolated affection is extremely rare, though as a complication of other diseases it is by no means uncommon. Neuralgia is more common outside of the joints than in them, and periarticular neuralgia is especially frequent about the knee and the ankle. Joint neuralgia may arise in any person, but it is more commonly found in young neurotic females. The pain may be persistent, or it may occur in periodic storms, and it is often associated with neuralgia in other parts. The pain may be dull and aching, but it is more often sharp and shooting. Joint neuralgia is associated with tenderness on pressure, soreness on motion, often with transitory swelling without redness, and sometimes with numbness of the extremity. The *diagnosis* depends on the temperament of the patient, the sudden onset of the pain, the absence of constitutional symptoms, and the free mobility

of the joint, especially under ether. Articular neuralgia may depend upon disease or injury of the central nervous system, upon malaria, syphilis, neurasthenia, rheumatism, gout, hysteria, or neuritis, and may be due to reflected irritation, especially from the ovaries, the uterus, or the rectum.

The **treatment** to be observed in joint neuralgia is to maintain the general health. Examine for a possible exciting cause, and, if found, remove it. Give a long course of iron, quinin, strychnin, or arsenic. In rheumatic or gouty subjects administer suitable drugs and insist upon the use of a proper diet. During the attack use phenacetin. Morphin must occasionally be given in severe cases, but be sparing of it, and never tell the patient she is taking it, as there is a possibility of her forming the opium habit. Locally, employ frictions, ointment of aconite, heat, and keep upon the part a piece of flannel soaked in a mixture of soap liniment, laudanum, and chloroform (Gross). Never allow the joint to stiffen; any tendency to stiffness should be met by daily massage, frictions, passive motion, and hot and cold douches. In some rare cases nerve stretching or neurectomy becomes necessary.

Articular Wounds and Injuries.—A *penetrating* wound is very serious, and it may be due to a compound fracture, to a compound dislocation, to a gunshot wound, or to a stab. If a bursa near a joint be opened, secondary penetration may occur as a result of suppuration. In a penetrating wound, besides pain, hemorrhage, and swelling, there is a flow of synovial fluid. A small amount of synovia flows from an injured bursa, a large amount from an open joint.

Treatment.—If a joint is opened aseptically (as when incised by the surgeon) the wound heals nicely under rest and asepsis. If a joint is opened by a septic body, suppurative arthritis is apt to arise, and the surgeon endeavors to prevent it by antisepticizing the surface, irrigating the joint, draining, applying antiseptic dressing, and securing rest. Normal salt solution is the best agent for irrigation, as it does not injure joint endothelium. Active antiseptics may lessen tissue resistance, and thus may actually favor infection. In gunshot wounds inflicted by pistol bullets or sporting rifle bullets, if antisepsis is not employed, suppuration is inevitable; hence military surgeons in the past, as a rule, have advocated amputation or excision in gunshot splinterings of large joints. We now know that the wound of a large joint produced by a hard-jacketed and small-caliber bullet may heal with little trouble. This statement is true in open fighting. It is not true in trench fighting. If we are able to regard the wound as probably aseptic the surface is sterilized, and usually the wound is enlarged, the finger is introduced to discover and remove foreign bodies, through-and-through drainage is secured, a tube is inserted, the joint is irrigated, antiseptic dressings are applied, and the extremity is placed upon a splint. In trench warfare every joint wound is regarded as infected, be it bullet wound (with or without fracture), shrapnel wound, or wound by a shell fragment. At the front the skin about the wound or wounds is painted with iodin, a field dressing is applied, the part is immobilized, and the patient is taken to the rear as soon as possible. Radical operation should be done at the first possible minute. It is done at the field hospital, the evacuation hospital, or the base hospital in accordance with grim *military* necessities.

In many cases the track of the wound is moistened with iodin, the wound is excised to the joint capsule, or synovial membrane, the projectile if lodged, is removed, bone fragments loose or hanging are taken away, the joint is irrigated with salt solution, the wound is sutured (a drainage-tube being inserted down to the synovial membrane), dressings are applied and the part is immobilized. If in spite of this treatment infection occurs, or if pus exists when operation is performed, make free incisions and use continuous irrigation or Dakin's fluid. In severe wounds arthrotomy, the usual operation in civil practice, is usually a failure, and is employed only when a missile is not retained or when it is well within reach. When it is done the infected synovial membrane should be removed (Taddei). The Carrel treatment is most disappointing. When the articular head is damaged a partial resection is performed by many, but a typical subperiosteal resection is usually the preferable procedure, and drainage should be secured (Taddei in "Chir. d. organ di mov.," Bologna, 1918, ii).

After operation the limb should be immobilized. Place the parts in the position indicated by Jones (page 608).

If the temperature mounts and suppuration persists, especially if albuminuria develops, amputate (Taddei, Ibid.).

In some cases it is necessary to remove considerable bone. Very severe joint injuries demand resection or even amputation. Ankylosis, more or less complete, often follows a gunshot wound of a joint. Because of the likelihood of ankylosis Sir

Robt. Jones lays down rules for the best position in which to dress each joint ("Brit. Med. Jour.," 1916, I).

They are as follows:

1. Shoulder-joint: Arm abducted to 50 degrees. Elbow slightly in front of body's coronal plane. When the forearm is in supination and the elbow at right angles to it the palm looks toward the face.
2. Elbow-joint: Fixation at 100 degrees. If both elbows have been wounded fix one at 80 degrees and the other at 100 degrees.
3. Wrist-joint: In dorsiflexion.
4. Hip-joint: Very slight abduction, extension of the thigh and a little external rotation.
5. Knee-joint: Extension and fixation.
6. Ankle-joint: Foot at right angles to the leg, sole in position of slight varus.

If the joint suppurates, the drainage must be made more free, sinuses must be slit up and packed, sloughs must be cut away, dead bone must be gouged out, and the patient must be placed upon a stimulant and tonic plan of treatment. A plan found to be valuable is the introduction of a drainage-tube into the subcrural pouch and placing the patient prone (Kellogg Speed in "Jour. Amer. Med. Assoc.," March 30, 1918).

Sprains.—A sprain is a joint wrench due to a sudden twist or traction, the ligaments being pulled upon or lacerated and the surrounding parts being more or less damaged. A sprain is often a self-reduced dislocation (Douglas Graham). The joints most liable to sprains are the knee, the elbow, the wrist, and the ankle. The smaller joints are also often sprained, but the ball-and-socket joints are infrequently sprained, their normal range of free movement saving them; they do occasionally suffer severely, however, as a result of abduction. In a severe sprain the ligaments are torn; the synovial membrane is contused or crushed; cartilages are loosened or separated; hemorrhage takes place into and about the joint; muscles and tendons are stretched, displaced, or lacerated; vessels and nerves are damaged; the skin is often contused; and a portion of bone or cartilage may be detached from its proper habitat, though still adhering to a ligament or tendon (sprain fractures). Very often a case is diagnosticated as a mere sprain when a fracture also exists. The wrist is a common seat of such a lesion. Ross and Wilbert ("Amer. Med.," Jan. 25, 1902) caution us to remember that when a patient comes to us a week or ten days after an accident, displaying "a wrist which is much swollen and rather painful," all ordinary remedies having failed, we should suspect a fracture of "one or more of the bones of that joint." This article of Ross and Wilbert is very valuable and considers so-called sprains in various regions. George Ross and L. F. Stewart ("Annals of Surgery," Oct., 1912) believe that all dislocations are "permitted by the primary occurrence of sprain fracture," the bony tissues giving way more easily than tendons or ligaments. This article is a comprehensive study of sprain-fracture. Sprains are commonest in young persons and in adults with weak muscles. They happen from sudden twists and movements when the muscles are relaxed. A large part of the support of joints comes from muscles, and when muscles are suddenly caught unawares they do not properly support the joint, and a sprain results. A joint once sprained is very liable to a repetition of the damage from slight force. Sprains are common in a limb with weak muscles, in a deformed extremity in which the muscles act in unnatural lines, and in a joint with relaxed ligaments.

Symptoms.—There is severe pain in the joint, accompanied by general weakness. Nausea, vomiting, and even syncope may occur. There is impairment or loss of ability to move the joint. The above-described condition is succeeded by a season of relief from pain while at rest, numbness being complained of, and pain on motion being severe. Swelling arises very early if much blood is effused. In any case swelling begins in a few hours. Extensive effusion, by separating joint surfaces, produces slight lengthening of the limb. Movements of the joint become difficult or impossible; the tear in the ligament may sometimes be distinctly detected by the examining fingers; pain and tenderness become intense; joint crepitus will be manifested, and in a day or two discoloration becomes marked. Moullin and others have pointed out that when a muscle is strained the skin above it becomes sensitive, especially at tendinous insertions over joints. As muscles are invariably strained when a joint is sprained, there is always some cutaneous tenderness. There is also tenderness over a sprained joint due to capsular injury, bands of adhesions, etc. Tenderness is apt to arise at certain reasonably fixed points: in a hip-joint injury it is found behind the great trochanter,

in a knee-joint injury by the side of the patella, in an ankle-joint injury to the inner side of the external malleolus (Culp). When the vertebral articulations are sprained the muscles of the back are rigid, the skin is often sensitive, pain may be awakened by pressure or by certain movements, but there is no sign of cord injury in an uncomplicated case.

Diagnosis and Prognosis.—Sprain-fractures can be diagnosticated with certainty by the *x*-rays only. In the *diagnosis* of a sprain, fracture and dislocation must be considered. In fracture, crepitus and mobility exist; in dislocation, rigidity. The diagnosis of sprain should be made by a consideration of the joint involved, of the age, of the nature of the force, of the length of the limb, of the fact that the patient could use the joint for at least a short time after the accident, and of the local feel and movements of the part. In some cases examine under ether, in some apply the *x*-rays. Many injuries about the ankle and wrist, which we would have formerly regarded as sprains, are shown by the *x*-rays to be fractures. The *prognosis* depends on the size of the joint, on the extent of laceration, on the amount of intra-articular hemorrhage, and on the age of the patient. The danger is ankylosis. A sprained joint is a point of least resistance to tubercle bacilli and to other micro-organisms. In rare cases after a sprain of the hip-joint osteo-arthritis arises. In some few cases after a sprain of the hip the head of the bone undergoes absorption.



FIG. 477. FIG. 478.

FIGS. 477, 478.—Gibney's method of strapping in sprains of the ankle.

Treatment.—In a mild sprain apply at once a silicate, rubber adhesive plaster, or plaster-of-Paris dressing. The first indication after the infliction of a severe sprain is to arrest hemorrhage and limit inflammation. For the first few hours apply pressure and an ice-bag. Wrap the joint in absorbent cotton wet with iced water, apply a wet gauze bandage, and put on an ice-bag. After some hours place the extremity upon a splint and to the joint apply flannel kept wet with lead-water and laudanum, iced water, alcohol and water, or a solution of chlorid of ammonium. These evaporating lotions produce cold. Instead of them an ice-bag may be used for a day. Leeches around the joint do good. Constitutionally, employ the remedies for inflammation. Morphin or Dover's powder is given for the pain. Judicious bandaging limits the swelling.

After twenty-four hours, if the symptoms continue or if they grow worse, use hot fomentations, the hot-water bag, plunge the extremity frequently in bearable hot water, or apply heat by Leiter's tubes. When the acute symptoms begin to subside rub stimulating liniments upon the joint once or twice a day and employ firm compression by means of a bandage of flannel or rubber. Frictions should be made from the periphery toward the body. Many cases do well at this stage under the local use of ichthyol and lanolin (50 per cent.), tincture of iodin, or blue ointment. Later in the case use hot and cold douches, massage, frictions, passive motion, and the bandage. Passive motion and massage are begun a day or so after swelling ceases. If they cause the swelling to return, abandon them for several days and then try them again. Blis-

ters are used when tender spots persist and stiffness is manifest. If stiffness becomes marked, move the joint forcibly. Give iodid of potassium and tonics internally, and insist on open-air exercise. If the person is gouty or rheumatic, use appropriate remedies. Van Arsdale treats sprains by massage almost from the start. Gibney treats them by strapping with adhesive plaster. Gibney's dressing is of great service in a sprain of the ankle (Figs. 477, 478). Many sprains may be put up in an immovable dressing the first day or two after the accident. If the joint contains much blood, aspiration should be practised before the dressing is applied.

The hot-air oven is a very valuable method for treating recent sprains, and the swelling, pain, and stiffness which follow sprains of the extremities. The sprained extremity is placed in an oven, and the part is subjected to heat for an hour. The next day the treatment is repeated, and on as many subsequent days as may be necessary. In an acute sprain the pain often disappears during the first application of heat. In the intervals between the use of the oven the extremity should be at rest, perhaps upon a splint.

Schlatter's Sprain (*Schlatter's Disease; Osgood-Schlatter Disease*).—This condition of partial functional incapacity is due to thickening, separation or partial separation of the tibial tubercle. Some think the condition is due to inflammation, others that it is a dystrophy. In view of the fact that many cases are bilateral, and that other muscular and ligamentous insertions may show periosteal thickening, the view that the condition is systemic would seem probable, the systemic trouble being manifested by weakening of connective tissues and thickening of periosteum. That attention is usually called to this condition by traumatism is certain. For instance, in a reported case a boy threw a stone and fell to the ground because of a disabling pain in the right knee. He walked home but the pain and partial disability continued. A month later examination made clear that there was swelling over the tuberosity of the tibia and great tenderness of the tuberosity, but neither ecchymosis nor crepitus. The *x*-rays showed that a small fragment of bone had been partially torn off. In such a case we would infer that a sprain-fracture had occurred in the diseased area (Costa's case. See "Abstract of Surgery," Jan., 1917).

Some suggest that the bone trouble is due to staphylococcic infection. Basseta's view of the condition is that pull by the ligament of the patella causes chronic irritation and excessive ossification ("Arch. di ortop.," 1913. See "Abstract of Surgery," June, 1914).

R. Connell ("Practitioner," 1914, xciii) believes that Schlatter's sprain is a purely traumatic condition, most common in those under seventeen years of age, and predisposed to by imperfect union of the tibial tubercle.

In some marked cases the tubercle should be nailed in place. In partial separation treatment is by strapping with adhesive plaster, firm pressure being made over the tuberosity. A firm bandage is applied over the plaster, pains being taken to avoid severe posterior pressure, which would interfere with the blood-supply. The plaster should be changed once a week.

Sprain of the Sacro-iliac Articulation.—This condition was first described by Goldthwait. A fall, lifting a heavy weight, a blow, or a twist may injure the articulation. Normally slight motion is possible at the joint. Rupture or stretching of ligaments may lead to increased motion, and any considerable range of motion at the synchondrosis means lack of solidity and want of support. A sprain may arise from long-continued standing, bending, lying, or sitting. A sprain of this articulation may be caused by parturition, and also, as shown by Dunlop, it may develop during anesthesia because of obliteration of the normal lumbar curve by lying on a flat table without a support under the lumbar region ("New York Med. Jour.," July 10, 1909). Dunlop thus explains, and I think truly, most of the cases of severe backache which is so common after general anesthesia.

A sprain causes severe pain, greatly aggravated by standing, by rising up from recumbency, by movements of the ilia which jar the joint, and frequently by direct pressure upon the synchondrosis. There is often lateral spinal curvature due to spasm, and the concavity is toward the injured side.

There is pain in the injured articulation, but there may be a general backache, and, just as in sacro-iliac tuberculosis (see page 585), there may be pain in the sciatic nerve, in the groin, and in the hip-joint.

When some of the sacro-iliac ligaments are ruptured or relaxed we get the chronic condition described by John Dunlop (Ibid.) and which he calls *sacro-iliac relaxation.* When this exists the individual may injure the articulation again and again because

of its unsteadiness, he may now and then have trouble, he may be in a constant condition of helplessness, with backache, groinache, pain in the hip and over the ischial tuberosity, lumbar rigidity producing lateral curvature, etc. I believe in the reality of the condition.

Treatment.—A recent sprain is treated by rest in bed and adhesive-plaster strapping, reinforced by a canvas roller around the pelvis. In a chronic case (sacro-iliac relaxation), after securing by manipulation normal relations in the articulation, insist on rest and apply a spica bandage of plaster of Paris or a brace. If there is marked and persistent tendency to displacement, ankylosis may be secured by operation. Fixation by a bone-graft from the tibia should give the most rapid and permanent result.

Rupture of the Crucial Ligaments of the Knee.—This is a rare injury. In nearly all cases the internal semilunar cartilage is involved and in rupture of the anterior crucial the internal lateral ligament is also torn. Rupture of both ligaments is unusual except in very grave injury, such as complete dislocation, and then other ligaments are also torn or destroyed.

The anterior crucial ligament instead of rupturing from force may cause avulsion of the entire tibial spine or of its inner tubercle (see page 572). A bit of bone may be torn from a femoral condyle. In most cases the *x*-rays show small bits of separated bone. When a portion of bone is not torn off, the ligament itself tears off from the femur rather than from the tibia. Bits of cartilage may be torn off. The posterior ligament, too, tends to tear off from femur rather than tibia. In the cases of injury of the anterior crucial I have seen the cause was internal torsion. It is claimed by some that forcible hyperextension may be causal. Pagenstecher ("Deutsch. med. Wchnschr.," Bd. xxix) believes that the anterior ligament may be ruptured by forced flexion of the knee and by blows applied to the posterior part of the head of the tibia when the knee is flexed. The same surgeon maintains that the posterior ligament may be ruptured by blows applied to the front of the head of the tibia when the knee is flexed. Pringle ("Annals of Surgery," Aug., 1907) maintains that the anterior ligament may be ruptured by "flexion, abduction, and internal rotation of the leg at the knee." If the ligaments are ruptured there will probably be abnormal freedom of anteroposterior movement between the femur and tibia.

Pringle (Ibid.) states that if, after an injury, the knee-joint becomes distended with blood, the inference should be that one or other crucial ligament has been injured or that the tibial spine has been torn off, unless some other lesion is obviously present; that if internal rotation of the extended leg is possible at the knee, or if the head of the tibia can be brought forward on the femur, or if there is unnatural abduction, the indications are that the anterior crucial ligament has been injured or the tibial spine torn off; that injury of the posterior crucial is suggested by the possibility of pushing the head of the tibia backward during flexion of the knee-joint.

With the knee completely extended there is internal rotation of the tibia on the femur and also "lateral rocking" (Surls and Osgood in "Jour. of Bone and Joint Surg.," Oct., 1923). The *x*-rays disclose any fracture of the tibial spine.

The condition causes great disability, pain, and muscular weakness. In many cases exploratory incision is required to make the diagnosis.

Treatment.—If the joint is distended with blood, aspirate. Many victims gain a useful and pain-free leg after prolonged immobilization (for details see Surls and Osgood, Ibid.). If immobilization fails, operate. If the tibial spine or a portion of it is loose, remove the fragment. Bore the femur and tibia. Pull a strip of fascia through the tunnels and suture it near the inner tubercle of the femur. This strengthens the internal lateral ligament and creates a new anterior crucial ligament (Groves-Smith operation). The posterior crucial is replaced by the tendons of the gracilis and semitendinosus, run through properly placed tunnels. Disability, pain, and weakness to a considerable degree may persist after operation.

Ankylosis.—When a joint-inflammation eventuates in the formation of new tissue in and about the joint, contraction of this tissue limits or destroys joint mobility, producing the condition known as "ankylosis." Ankylosis may be *complete* (bony) or *incomplete* (fibrous); it may arise from contractures in the joint (*true* or *intra-articular ankylosis*) or from contractures in the structures external to the joint (*false* or *extra-articular ankylosis*).

There are qualifying terms to indicate the extent of stiffness—viz., false, spurious, true, bony, ligamentous, partial, complete, or incomplete ankylosis. The significance of the above terms will be better appreciated if ankylosis is considered as meaning a

stiff joint. It may be stiff without being rigid. Fibrous adhesions produce stiff joints and they become rigid only when bony union takes place between the bones forming a joint.

Spondylitis deformans is bony ankylosis of vertebræ due to osteo-arthritis.

Arthritis ossificans is a progressive bony ankylosis in which numerous joints are involved and are finally completely obliterated. It is an ossifying arthritis.

Etiology.—There are various causes—viz., traumatism, eruptive fevers resulting in acute or suppurative synovitis or arthritis, gonorrheal arthritis, tuberculous arthritis, syphilitic affections of joints, bony fixation when a fracture is near or extends into a joint, and osteitis deformans. Simple fixation of an uninflamed joint cannot cause true ankylosis.

Pathology.—In complete—*i. e.*, bony—ankylosis the bones forming a joint become united by callus in much the same manner as bone fragments are united after a fracture, or osseous bridging takes place at one or more places around the joint. Osseous ankylosis is preceded by a more or less prolonged stage of fibrous or partial ankylosis. In fibrous ankylosis bands of fibrous connective tissue unite the bones forming a joint, thereby limiting the motion. In cases of joint stiffness produced by extra-articular fibrous, tendinous, or cicatricial contracture the joint proper remains free from adhesions for years, provided it is not and has not been involved in inflammatory action.

Diagnosis of bony ankylosis is usually made without difficulty except where there are several joints near together, as the carpus, tarsus, and the spine. When there are several joints near together the limitation of motion in one joint is generally compensated for by the excess in mobility of another, thereby rendering the associated parts capable of closely approaching normal function. True fibrous ankylosis is more difficult to recognize, especially if pain accompanies manipulative measures. It is most apt to be confused with fibrous, ligamentous, or cicatricial contractures of soft parts outside of a joint, but having more or less direct functional relations therewith.

Extra-articular thickening may usually be detected by the existence of resistance to free joint motion in one direction only, *i. e.*, that produced by the fibrous contracture while the joint moves freely in other directions. Muscular contracture, whether voluntary or involuntary, is but temporary, and is easily detected by the preternatural rigidity of muscles about the joint. In bony ankylosis no voluntary muscular action can be detected, inasmuch as in the process of the formation of the callus uniting the bones the muscles have become atrophied from disuse. Conversely, voluntary muscle action about a joint always indicates that joint mobility is not entirely destroyed.

As muscular rigidity is one of the most important and reliable symptoms of joint inflammation and tuberculous invasion, it is a serious error to anesthetize a patient for examination of a joint until the full significance of the muscular action has been carefully studied.

Anesthesia removes the pain and abolishes muscle fixation and thus leaves the unguarded joint free for manipulative movements, which are generally prejudicial and rarely beneficial. Where no muscle fixation is present, much may be learned by the careful study of a joint while the patient is anesthetized. We thus determine the character of the adhesions, whether they are extra-articular or intra-articular, whether they are fibrous, cicatricial, or osseous, and if bony union exists, whether it involves the entire joint or only a portion of it.

Skiagraphs are invaluable helps in making an accurate diagnosis, especially when stereoscopic plates are made. Definite information can thus be obtained as to the character of the uniting material, its extent, and definite location. Positive information will be given as to the relationship of the bones composing the joint, whether there is luxation, subluxation, flexion, or other abnormal position that may influence decision as to the therapeutic measures to be adopted. It is important to remember that a joint very rarely becomes ankylosed in the position of extension (the elbow may if treated in extension for intra-articular fracture). The almost invariable rule is that flexion is the posture of such joints, and the tendency is toward increase of the flexion until bony ankylosis occurs. In the steady progress of the flexion subluxation is apt to be induced.

Treatment of Intra-articular Ankylosis.—It is most important to prevent the occurrence of ankylosis, or in the event of its becoming inevitable, to avoid postures that will render the parts unfit for future usefulness when ankylosed.

The most useful position for a stiff joint is a matter of individual opinion; no definite rules have been accepted. In ankylosis of the elbow the flexed position is more useful in certain occupations than the fully extended arm. In other occupations the

extended arm is most useful. In walking when the knee is ankylosed and does not tend toward flexion the extended leg is more useful than the flexed leg, but it is more difficult to manage when sitting.

The hip, when ankylosed at various angles, is made useful by the increased latitude of motion of the other hip and by the compensatory motion of the lumbar spine. To such an extent is the lower spine reciprocal when one or both hips are abnormal that it has been termed the third hip-joint. For general usefulness the best position for an ankylosed hip is 10 to 15 degrees of flexion, 10 to 15 degrees of abduction, and 5 degrees of external rotation. In this position, when supplemented by reciprocal action of the other hip and by the lower spine, a gait very closely approaching normal carriage may be obtained in walking, and the sitting posture may be possible.

Each individual joint has its own peculiar requirement and must become a subject for careful study in determining the most useful posture if ankylosis is to be permanent. The trend of modern surgery is to reduce greatly the time of fixation of a fractured bone in order to avoid joint stiffness and prevent muscular wasting. Early passive motion when judiciously employed does not interfere with the efficient treatment of a fracture, but does lessen the joint stiffness that is often a serious and painful sequel.

Stereo-arthrolysis "is that branch of arthroplasty whose object is to loosen stiff joints and produce new joints with mobility, following ankylosis" (R. Tunstall Taylor, "Surgery, Gynecology, and Obstetrics," April, 1912).

Brisément forcé or *recressement* are terms applied to the use of such manipulative force as the surgeon can judiciously employ in freeing a joint from fibrous adhesions. It is important to keep constantly in mind the danger of breaking the shaft of a bone or of separating the epiphysis when unguarded leverage of the entire shaft of the bone is used. It is of paramount importance to avoid brisément forcé in all cases where the ankylosis has resulted from tuberculosis. The plan is said to have been suggested by Louvrier, of Paris. It was advocated by Langenbeck. Brisément forcé is only curative when the adhesions are limited to the synovial membrane. When portions of that membrane have been destroyed or when there are dense fibrous adhesions the ankylosis invariably recurs after manipulative force and often becomes worse than before. In bony ankylosis the method is out of the question.

In applying manipulative force it is not always advantageous to have the patient profoundly anesthetized. If he is profoundly anesthetized we may be tempted to apply too violent force. Severe lacerations of fibrous adhesions produce painful joints which necessitate fixation or rest for several days to permit the repair of the torn structures. A little gain, care being taken to maintain the motion gained, mobility being gradually increased by short progressive steps, is always better than attempts to do a great deal at once. Of course, the patient's co-operation is necessary.

When pain is great, much can be accomplished during primary ether anesthesia or while the patient is under the influence of nitrous oxid. Bromid of ethyl and chlorid of ethyl are used by many because of their rapid action and brief effect. As stated elsewhere (see pages 1214, 1215), I seldom use either of these drugs.

Fixation appliances of any kind are contraindicated during corrective manipulations, as increased freedom of motion is essential rather than fixation. Voluntary efforts are needed to maintain the joint motion already secured as well as to increase the muscle function controlling the affected joint.

Among the operative procedures applicable to intra-articular ankylosis are excision to obtain a new joint (pseudo-arthrosis), excision to obtain a better position for the usefulness of the limb, breaking the bone after partially cutting it with an osteotome (osteotomy), transplantation of a joint, arthroplasty, and breaking the bone without any incision (osteoclasis). These several procedures have special advantages in different joints.

Lexer ("Zeit. f. Chir. Med. Orth.," Oct., 1908, p. 476), after resecting a knee-joint ankylosed at a right angle, transplanted the entire knee-joint apparatus from a freshly amputated limb. Complete union resulted. Muscle training was subsequently practised to improve the weak muscular control. Three and a half years later the result was excellent.

Lexer reported a case six years after operation. The functional condition was satisfactory in spite of the fact, learned by means of the *x*-rays, that there was partial absorption of the transplant (see "Review of Recent Advances in Orthopedic Surgery," by M. S. Henderson in "Internat. Abstract of Surg.," Jan., 1915).

Tuffier twice transplanted an elbow-joint. In one case an elbow-joint was trans-

planted from a fresh cadaver which had been in cold storage for five days, and a year and a half later the functional condition was excellent.

Weglowski ("Zeit. f. Chir.," April 27, 1907) resorted to cartilage transplantation in a case of ankylosis of the elbow. After freeing and re-forming the ends of the three bones, two plates of cartilage (one-half thickness of rib cartilage) with perichondrium were taken from the sixth and seventh ribs and placed between the newly formed joint surfaces, the perichondrial surface being turned toward the humeral epiphysis. No special fixation was used. No drainage was employed. Active and passive motion was begun on the tenth day. In a month the patient had 60 degrees of free flexion and extension and full pronation and supination. Death from pleuropneumonia of three days' duration occurred in five weeks. Postmortem showed that the perichondrial surface of the cartilage was united to the humerus, while the opposite side was smooth, even shining; the cartilage was enlarging and passed without definite margin into the surface of the humerus.

Microscopic examination showed newly formed blood-vessels between the cartilage and bone; the cartilage was well preserved in its entire extent, the cells and nuclei staining well.

Huguier and Murphy revived a suggestion fifty years old. The operation is known as arthroplasty (page 614). They interpose soft tissue between the bone ends after freeing the ends from ankylosing material ("Traitement des Ankyloses par la Résection Orthopedique et L'interposition Musculaire," par Le Dr. Alphonse Huguier). The plan was first suggested by Verneuil in 1860 ("Archives de Medicine," 1860). He cured temporomaxillary ankylosis by the interposition of temporal muscle and fascia. In 1899 Helferich suggested inserting a portion of the vastus internus muscle between the patella and femur, and two years later Cramer reported some successful cases. Hoffa followed this method. Helferich, in 1893, mobilized the temporomaxillary joint by the insertion of a flap from the temporal muscle. This was repeated by Lentz, Henle, and others. Mikulicz, in 1895, used a flap from the masseter muscle. Similar procedures were employed by Bilezguski, Hoffa, and Kusnetzow. Rochet and Schnudt with Glück, in 1902, used a skin-flap and had previously employed ivory joints to take the place of the excised structures. In 1901 Murphy operated by Verneuil's plan.

J. B. Murphy ("Jour. Amer. Med. Assoc.," May 20–27, June 3, 1905) reviews the literature of the attempt to produce new joints and says: "In our work we have been able, by the interposition of fascia and muscle, covered with a layer of adipose tissue, to produce normal movable joints with capsules and collagen intra-articular fluid." In cases of synovitis with adhesions he resects the fibrous area and replaces it by aponeurosis or muscle, and it is desirable, when possible, that the replacing piece contains fat, which, under pressure, will form a hygroma or artificial synovial cavity. In bony ankylosis he operates, separates the bones, removes adjacent bony prominences or processes, frees the soft parts, prevents the bones coming again in contact, and interposes between them tissue which will remain fibrous or will form a hygroma or artificial synovial surface. After wound healing has taken place, passive motion, active motion, and forcible extension are required.

W. S. Baer ("Amer. Jour. Orthop. Surg.," 1907, p. 234) advocates the use of sterilized oil injected into joints to prevent the formation of adhesions and thus increase the arc of motion. Oil may also be poured into a joint after arthrotomy. After using oil in the manner described, Baer summarizes as follows: "That injection of oil into joints under proper precautions is a harmless procedure; that the joint will apparently tolerate as much as it will hold.

"It is most useful in cases where adhesions have followed some acute infectious process, or in those stiff joints which are classified as arthritis deformans of the infectious type.

"Passive motions are made with less pain where the joint contains oil.

"It plays some part in preventing adhesions, so that the mobility of the joint is increased more rapidly."

W. S. Baer (Ibid., Aug., 1909) reviews the literature of the operative treatment for mobilizing joints, and advocates the use of chromicized pig's bladder as the most satisfactory material to place between the surfaces of the recently separated bones.

Chlumsky, disappointed with the results of muscle flaps, used non-absorbable materials, zinc, rubber, celluloid, silver, and layers of colloidin, but no permanent mobility was obtained. He then employed absorbable plates of decalcified bone, ivory, and magnesium, with somewhat better results. Baer's method of inserting chromicized pig's bladder followed the unsuccessful employment by him of Cargile mem-

brane. The pig's bladder is tightly stitched by catgut sutures around the recently denuded bone and the wound is closed. A hip-joint two months after this procedure showed a voluntary flexion of 35 degrees; abduction of 15 degrees; adduction of 10 degrees; rotation of 25 degrees. Seven months after operation the mobility was better than that recorded at two months. Similar results are recorded of the knee and elbow.

Baer emphasizes the necessity of having the pig's bladder so prepared as to be absorbable in thirty to forty days. It should be pliable enough to be adapted to the contour of the joint. Every raw surface should be absolutely separated by it from that with which it would tend to come in contact.

Thorn, after mobilizing the joint, transplants a free flap of fascia to between the bone ends ("Zeitschr. f. Chirurgie," Bd. cviii). Bauer, of Baltimore, has also done this successfully. R. Tunstall Taylor has experimented elaborately in the endeavor to find a liquid and absorbable animal substance which, when injected by a syringe between the denuded ends of the bones, would immediately solidify and prevent contact of bone ends for six or eight weeks. He finally selected yellow wax 1 part and lanolin from 2 to 6 parts (this melts at from 120° to 135° F.). Taylor has had some excellent results from this method ("Penna. Med. Jour.," Jan., 1913). He cautions us not to operate by any method for ankylosis due to infective arthritis until joint inflammation has been quiescent for a year or more.

Surgical mobilization by interposition of flaps of fat, fascia, or muscle (*arthroplasty*) has not altogether fulfilled the high hopes once accorded it.

In the lower extremity we must have solidity. The surgeon may regard ankylosis in a useful position as preferable to a mobilization operation with the danger of a flail-joint. In most cases of ankylosis in the lower extremity the wisest plan, if the limb is in a faulty position, is to do an operation which will let the surgeon set it in a useful position when it will undergo re-ankylosis. Bergmann opposed doing mobilization operations upon the lower extremity ("Internat. Abstract of Surgery," Jan., 1917).

The best results are obtained on the elbow, next on the shoulder and hip. Results are good for the patella and lower jaw. The knee shows the poorest results. Personally I am doubtful about such an operation on the hip and ankle. I would not do it at all on the knee if one knee alone were ankylosed. Even in the upper extremity when the operation succeeds there is marked loss of strength. Tubby would minimize the loss of stability apt to follow the operation on a lower extremity by leaving only a small space between the bones. In the upper extremity he secures a much larger space between the bones. If autoplastic flaps are employed, drainage is unnecessary ("Internat. Abstract of Surgery," Jan., 1915).

If ankylosis interferes very gravely with joint function, the operation of mobilization (arthroplasty) must be considered. The best prospects are afforded in bony ankylosis when the bones and muscles are free from infection. It is seldom proper to do the operation in a tuberculous case, because the involvement is wide-spread and there is probably still lurking infection. The only tuberculous cases suited for mobilization are those in which the infection is purely synovial and the bones are firm and healthy (E. W. Hey Groves, of Bristol, "Brit. Jour. of Surgery" Oct., 1923). Operation is contraindicated if any infection exists. Muscular adhesions and toxic atrophy are also contraindications. Groves (Ibid.) names in the order of benefit: (*a*) That is, the best, ankylosis due to trauma; (*b*) to pyemia; (*c*) to gonorrhea; (*d*) to tuberculosis; (*e*) to osteo-arthritis; (*f*) to rheumatism, but he insists that when the patient is not suffering from pain and there is bony ankylosis in good position, no operation is justifiable unless mobilization will enable a man to earn a living. Of course, an ankylosis in bad position may call for operation and so may one that is painful. Groves points out in this very able article that if the hip and the knee are involved it may be advisable to mobilize the hip alone, and if both knees are involved one might elect to mobilize one knee. He lays it down as a rule that in the upper limb mobility is more useful than strength, and in the lower limbs stability is more useful than mobility. If only one knee is involved it is unwise to perform arthroplasty. While the bones are still growing the operation should not be done, but the prognosis is better in youth after this period than in older persons. At a meeting of the International Society of Surgery, held in London on July 18, 1923, the subject of arthroplasty was discussed. This discussion is set forth most carefully by Allen H. Todd, of London, in the "British Journal of Surgery," October, 1923, and I recommend all readers to consult this most valuable analysis.

Treatment of Extra-articular Anklyosis.—The treatment of false ankylosis depends upon the case. Recently contracted muscles or tendons require motion, massage,

frictions with stimulating liniments, hot and cold douches, and the use of the hot-air apparatus. Violent breaking up is not satisfactory, neither is tenotomy nor myotomy. Old contractions of tendons require tendon lengthening by tendoplasty or myoplasty. Chronic inflammation of tendon sheaths with adhesion of tendons requires excision of the sheaths. Whenever possible, excise a cicatrix that causes false ankylosis, and fill the gap with sound cutaneous tissue and fat. When the fixation is due to adhesive synovitis of the capsule, excise the capsule and attached ligaments; "the head and neck of the bones should then be surrounded by an aponeurosis or muscle to prevent the re-forming of adhesions" (John B. Murphy in "Jour. Amer. Med. Assoc.," May 20–27 and June 3, 1905). Bony deposits are gouged away and tumors are removed. Contractures in cases of paralysis require electricity, passive motions, frictions with stimulating liniments, the hot-air bath, and general treatment. Constant and graduated pressure by means of splints and braces (with ratchet or screws) will, in many instances, restore function. The patient can be taught to alter the pressure frequently, making it as powerful as he is able to bear it.

Loose Bodies in Joints (Floating Cartilages).—The knee is the joint affected in 90 per cent. of cases, but the elbow, shoulder, hip, wrist, lower jaw, and ankle may suffer. There may be but one loose body in a joint, there may be two or more, there may be many, or even hundreds. More than one joint may be involved. The condition is commonest in adult men. These bodies may be free or may have a stalk or pedicle; they may move about and occasionally block the joint, or may lie quietly in a joint recess or diverticulum. They may be flat or ovoid, smooth or irregular, as small as peas or as large as plums, and may be composed of fibrous tissue, of cartilage, or of bone. There are numerous different modes of origin of these bodies, many being "detached ecchondroses or pieces of hyaline cartilage hanging by narrow pedicles" (Sir J. Bland-Sutton), and they result from enlargement and chondrification of the villi of the synovial membrane. Loose bodies are found in the course of osteo-arthritis and osteochondritis dissecans.

Symptoms.—Some bodies give rise to no symptoms for a long time and others merely cause synovitis. A loose body may produce pain and interfere with joint function. The joint is weak and a little swollen, and the patient can perhaps feel the body and can even push it into a superficial area of the joint, where it may be felt by the surgeon. From time to time the body may get caught, thus suddenly locking the joint and producing intense and sickening pain, extension and flexion being impossible until the body slips out. It may slip out in a moment, but may not for hours or even for many days. A rather small body seems more apt to cause locking than a very large one, but if a large one does cause locking, it is more difficult to dislodge than is a small one. Locking of a joint by a loose body is followed by inflammation and effusion. If the loose body is dense and large the *x*-ray may disclose it. Sesamoid bones in the gastrocnemius muscle must not be confused with loose bodies in the knee-joint. In some cases of loose body in the knee the diagnosis is impossible from dislocation of a semilunar cartilage, inflamed semilunar cartilage, and synovitis with proliferation of villi.

Treatment.—To relieve locking, employ forced flexion and sudden extension. Cure can be obtained by operation only. Let the patient try to bring the foreign body to a point where it can be felt by the surgeon, so that he can determine where it lodges. Asepticize the knee with the utmost care. Operate usually under local anesthesia; we seldom need ether. If the body is felt before operating, fix it with a pin. The joint is now opened, explored with the finger, the foreign body extracted, and an exploration made to see that no other bodies are present. If a body has an attachment the pedicle is snipped through by scissors. The wound is sutured intwo layers and the leg is placed upon a splint. Asepsis must be most rigid. The operation does not cure the causative process, and these bodies are apt to form again. When the knee is involved, some surgeons saw the patella transversely, open the joint widely, remove all foreign bodies, and seek to cure any causative process. Sir Robert Jones divides the patella longitudinally, a most satisfactory operation.

Luxations or Dislocations

A dislocation is the persistent separation from each other, partially or completely, of two articular surfaces. A self-reduced dislocation is called a sprain (Douglas Graham). There are three forms of dislocations: (1) traumatic; (2) spontaneous or pathologic; (3) congenital.

1. Traumatic dislocations are due to injury. They are divided into—*complete* dislocation, in which the two articular surfaces are entirely separated and the ligaments are torn; *incomplete* or *partial* dislocation or *subluxation*, in which the two articular surfaces are not completely separated and the ligaments are rarely lacerated; *simple* dislocation, in which there is no wound leading from the surface to the articulation; *compound* dislocation, in which a wound leads from the surface to the joint; *complicated* dislocation, in which, besides the dislocation, there is a fracture, extensive damage of the soft parts, an opening which makes the case compound, or damage of a nerve or blood-vessel; *primitive* or *primary* dislocation, in which the bone remains as originally displaced; *secondary* dislocation, in which the dislocated bone assumes a new position, for instance, a subglenoid luxation of the humerus is primary, and it may become secondarily a subcoracoid luxation because of muscular contraction or attempts at reduction; *recent* dislocation, in which the displaced bone is not firmly fastened by tissue changes in its new situation, and its old socket is not obliterated; *old* dislocation, in which the displaced bone is firmly fastened by tissue changes in its new habitat, and the old socket is to a great extent obliterated (whether a dislocation is old or new depends on the state of the parts rather than on the time which has elasped since the accident); *double* dislocation, in which corresponding bones on each side are dislocated; *single* dislocation, in which only one joint is dislocated; *unilateral* dislocation, in which one articulation of one bone is out of place; *bilateral* dislocation, in which symmetric articulations are dislocated; and *relapsing* or *habitual* dislocation, which recurs frequently from slight force because of relaxed ligaments or lack of complete repair after the ligamentous rupture of a first dislocation.

2. Spontaneous, Pathologic, or Consecutive Dislocation.—Spontaneous dislocation arises from such very slight force that the cause may not be identified, and it acts on a joint rendered lax by disease. It may arise in the course of chronic synovitis, tuberculous joint disease, or rheumatoid arthritis. In Charcot's joint a spontaneous dislocation will occur sooner or later. In typhoid fever spontaneous dislocation is not very uncommon. The hip-joint is most often the one attacked. *Dislocation of the hip in typhoid fever* follows a severe joint inflammation, is usually upon the dorsum of the ilium, and is frequently not noticed until convalescence has set in. If a typhoid dislocation is seen early, reduction is easily effected, but if seen late, is impossible. The treatment for irreducible typhoid dislocation is the same as for any other irreducible dislocation. Dislocation may occur in the acute infectious arthritis of scarlatina, pneumonia, etc., from distention of the joint cavity with septic products or exudates. In infantile palsy muscular atrophy may be so great that a shoulder or hip may be easily dislocated.

3. Congenital Dislocations (Fig. 479).—A congenital dislocation is due to a congenital joint malformation which renders it impossible for the bone to maintain a normal position, or is due to external violence during the period of uterine gestation. Congenital dislocations should not be confounded with dislocations produced during delivery. The hip is the joint most often involved. The shoulder suffers occasionally. Lannelongue maintains that congenital dislocation of the hip is due to artophy of the muscles and of the acetabulum following spinal cord disease. Verneuil thinks the dislocation is paralytic. Broca says that in view of the fact that the head of the bone is larger than the cavity in which it belongs, it is useless to attempt reduction by manipulation or extension, but many successful cases by the Lorenz bloodless method prove Broca's condemnation to have been too sweeping. Lorenz and Hoffa have each devised an operation for this condition (see page 667). Congenital dislocation of the shoulder may require incision, possibly excision, or the paring down of the head to fit the glenoid cavity (Phelps).

Traumatic Dislocations.—In the succeeding pages the traumatic form of dislocation will be particularly considered.

The **causes** of traumatic dislocations are divided into *predisposing* and *exciting*.

Predisposing causes are: (1) *age;* dislocations are commonest in adolescence and middle life, the usual lesion of the young being greenstick fracture, and that of the old being fracture; dislocations of the head of the radius are not uncommon in youth; (2) *muscular develpoment*, dislocations being commonest in those with powerful muscle; (3) *sex*, males being more predisposed than females, because of their occupations and muscular strength; (4) *occupation* predisposes as a cause according as it demands the employment of muscular force, as in the carrying of burdens; (5) *nature of the joint*, ball-and-socket joints being more liable to luxation than are ginglymoid joints, because of the wider range of motion of the former; (6) *joint disease* predisposes by relaxing the

ligaments; (7) *situation of the joint*, some joints being more exposed to injury than others.

Exciting causes are divided into—(1) external violence and (2) muscular action. *External violence* may be *direct*, as when a blow upon one of the bones forces it directly away from the other; or it may be *indirect*, as when force applied to a distant part of a bone is transmitted to its end and drives the bone out of its socket. *Muscular action* is a cause when sudden and violent muscular contraction occurs during the assumption or maintenance of a position of the joint which gives the muscles full sway, and throws the head of the bone against the weakest part of its retaining ligaments.

Pathologic Conditions.—In a recent complete traumatic dislocation the ligaments are damaged, and may perhaps exhibit extensive laceration, or may show only a buttonhole laceration through which a bone projects. External force produces much laceration and little stretching of the ligaments; muscular action produces little laceration and much stretching of the ligaments. In some cases of dislocation due to external violence the structures about the joint are bruised or otherwise damaged; the old socket is filled with blood, and the bone in its new situation lies in a bloody



FIG. 479.—Congenital dislocation of the hip (skiagraphed by Dr. Manges).

area. Large vessels and nerves are rarely torn, though they are not unusually compressed. Sprain fracture is certainly common, in fact, almost invariable (Ross and Stewart, "Annals of Surgery," Oct., 1912).

If a dislocation is not soon reduced, inflammation arises in the old joint cavity and about the displaced bone, and the whole area becomes glued together, first, by coagulated exudate, and finally by fibrous tissue. After a time, in ball-and-socket joints, the old socket fills with fibrous tissue, contracts, becomes irregular, and may even be obliterated; the head of the dislocated bone is altered in shape, its cartilage is destroyed or converted into fibrous tissue, and the pressure of the head of the bone forms a hollow in its new situation, which hollow becomes surrounded by fibrous tissue or even by bone. A new joint may form, the surrounding tissue becoming a compact capsule, and a bursa forming between the head of the bone and its new socket. In a dislocated hinge-joint the ends of the bone alter greatly in shape and their cartilage is converted into fibrous tissue. In an unreduced dislocation the muscles shorten or lengthen or undergo atrophy or fatty degeneration, as the case may be. An unreduced dislocation of a ball-and-socket joint may give a fairly movable new joint, but an unreduced dislocation of a hinge-joint rarely allows of much motion.

General Symptoms of Traumatic Dislocation.—In general, traumatic dislocations are indicated—(1) by *pain* of a sickening, nauseating character; (2) by *rigidity*, voluntary motion being impossible except to a slight extent in the direction of the deformity. (For instance, in dislocation of the inferior maxillary the jaw can be opened a little more, but it cannot be closed.) This rigidity brings about loss of function. When the surgeon attempts to move the joint he finds it very rigid; (3) by *change in the shape of the joint* (as flattening of the shoulder after dislocation of the humerus); (4) by *alteration in the mutual relations of bony prominences about a joint* (as the alteration of the relation between the olecranon and humeral condyles in dislocation of the elbow backward); (5) by feeling the displaced bone in its new situation; (6) by missing the head of the bone from its proper situation; (7) by alteration in the length of the limb (in dislocation of the femur into the thyroid foramen the limb is lengthened, but in dislocation on to the dorsum of the ilium it is shortened); (8) by alteration in the axis of the bone (in dislocation upon the dorsum of the ilium the axis of the injured thigh would, if prolonged, pass through the lower third of the sound thigh); and (9) by seeing the dislocation with a fluoroscope or looking at a skiagraph of it.

Diagnosis of Traumatic Dislocation.—A dislocation may be mistaken for a fracture. In dislocation there is rigidity, in fracture there is preternatural mobility; in dislocation there is no true crepitus (there may be tendon or joint crepitus), in fracture there usually is crepitus; in uncomplicated dislocation the deformity does not tend to recur after reduction, in fracture it does recur after extension is relaxed. In a sprain the movements of the joint are only limited, not abolished, by the almost complete rigidity encountered in dislocation. The change which a sprain may cause in the shape of a joint is due to effusion or to bleeding; there is no alteration in the relation of the bony prominences to one another; there is no notable alteration in the length of the limb (in a sprain a very slight increase in the length of the limb may arise from joint effusion, or the head of the bone may subsequently be absorbed and thus produce shortening after some weeks); there is no alteration in the axis of the bone; the bony head is not felt in a new position, and it is found in its normal place. Always remember that a fracture may exist with a dislocation. In any doubtful case—in fact, in most cases—give ether, for a dislocation should be reduced while the patient is anesthetized (except in dislocation of the jaw, of a finger, of the carpus, etc.). In some cases swelling renders the diagnosis difficult or impossible. Always compare the injured joint with the corresponding joint of the sound side. The *x*-rays constitute an invaluable method of diagnosis.

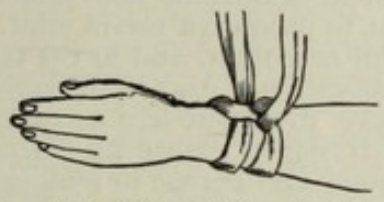


FIG. 480.—Clove-hitch knot applied above the wrist in dislocation of the elbow. In dislocation of the shoulder this knot is put above the elbow (after Erichsen).

Treatment of Traumatic Dislocation.—*Recent Simple Dislocation.*—Reduce a simple dislocation under ether, as a rule. Try *manipulation*, a procedure which seeks to make the bone retrace its own pathway. If this procedure fails, employ extension and counterextension. If considerable force is needed, an assistant makes counterextension, and the surgeon fastens to the extremity a clove-hitch, which he ties about his waist, and thus secures powerful extension. Counterextension may be obtained by bands, or, in some instances, by the foot of the surgeon. The *clove-hitch* (Fig. 480) is used because it will not tighten by traction; a tightening band would lacerate the soft parts. If great power is needed, it can be obtained by compound pulleys, such as the Jarvis adjuster or some similar appliance, but at the present day pulleys are very rarely used (see page 628). If these means fail, cut down upon the bone and restore it to position; operation is much safer than the application of great force. After reducing a dislocation, immobilize the joint for a time, which varies for different joints, and for the first hours combat swelling and inflammation by rest of the part and the use of evaporating lotions or an ice-bag. If there exists a fracture of the dislocated bone, apply splints and then try to reduce by manipulations, grasping the limb and the splints with one hand below and, if possible, the head of the bone with the other hand above the seat of the fracture. Allis believes that a dislocation can be reduced even when a fracture exists. It is possible to pull the dislocated head down to the joint, because a portion of periosteum and possibly tendinous material and muscle still hold the two fragments as a strap might unite two sticks. The head may be forced into place by the fingers while traction is being made. If the fracture

is near the joint and the fragments cannot be fixed, try to reduce the dislocation, first striving to press the bone into place. This attempt can be greatly aided by traction upon the lower fragment. In some cases with fracture reduction can be much aided by making a small incision, screwing a gimlet into the head of the bone, and using this tool as a handle. McBurney incises, drills a hole in each bone, inserts hooks into them, and pulls the dislocated bone into position (see Figs. 315 and 316). Incision is preferable to hooks, as it enables us to mechanically fix the bone fragments by wiring or plating.

Compound Traumatic Dislocation.—The opening in the soft parts may be due to external violence or to projection of a bone. Compound dislocations are very serious. Hinge-joints are more liable to these injuries than are ball-and-socket joints. Many cases require excision; some, amputation; one that does not demand excision or amputation should be treated by sterilizing the parts and restoring the dislocated bone. Considerable ankylosis generally ensues, except sometimes in the small joints. It is scarcely ever necessary to cut away any portion of the protruding bone to effect reduction. If a joint is badly splintered, or if the soft parts are extensively damaged, it may be necessary to excise or amputate; if the main vessels of a limb are seriously injured, amputation must be considered. If the patient is so old or so feeble that it is perilous to force him to combat a long illness, amputation should be performed.

Old Traumatic Dislocation.—The problem always presented in an old dislocation is, Shall reduction be tried or shall the bones be let alone? Sir Astley Cooper laid down this rule: "Do not attempt to reduce a shoulder dislocation after three months, nor a hip dislocation after two months"; but this rule was put forth before the days of ether. Do not select any fixed period of time to determine what action is advisable. In dislocation of a ball-and-socket joint considerable motion may become possible and a new joint may form. If movement does not produce pain, a useful new joint may be obtained by the persistent employment of active and passive movements; if movement of the limb does produce pain, enough motion will not be attempted by the patient to produce a useful joint. In the former case it may be best to try to obtain a useful new joint, and in the latter case the surgeon should endeavor to reduce the old dislocation. Always remember that dislocation of a hinge-joint, if left unreduced, will never eventuate in a useful new joint.

In trying to reduce an old dislocation give ether, make movements to break up adhesions, and persist in making these motions until the head of the bone is felt to move; then try at once to reduce by manipulation or extension and counterextension, not waiting for two days, as some suggest. If the head of the bone cannot be made to move, the Dieffenbach plan has been advised, which is to cut the tense restraining bands with a tenotome. Lord Lister, being much impressed with the danger inevitably linked with forcibly dragging old dislocations into place, preferred to cut down and restore the bone, employing, of course, the strictest asepsis, and surgeons in general have adopted this view. In some old dislocations excision of the head of the bone is the proper operation.

Special Traumatic Dislocations.—Mandible.—A dislocation of the lower jaw, when there is no fracture, is almost invariably forward. Backward dislocation without fracture is extremely rare, and some have maintained that it cannot occur. Croker King reported a case in 1858. Theim has observed it 7 times in 5 women. The condyle passes under the lower surface of the auditory canal.[1] The common dislocation is forward, and this is the form meant when we simply speak of dislocation of the jaw. There are two forms of forward dislocation—the *unilateral*, which is rare, and the *bilateral*, which is common. Dislocations of the jaw are commonest in women and during middle life. When the mouth is open, contraction of the external pterygoid muscle may pull the condyle over the articular eminence; this contraction may be brought about by yawning, vomiting, scolding, etc. When the mouth is open, dislocation of the lower jaw may be caused by a blow upon the chin; it may also be caused by forcing the mouth more widely open by pushing a bulky body between the teeth.

Symptoms of Lower Jaw Dislocation.—In the *bilateral* form the mouth is open and fixed, and it cannot be closed, though it can be opened a little more. The condyles are in front of the articular eminences, and are fixed by the action of the masseters and internal pterygoids, the coronoid processes being wedged against the malar bones. The lower jaw is advanced in front of the upper jaw and the face looks longer than natural. The lips cannot close, the saliva dribbles, swallowing and speech are difficult, there is a depression in front of each ear, the condyles are recognizable in their

[1] Theim in "Rev. de Chir.," vol. viii, 1888.

new abodes, the coronoid processes are detected by a finger in the mouth, and the masseters and temporals stand out in a state of rigidity. Pain may be severe, may be moderate, or may be absent. In the *unilateral* form the chin deviates toward the sound side, and the mouth is not so widely open as in the bilateral form, neither is the jaw so fixed. The symptoms are similar to those of a bilateral luxation, but are not so pronounced. The hollow in front of the ear and the abnormal situation of the condyle are detected upon one side only. In an unreduced dislocation the patient may after a time establish some movements of the jaw, but the power of mastication will always be seriously impaired.

Treatment of the Lower Jaw Dislocation.—In reducing a dislocation of the lower jaw the patient is usually placed with his head against the back of a chair or against the body of an assistant. The surgeon, after wrapping up his thumbs to protect them from being bitten, stands in front of the patient, puts his thumbs upon the last molar teeth, and grasps the chin with his free fingers. He now presses downward and backward on the jaw, and as soon as the condyle is loosened, closes the jaw over the thumbs by pushing up the chin, using his thumbs as levers. For the past few years I have followed the excellent suggestion of W. J. Young ("Brit. Med. Jour.," March 23, 1913), which is to stand behind, the right thumb far back in the right side of the patient's mouth and grasp the chin with the left hand. The right hand easily depresses the jaw and the left guides the condyle into place. Then the procedure is reversed and the left side reduced. If reduction by the hands fails, wedges should be put between the molar teeth and the chin should be pushed up either by the hands or by a tourniquet, the band of which surrounds the head and chin. In a unilateral dislocation the wedge should be used only on the injured side. In difficult cases Sir Astley Cooper pushed a round wooden ruler between the molar teeth, used the upper teeth as a fulcrum, and raised the end of the ruler as the handle of a lever. The forceps used by an anesthetist may depress the condyle from its point of fixation, whereupon the chin may be pushed up and back. Nélaton advised that the surgeon place his thumbs in the mouth of the patient and push the coronoid processes backward. After reduction a Barton bandage should be applied and worn for over two weeks. The dressing should be renewed once a day, and passive motion be begun in the second week. The bandage may be discarded during the third week. Liquid diet is advisable for three weeks after the accident. In an old dislocation reduction should always be attempted, at least up to a period of six or seven months after the accident. An irreducible dislocation requires osteotomy of the neck of the condyle if the dislocation cannot be restored after incision.

Dislocation of the Clavicle. Sternal End.—There are three forms of dislocation of the sternal end of the clavicle, namely: (1) forward; (2) backward, and (3) upward.

Forward Dislocation of the Sternal End of the Clavicle (Presternal Dislocation).—The *causes* of forward dislocation of the clavicle are blows, falls, or pulls which drive or draw the shoulder backward.

Symptoms and Treatment of Forward Dislocation of the Sternal End of the Clavicle.—The symptoms manifest in forward dislocation of the clavicle are: prominence in front of the sternum; the acromion is nearer to the sternum on the injured than on the sound side; the clavicular origin of the sternocleidomastoid muscle is rigid; movement is difficult and painful. To reduce a dislocation, pull the shoulders back against the knee of the surgeon, which is placed between the scapulæ. Dress with a posterior figure-of-8 bandage or a Velpeau bandage. The dressing is to be worn for three weeks. After removal of the dressing apply a truss, the pad of which is put over the head of the clavicle. The instrument is to be worn for a month. Dislocation of the clavicle is difficult to keep reduced, but even if it becomes fixed in deformity, the motions of the arm will not be impaired permanently. It can be reduced and fixed by incision and wiring.

Backward dislocation of the sternal end of the clavicle is very rare. The *causes* are direct violence and indirect force, such as falls or blows which drive the shoulder forward and inward.

Symptoms and Treatment of Backward Dislocation of the Sternal End of the Clavicle.—The symptoms are: pain, loss of function in the arm; inclination of the head toward the injured side; stiffness of the neck; the shoulder passes forward and inward, and often falls downward; a depression exists over the sternoclavicular joint; the head of the clavicle cannot be felt, or is found back of the sternum. The displaced clavicle may press upon the trachea, the esophagus, or the great vessels, inducing dyspnea, dysphagia, obliteration of pulse in the arm of the injured side, or great venous con-

gestion of the head (see Pick). The usual method of treatment is to pull the shoulders backward and apply a posterior figure-of-8 bandage, which must be worn for three weeks. If pressure symptoms are urgent, it is the rule to incise, restore the bone to place, and wire it, or resect the displaced head.

Upward dislocation of the sternal end of the clavicle is very rare. The *cause* is indirect force, which carries the shoulder downward, inward, and backward (Smith).

Symptoms and Treatment of Upward Dislocation of the Sternal End of the Clavicle.—The chief symptom is impaired function of the arm; the shoulder passes downward and inward, the clavicular axis is altered, and the displaced head is felt. Dyspnea may or may not exist. To treat this dislocation, put a pad in the axilla and press the elbow to the side (in order to throw the bone outward), and try to push the end into place. Apply a Desault bandage and place a firm pad over the sternoclavicular joint. The deformity is apt to recur, but a useful limb will nevertheless usually be obtained. The best method of treatment is to wire the bones in place.

Dislocation of the acromial end of the clavicle is almost always upward, but it may be below the acromion. The *cause* is violent force, which, if so applied to the scapula as to drive the shoulder forward, may produce a dislocation upward. A dislocation downward is due to blows upon the upper surface of the outer end of the clavicle.

Symptoms and Treatment.—In dislocation of the acromial end of the clavicle upward there are noted: prominence of the clavicle upon the top of the acromion;

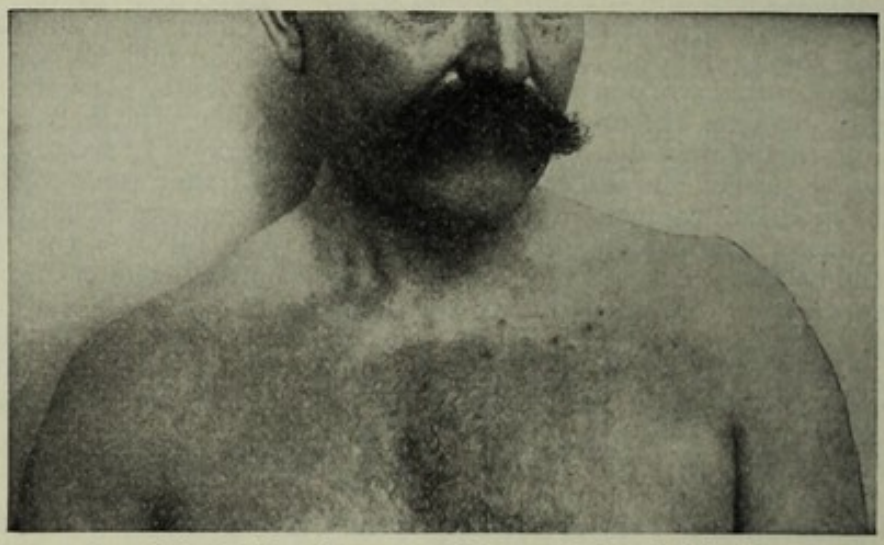


FIG. 481.—Dislocation upward of acromial end of clavicle.

impaired function of the arm (it cannot be lifted over the head); the shoulder falls downward and passes inward; there is apparent lengthening of the arm; the head is bent toward the injured side, and the clavicular origin of the trapezius is strongly outlined (Pick). In *dislocation downward* both the acromion and the coracoid are very prominent, the clavicular axis is altered, and there is depression over the sternoclavicular joint. The surgeon usually endeavors to reduce a dislocation upward by placing the patient supine on a hard table, pulling the shoulder back, and pushing the bone into place. After reduction the old method of treatment was to apply a Desault bandage, which was kept on for three weeks, and decided deformity, enduring pain, and disability were looked for as inevitable. Stimson used to apply dressings of adhesive plaster. The author has seen several cases treated by the apparatus of Colonel Thomas Leidy Rhoads, U. S. A. The apparatus completely corrected the deformity, and the patients made a most satisfactory recovery. The essential element of Rhoads's apparatus is a trunk-strap applied after reduction of the dislocation, as shown in Figs. 482, 483. If the deformity can be completely corrected, Rhoads's apparatus will serve a good purpose, but in many cases it is impossible really to reduce the deformity, or after apparent reduction the deformity at once returns. This is due, as Moore[1] points out, to the fact that the superior acromioclavicular ligament is torn from the clavicle, but remains attached to the scapula, and when reduction is attempted, is pushed under the clavicle and nothing remains to hold the clavicle "in place but the skin and superficial fascia." I agree with Moore that the best treatment is incision, replacement,

[1] "Annals of Surgery," May, 1902.

and suturing the acromion to the outer end of the clavicle. The bones are sutured with silver wire or kangaroo-tendon, the acromioclavicular ligament is sutured with catgut, the wound is closed with sutures of silkworm-gut, and the patient is kept supine in bed for three weeks. I have operated successfully on 5 of these cases.

Dislocation downward is reduced and treated in the same manner as dislocation upward.

Simultaneous dislocation of both ends of the clavicle is a very rare injury. It is treated as is single dislocation.

The so-called **dislocation of the lower angle of the scapula** is not, as was long taught, a dislocation at all. The lower angle and vertebral border deviate from the chest. This condition was thought to be due to the bone slipping from under the latissimus dorsi muscle, but it is now known to be due to *paralysis* of the *serratus magnus muscle*, the bone being acted upon by the trapezius, pectoralis minor, levator anguli scapulæ, and the rhomboid muscles. Examination shows that the scapula will not rotate normally forward. This is demonstrated by extending the arms in front to a right angle, the gliding forward of the scapula upon the sound side being marked, but upon the diseased side being slight or absent.

Treatment of paralysis of the serratus magnus muscle comprises massage, electricity, passive motion, and deep injections of strychnin.

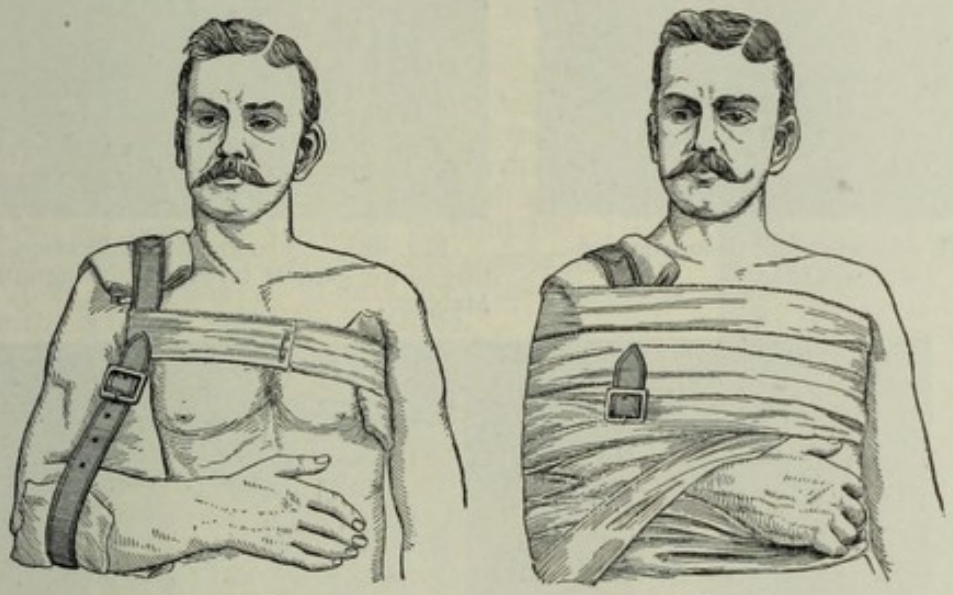


FIG. 482. FIG. 483.

FIGS. 482, 483.—Rhoads's apparatus for treating dislocation upward of the acromial end of the clavicle.

Katzenstein advocates operation for serratus palsy. He makes an incision near to the midline of the back, exposes portions of origin of the trapezius and rhomboideus major, divides them, carries the cut muscles downward and outward, and sutures them to the periosteum of the seventh, eighth, and ninth ribs and to the latissimus dorsi. He then makes an "incision along the inner surface of the arm from the middle up through the axilla to end on the thoracic wall." He divides the humeral insertion of the great pectoral and sutures its tendon to the axillary border and the anterior scapular muscles (Binnie's "Operative Surgery").

Dislocation of the Humerus (Shoulder-joint).—This injury is quite frequent because of the free mobility of the shoulder-joint, its anatomic insecurity, and its exposed situation; it rarely occurs in the very young and in the aged, and is oftenest encountered in muscular young adults. Shoulder dislocation is produced by throwing the arm into abduction. In this position the head of the humerus presses against the lower and front part, that is, against the thinnest and most poorly supported portion of the capsule. In almost all cases the tear in the capsule occurs between the tendons of the subscapularis and the triceps. Hence, most dislocations are *primarily* subglenoid, although the bone usually moves to some other position, being dragged or driven there by the injuring force or being pulled there by muscular action. Dislocation forward is much more common than dislocation backward because the long head of the triceps keeps the head of the bone from going posterior and because the anterior are stronger

than the posterior muscles. Four chief forms of shoulder-joint dislocation exist, namely: (1) forward, inward, and downward, under the coracoid process—sub-

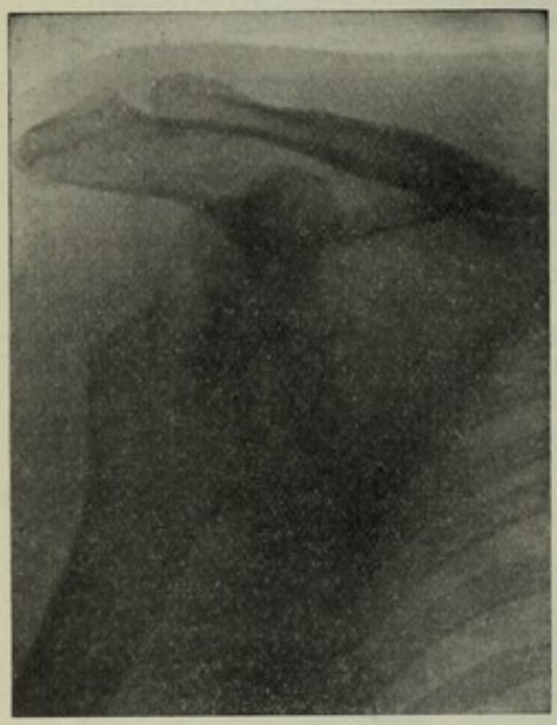


FIG. 484.—Subcoracoid dislocation of shoulder.



FIG. 485.—Subcoracoid dislocation with fracture of the greater tuberosity (skiagraphed by Dr. Manges).

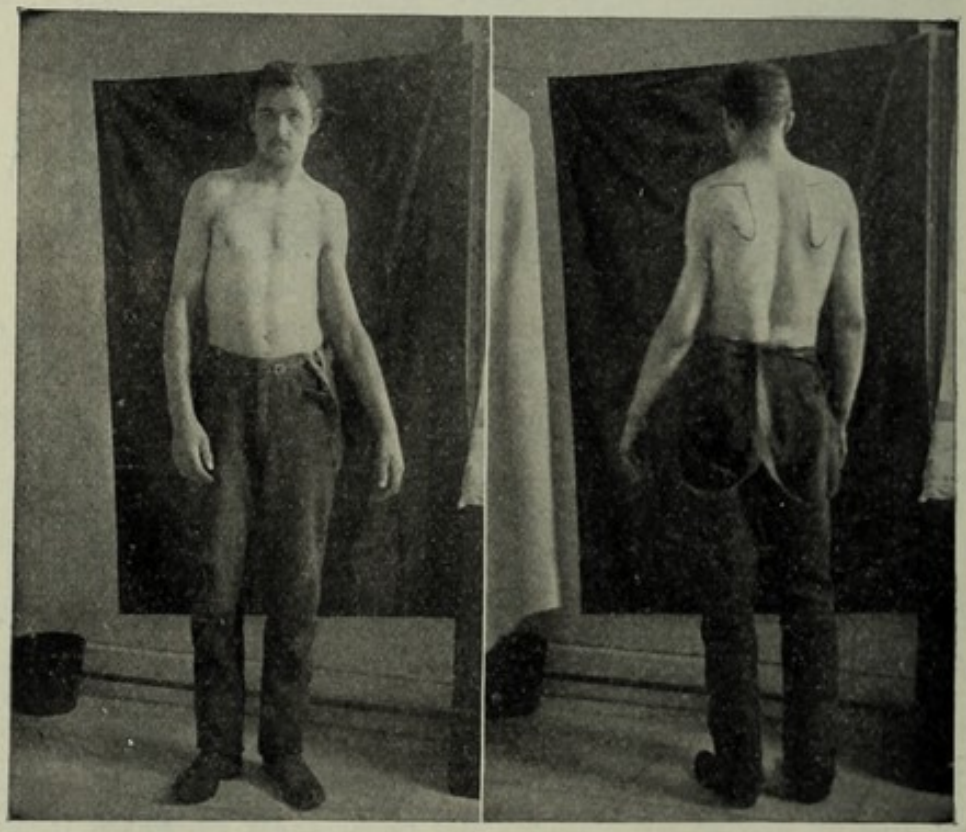


FIG. 486.—Subcoracoid dislocation of the left humerus (St. Joseph's Hospital case; photographed by Dr. Nassau).

coracoid; (2) downward, forward, and inward, beneath the glenoid cavity—subglenoid; (3) backward, inward, and downward, under the spine of the scapula—subspinous; and (4) forward, inward, and upward, under the clavicle—subclavicular.

A very rare form of shoulder-joint dislocation is known as the *supracoracoid*. Another rare form is the *luxatio erecta*.

Subcoracoid Luxation (Figs. 484–486).—The subcoracoid variety of dislocation embraces three-fourths of all shoulder-joint luxations. It may be caused by direct force driving the head of the humerus forward and inward, or by indirect force, such as falls upon the hand or the elbow. In this dislocation the head of the bone lies against the anterior surface of the scapular neck below the coracoid process. A part of the anatomic neck of the humerus lies upon the anterior margin of the glenoid cavity, and the head of the bone is above the tendon of the subscapularis muscle.

Subclavicular luxation is very rare. It is caused by the same sort of violence which produces subcoracoid luxation. The head of the bone rests upon the thorax, below the clavicle, and underneath the pectoralis major muscle.

Subglenoid or Axillary Luxation (Fig. 487).—It may be produced by contraction of the great pectoral and latissimus dorsi muscles when the arm is at a right angle to the body, but it is usually due to falls upon the hand or the elbow when the arm is raised and the head of the bone is against the lower portion of the capsule. In this dislocation the head of the bone rests upon the border of the scapula, below the tendon of the subscapularis, in front of the long head of the triceps, and above the teres muscles. Most dislocations of the shoulder are primarily subglenoid, the position perhaps being subsequently altered by muscular action.

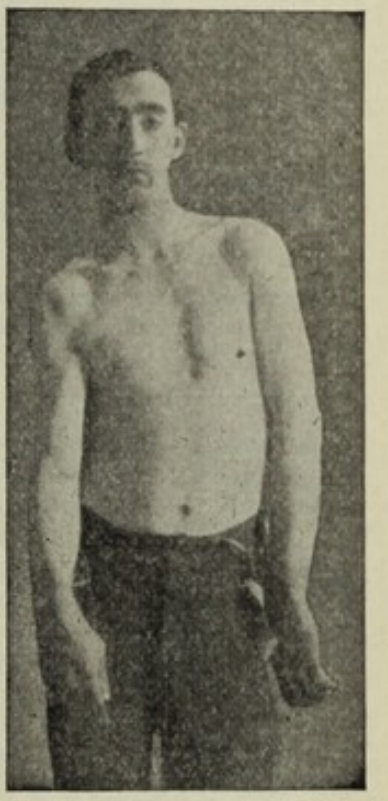


FIG. 487.—Axillary dislocation of the right humerus.

Subspinous luxation is a rare injury. Pick met with this accident in a man who, while having his hands in his pockets, fell upon the front of the point of the shoulder. The head of the bone reposes beneath the scapular spine, between the infraspinatus and teres minor muscles.

Supracoracoid luxation is seldom encountered. The head of the humerus rests upon the coraco-acromial ligament or upon the acromion process, and the acromion process or the coracoid is always fractured.

Luxatio Erecta.—In this injury the arm is markedly abducted and in some cases the elbow is actually raised above the patient's head. As a rule, the forearm rests behind the occiput, but sometimes on the top of the head. The patient holds the forearm to the occiput or vertex to avoid pain. It is, in reality, a form of subglenoid luxation. In such an injury the head of the bone has passed under the subscapularis muscle and also under the teres major or the lower border of the great pectoral. Judd, Hulke, Cleland, and others have reported cases.

Symptoms of Dislocation of the Shoulder-joint.—Dislocation is diagnosticated by: (1) pain of a sickening character; (2) flattening of the shoulder, the head of the bone having ceased to bulge out the deltoid muscle; (3) apparent projection of the acromion through sinking in of the deltoid; (4) a hollow beneath the acromion, over the empty glenoid cavity, and the bone missing from its normal habitat. This hollow may be easily appreciated by the finger, especially when the extremity is somewhat abducted; (5) rigidity (some movement is possible in the direction especially of an existing deformity, but mobility is strictly limited and attempts at motion produce great pain); (6) Dugas's sign: the elbow cannot touch the side when the hand is placed upon the sound shoulder, and the hand cannot be placed upon the sound shoulder if the elbow is to the side (this is due to the rotundity of the chest. In a dislocation the head of the bone is already touching the chest, and the bone, being approximately straight, cannot touch the spheric surface of the chest in two places at the same time. If the elbow can be placed against the chest with the hand on the sound shoulder there cannot be dislocation; if it cannot be so placed, there must be dislocation); (7) finding the head of the bone in a new situation; (8) examining by means of the *x*-rays. Symptoms 1 to 5 inclusive may be grouped as Erichsen's list of signs. The form of dislocation is made out by a study of the direction of the axis of the limb, the existence and extent of lengthening or of shortening, and the situation of the head of the bone.

In a shoulder-joint dislocation the head of the bone may press upon the brachial

plexus and produce pain and numbness, and occasionally traumatic neuritis or paralysis; sometimes pressure upon the axillary vein causes intense edema, and pressure upon the axillary artery diminishes or obliterates the pulse. The axillary vessels may be torn and the muscles may be lacerated badly. The capsule is torn and considerable blood is usually effused. Swelling is due first to hemorrhage, and second to inflammation. Partial dislocation sometimes, though rarely, occurs. What is usually spoken of as "partial dislocation" or "subluxation" is a condition in which the head of the humerus passes forward under the coracoid because of rupture of the long head of the biceps or because this tendon slips out of its groove, the ligaments of the shoulder-joint being intact.

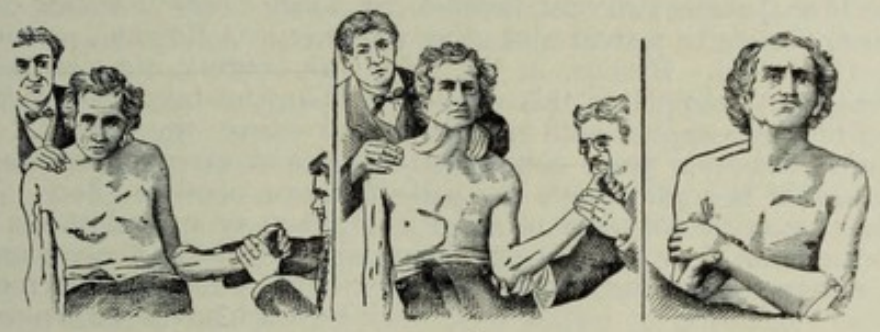
The following table from T. Pickering Pick's work on "Fractures and Dislocations" makes the above points clear:

	Direction of the axis of the limb.	Alteration in the length of the limb.	Presence of the head of the bone in new situation.
Subcoracoid.	The elbow is carried backward and slightly away from the side.	Very slight lengthening.	The head of the bone cannot easily be felt; it is found at the upper and inner part of the axilla.
Subglenoid.	The elbow is carried away from the trunk and slightly backward.	Very considerable lengthening.	The head of the bone can easily be felt in the axilla.
Subspinous.	The elbow is raised from the side and carried forward.	Lengthening intermediate in degree between the subglenoid and the subcoracoid.	The head of the bone can be felt and be grasped beneath the spine of the scapula.
Subclavicular.	The elbow is carried outward and backward.	Shortening.	The head of the bone can readily be seen and be felt beneath the clavicle.

Diagnosis of Shoulder-joint Dislocation.—In *fracture of the neck of the scapula* the acromion is prominent, a hollow is detected below it, and a hard body is felt in the axilla; but the coracoid process descends with the head of the humerus, which it does not do in dislocation. Furthermore, in fracture there is mobility, in dislocation, rigidity. In fracture crepitus is present; in dislocation it is absent. In fracture the deformity is easily reduced, but it at once recurs; in dislocation the deformity is with difficulty reduced, but does not recur. In fracture the elbow can be made to touch the side when the hand is upon the sound shoulder; in dislocation it cannot be so manipulated. In *fracture* of the *anatomic neck of the humerus* deformity is slight; the head of the humerus is found in place, does not move when the shaft is rotated, and is not in line with the axis of the bone. Crepitus exists in the fracture if impaction is absent. In *paralysis of the deltoid muscle* there is distinct flattening, but the bone is felt in place and there is no rigidity. The *x*-rays are invaluable in diagnosis.

Treatment of Shoulder-joint Dislocation.—Reduction by manipulation is usually readily accomplished in a recent case of shoulder-joint dislocation. If a simple trial without ether fails, an anesthetic should be administered. Ether is given, but not chloroform, for chloroform seems to be particularly dangerous to life when given to enable the surgeon to reduce a dislocation of the shoulder. *Forward dislocations* (subcoracoid, subclavicular, and axillary) are reduced by *Kocher's method* (Fig. 488). This method was introduced by Kocher in 1870 ("Sammlung klin. Vorträge," No. 83). Reduction by this method can frequently be effected without the aid of ether. The patient should be recumbent. Slowly but forcibly adduct the abducted elbow and get it finally against the side. At the same time draw it slightly backward. The forearm is flexed to a right angle. If there is much muscular resistance, follow Keetley's advice, and not only bring the elbow to the side, but push it backward and inward toward the spine. Grasp the elbow with one hand, and the wrist with the other, and slowly make external rotation until the forearm points outward from the body. We thus carry the head of the humerus to the margin of the glenoid cavity. External rotation must be done slowly and gently. When we first try it there is much muscular resistance. If enough force is used to overcome the resistance the surgical neck of the bone may be broken. By gently and gradually persisting in external rotation the muscles are finally tired out and relax. Next lift the elbow anteriorly as far forward

as it will go, so as to bring the head of the humerus to the glenoid margin just opposite the capsular tear (Keetley). Then throw the bone into place by gradually swinging the forearm inward across to the other side of the chest, that is, by internal rotation. The formula is, flexion of the forearm, external rotation, lifting the elbow forward, internal rotation of the arm, and lowering the elbow. The motions to unlock the bone and start it to retrace the steps it took when emerging should be gentle, not forcible, slow, not sudden, and rigid muscles should be tired out and made to relax by steady traction upon them. Sudden and violent motions increase rigidity. Adduction stretches the upper portion of the capsule and presses the head against the glenoid. External rotation opens the tear in the capsule. Elevation relaxes the



a *b* *c*

FIG. 488.—Kocher's method of reduction by manipulation: *a*, First movement, outward rotation; *b*, second movement, elevation of elbow; *c*, third movement, inward rotation and lowering of the elbow (Ceppi).

untorn part of the capsule and coracohumeral ligament and stretches the torn portion. On this fulcrum the head, which is the end of a lever, is forced into place. If in trying Kocher's plan external rotation of the humerus does not take place, abandon the method, as persistence will fracture the humerus. Another method of manipulation is as follows: if the *right* shoulder is dislocated, the surgeon stands behind the patient (who is sitting erect); if the *left* shoulder is dislocated, he stands in front of the patient. The surgeon holds the forearm flexed upon the arm with his right hand and makes external traction and rotation, and with the fingers of his left hand he tries to force the bone into place.

In *Henry H. Smith's method* for forward dislocation the surgeon stands in front of the patient. If the *left* shoulder is dislocated, the surgeon grasps it with his left hand; if the *right* shoulder is dislocated, he grasps it with his right hand, the thumb resting on the head of the bone. With his disengaged hand the surgeon grasps the elbow, abducts it, makes traction and external rotation, and suddenly sweeps the elbow inward, aiming it at the sternum, and tries with his thumb to push the bone into place. In *subspinous luxations* reduction may be effected if the surgeon stands behind the patient, makes abduction, traction, and internal rotation, sweeps the elbow inward toward the spine, and with the thumb aids the bone in its return into position. Raising the elbow far above the head and sweeping it inward will reduce some dislocations. As the head of the bone slips back a distinct jar is felt and a snap is heard, the motions of the joint are again obtainable, and with the hand on the opposite shoulder the elbow may be made to touch the side.

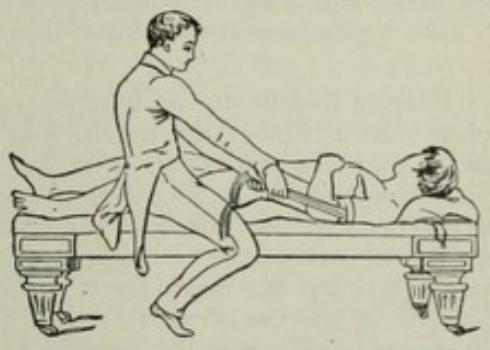


FIG. 489.—Reduction of shoulder-joint dislocation by the foot in the axilla (Cooper).

Reduction by Extension.—Before attempting the reduction of a dislocation of the shoulder-joint by extension the patient should be anesthetized and placed upon a low bed or upon the floor. The surgeon then places his foot, covered only by a stocking, in the axilla. Place the sole of the foot, not the heel, against the chest high up, the instep being made to touch the humerus and the heel the border of the shoulder-blade, a towel being first put into the axilla to rest the foot against (Fig. 489). If the left arm is dislocated, use the left foot, and vice versa. The elder Gross approved of making extension while sitting between the patient's limbs. Make steady exten-

sion, which will in many cases bring about the reduction. If it fails to cause reduction, bring the patient's arm across the chest and use the foot as the fulcrum of a lever. If the humerus is pretty firmly fixed in its abnormal position, make counterextension with a foot in the axilla and make extension by fixing a clove-hitch (see Fig. 480) *above the elbow*. We may fasten to it bands which go over one shoulder and under the other shoulder of the surgeon. The back may thus be used for extension, the hands being left free for manipulation (Allis's and Pick's plan). Lateral extension is used by some surgeons. The patient lies down, a large piece of canvas is split, the arm is passed through the split, and the body is thus fixed. The arm is pulled to a right angle with the body and traction is applied.

The late Prof. Joseph Pancoast favored *Sir Astley Cooper's method* of placing the unanesthetized patient in a chair and using the knee as a fulcrum, pushing the elbow to the side (Fig. 490). Brunus, in the thirteenth century, devised the method of *upward extension*. In applying this method the surgeon takes his place behind the patient, steadies the scapula with one hand, and carries the patient's arm upward and backward above his head, making extension and external rotation (Fig. 491). *La Mothe's method* is applied with the patient supine upon the floor. The surgeon places his foot upon the shoulder to make counterextension, and makes extension as in Brunus's method. It is a useful expedient, when either of these plans is applied, to have an assistant make the traction while the surgeon manipulates the head of the bone. Cock advises, when reduction fails, that an air-pad be placed in the axilla and the arm be bound to the side—a method by which reduction will sometimes take place after two or three days.



FIG. 490.—Reduction of shoulder-joint dislocation by the knee in the axilla (Cooper).



FIG. 491.—Reduction of shoulder-joint dislocation by upward extension (Cooper).

Pulleys should not be used to pull the bone into place, as they develop a dangerous force. In a dislocation irreducible by ordinary force antiseptic incision is safer and better than the pulleys. After incision try to restore the bone to place.

In reducing a dislocation the axillary artery or vein may be ruptured, fracture of the neck of the humerus may take place, injury to the brachial plexus may occur, or the soft parts may be badly damaged. After reducing a dislocation apply a Velpeau bandage, keep the shoulder immobile for one week, then make passive motion daily, reapplying the dressing after each séance. The patient may wear a sling only during the third week, after this period he may use the arm. (For Compound Dislocations see page 620.)

Unreduced and Irreducible Dislocations of the Shoulder.—In some cases where we find there is considerable movement without pain we can, by manipulation and active motion, increase the range of movement and the usefulness of the new joint.

As a rule, in a youth or a middle-aged person we attempt bloodless reduction if the head of the bone is movable and there is no prospect of a useful new joint. Give ether, break up adhesions by forced flexion and extension, and try Kocher's method, and, if this fails, the other methods, but never use violent force. In reducing an old dislocation we may fracture the surgical neck of the humerus. I have seen this happen twice. The proper method of reduction is incision and pulling the head into place by McBurney's hooks. In attempting reduction of an old dislocation by force the brachial plexus may be lacerated or one or both of the axillary vessels may be torn. If an axillary vessel is torn, it must be at once exposed by incision. A large tear in either vessel requires a ligature about the vessel on each side of the tear. A small tear may

be sutured (Keetley in "Lancet," Jan. 23, 1904). Rather than use sufficient force to endanger the vessels in attempting to reduce an old dislocation, practice incision. In some cases after incision the head of the bone can be pulled and pushed into place. In other cases the head must be resected. After reduction of an old dislocation put up in bandages for three weeks, and begin passive motion after seven days.

If a *dislocation* is *complicated* by a *fracture of the humerus* try to pull the head of the bone opposite the joint. This may be possible if the two fragments are held partly together by a fair amount of periosteum and muscle. Traction is exerted upon the arm, and an attempt is made to manipulate the head into the socket (Allis's plan in the hip). McBurney incises, fixes a hook in the scapula and a hook in the head of the humerus, pulls the head into place, and wires the fragments (see Figs. 315, 316). In an emergency gimlets may be used instead of the hooks. In some cases it is necessary to excise the head of the bone.

Habitual or **recurrent dislocation** of the shoulder, following an original traumatic dislocation, results usually from a slight or trivial force. It is apt to take place when the arm is in abduction, slight rotation frequently being necessary. In some cases rotation will produce a dislocation while the arm is near the side of the body. Little is known of the frequency with which these cases occur, but they are probably much more frequent than is generally supposed. The frequency of the recurrences in the individual cases varies widely. In some they occur more or less regularly every two or three years, while in others they have been known to take place daily and even several times a day. In most cases in the intervals between the recurrences the joint functionates normally without difficulty, although the patient fears abduction because of its influence in favoring a recurrence. In rare cases pain persists a long time after each dislocation, so that if the recurrences are frequent, the patient may be compelled to give up work.

Cause.—The essential cause is a relaxation of the capsule at the site of the original tear, produced by the addition to the old or original portion of capsule of a new or cicatricial portion bridging over the gap between the margins of the tear produced by the first dislocation. The failure of these margins to unite closely is due to the repeated emergence of the humeral head forcing them apart before union is complete. The defects in the head of the humerus which have been found at autopsy and operation have, probably, only a slight and secondary causal importance, while the fractures of the greater tuberosity of the humerus sometimes occurring in dislocations of the shoulder are probably not followed by recurrent dislocations.

Treatment.—Excision of the head of the humerus has been abandoned in these cases. Capsulorrhaphy for the shortening of the relaxed anterior portion of the capsule has given excellent functional results. Dawbarn, of New York, did this operation in my clinic, upon a city fireman, and the result was a perfect success. I have had two gratifying results. The capsule may be exposed through the usual resection incision along the anterior margin of the deltoid. This may be modified by an additional incision outward at right angles to the first, and the insertion of the pectoralis major may be partially divided. T. Turner Thomas advocated an axillary incision along the inner border of the coracobrachialis, passing between this muscle and the axillary vessels and nerves, and avoiding particularly the circumflex and musculocutaneous nerves. The subscapularis muscle is partially divided to give a freer exposure of the capsule. This route exposes, by a small incision, the site of the original tear in the capsule. It avoids division of the deltoid and gives dependent drainage if drainage is necessary. At present he prefers a posterior axillary incision. He has operated on 18 shoulders and has had 16 complete successes ("Surgery, Gynecology, and Obstetrics," 1914, xviii).

The relaxed portion of the capsule may be shortened by taking up a reef with catgut or silk sutures, without opening and exploring the joint for loose pieces of bone; the capsule may be incised transversely to its longitudinal fibers and the margins of the incision overlapped; an oval piece may be excised and the edges united by sutures; or the margins of the original tear may be found and sutured together.

Dislocation of the elbow-joint is not infrequent, and is commonest in children. Both bones or only one bone of the forearm may be dislocated, and the dislocation may be partial or complete.

Dislocation of Both Bones Backward (Figs. 492, 493, 494, 495). — The *causes* of backward dislocation of both bones of the forearm are falls upon the extended hand or twists inward of the ulna (Malgaigne). The coronoid process lodges in the olecranon fossa of the humerus.

Symptoms of Backward Dislocation.—In complete dislocation of both bones of the forearm the olecranon is very prominent. The distance between the point of the olecranon and the apex of the inner condyle is notably greater than on the sound side; the forearm is flexed, supinated, and shortened; the lower end of the humerus projects in front of the joint, below the skin crease; the head of the radius is found back of the outer condyle; and there are the general symptoms of dislocation. Fracture of the coronoid rarely occurs with backward dislocation, but if it does occur, there will be crepitus and mobility. Fracture at the base of the condyles is distinguished from dislocation of both bones of the forearm backward by the following points: in fracture there are found the ordinary symptoms; measurement from the condyles to the styloid

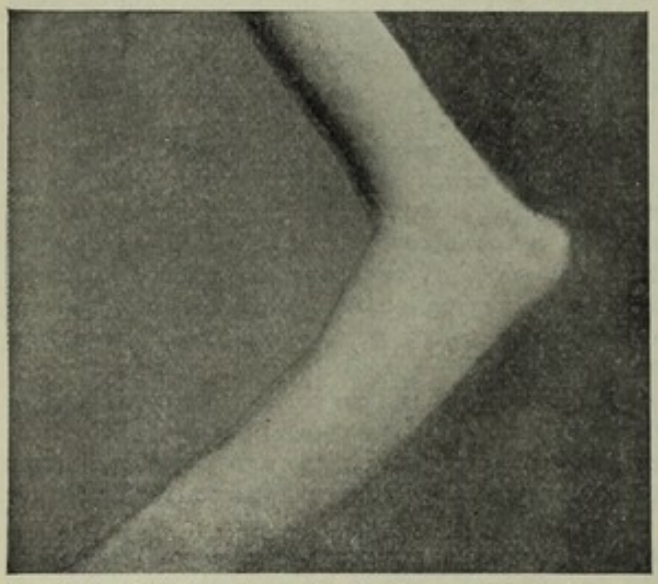


FIG. 492.—Dislocation of both bones of the forearm backward.



FIG. 493.—Complete posterior dislocation of both bones of left forearm (Dr. Ellis E. W. Given).



FIG. 494.—Posterior dislocation of the ulna and radius (U. S. Naval Hospital, League Island, Pa.; skiagraphed by Lieut. George U. Pillmore, Medical Corps, U. S. Navy).

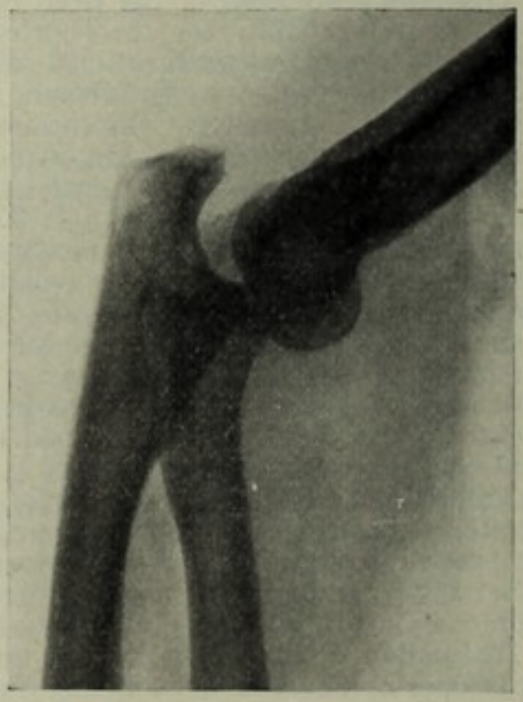


FIG. 495.—Posterior dislocation of the elbow (skiagraphed by Dr. Manges).

processes does not show shortening; there is no alteration of the normal relation between the olecranon process and the condyles; and the projection in front of the joint is above the crease of the bend of the elbow.



FIG. 496.—Professor Laplace's case of old backward dislocation of the elbow. There are calcareous deposits in the ligaments (skiagraphed by Dr. Pfahler).

Treatment of Backward Dislocation.—Reduction must be effected early in dislocation of both bones of the forearm, because it will soon become impossible, and an unreduced dislocation means a limb without the powers of flexion, pronation, and

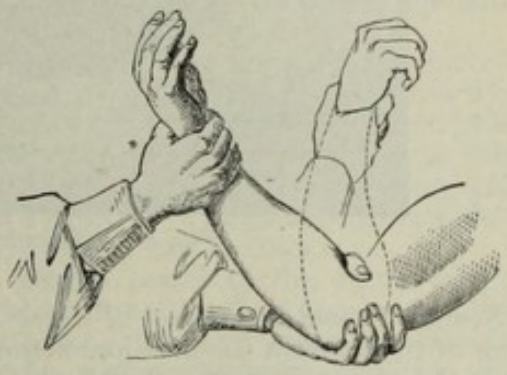


FIG. 497.—Reduction of elbow-joint dislocation.

supination (Fig. 496). The surgeon may place his knee in front of the elbow-joint, grasp the patient's wrist, press upon the radius and ulna with his knee, and bend the forearm with considerable force, the muscle pulling the bones into place (Sir Astley Cooper's plan). Forced flexion, traction, and extension may be tried (Fig. 497). Put the arm in Jones's position for two weeks, and make passive motion daily after the first few days.

Dislocation of Both Bones Forward.—The *cause* of forward dislocation of both bones of the forearm is a blow on the olecranon when the arm is flexed. It is an unusual accident.

Symptoms and Treatment.—The *symptoms* of forward dislocation of both bones of the forearm are: the forearm is flexed and lengthened; some slight motion is possible; the olecranon is on a level with the condyles if unfractured, hence its prominence is gone; the humeral condyles are felt posteriorly, and the radius and ulna are felt anteriorly. The *treatment* of this injury consists in early reduction, which is accomplished by means of forced flexion, extension, and pressure, placing the part in Jones's position for two weeks, and making passive motion daily after the first few days.

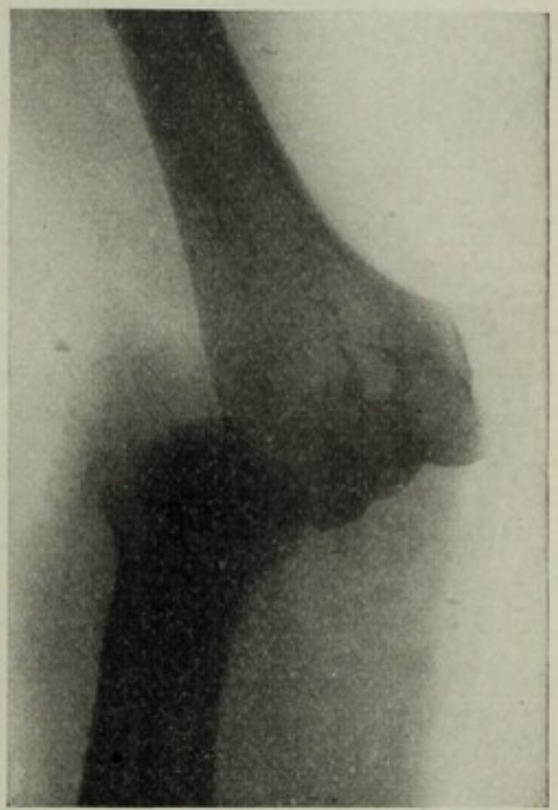


FIG. 498.—Lateral dislocation of the elbow (skiagraphed by Dr. Manges).

Lateral dislocation of both bones of the forearm is usually incomplete (Fig. 498).

Symptoms and Treatment of Outward Dislocation.—The *symptoms* of outward dislocation of both bones of the forearm are: the forearm is flexed, fixed, and pronated; the joint is widened; the head of the radius projects externally and has a depression above it; the inner condyle projects internally and has a depression below it; the olecranon is nearer than normal to the external condyle and further than normal from

the internal condyle. Reduction is effected by extension of the forearm and pressure inward upon the head of the radius. Apply an ascending spiral reversed bandage of the forearm, a figure-of-8 bandage of the elbow-joint, and a sling. Make passive motion after a few days. The bandages must be worn for two weeks.

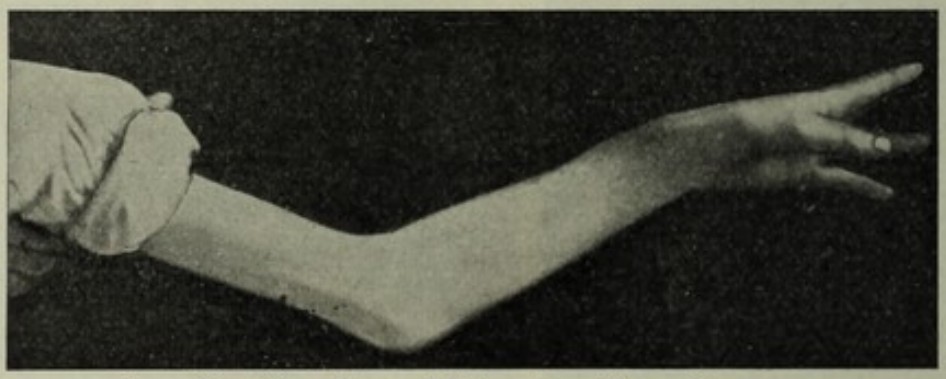


FIG. 499.—Forward dislocation of the radius.

Symptoms and Treatment of Inward Dislocation.—In dislocation inward of both bones of the forearm the position of the forearm is the same as that in dislocation outward; the sigmoid cavity of the ulna projects internally, and the external condyle of the humerus projects externally. Reduction is effected by extension of the forearm and pressure outward on the ulna, subsequent treatment being the same as that employed in the preceding form.

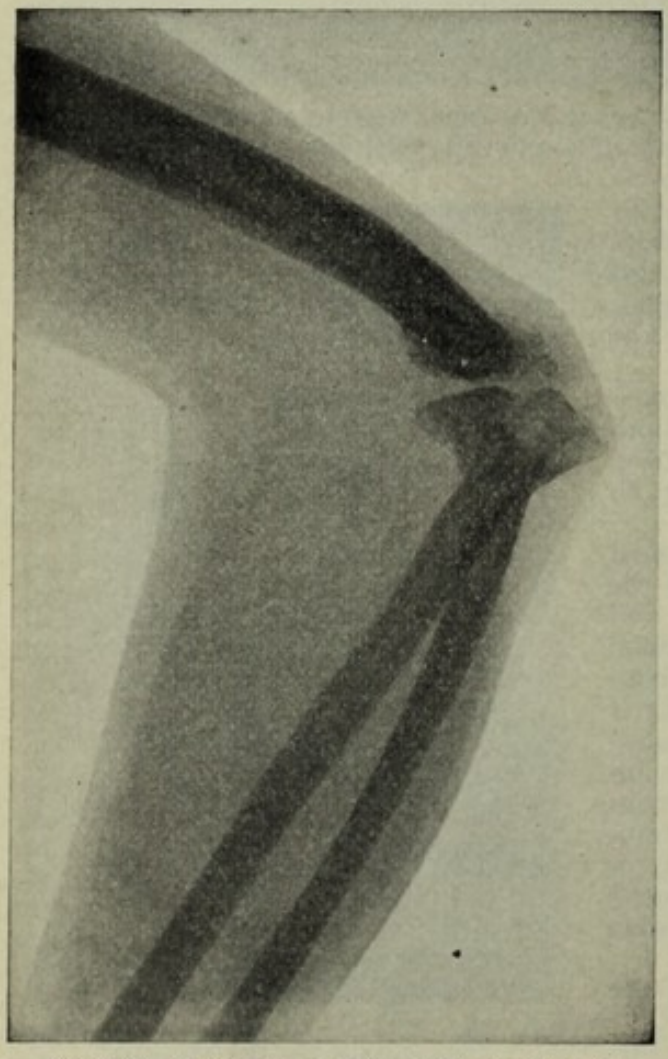


FIG. 500.—Dislocation of the radius backward.

Dislocation of the ulna alone is very rare, and can take place backward only.

Symptoms and Treatment.—Dislocation of the ulna alone is indicated by the forearm being flexed and pronated. The head of the radius is found in place, and the olecranon projects posteriorly. The *treatment* of this injury is the same as that for dislocation of both bones.

Dislocation of the radius forward (Fig. 499) is the commonest form of dislocation of the elbow. This injury is caused by a fall upon the hand with the forearm in pronation and extension, or is produced by blows on the back of the joint; forced pronation alone will not cause it.

Symptoms and Treatment.—The *symptoms* in dislocation of the radius forward are: the forearm is midway between pronation and supination, and is semiflexed; attempts to increase flexion cause the radius to strike against the humerus with a distinct blow; the head of the radius is felt in front of the outer condyle and is missed from its proper abode. Reduction is effected by flexion over the knee, extension, and manipulation. The subsequent treatment is Jones's position and passive motion. Deformity is apt to recur after reduction because of rupture of the orbicular ligament. If permanent dislocation exists, resection of the head of the radius is necessary. Passive motion

should be begun in two weeks after the resection. The results as to function and strength are usually excellent.

Dislocation of the radius backward (Fig. 500) is caused by falls on the hand or by blows on the front of the joint.

Symptoms and Treatment.—Backward dislocation of the radius is indicated by the forearm being slightly flexed and fixed in pronation, by some impairment of flexion and extension, and by the head of the radius being felt behind the outer condyle. Reduction is effected by flexion over the knee, extension, and manipulation, and the subsequent treatment is the same as that given for the preceding dislocation.

Dislocation of the radius outward is very rare. In this injury the head of the radius is distinctly felt. Reduction is effected by extension and pressure; the subsequent treatment is the same as that for the above-mentioned dislocations.

Subluxation of the Head of the Radius.—This name is given to an injury which is very frequent in children between two and four years of age. It results from traction upon the hand or the forearm, and often arises when the nurse or the mother pulls upon a child's arm to save it from a fall or to lift it over a gutter. Some writers hold that pronation as well as extension is required to produce the injury; many surgeons claim that extension and adduction are the causative forces. Hutchinson asserts that supination may cause subluxation. Bardenheuer assigned falls as causes.

The *symptoms* are very characteristic. The history points to the injury. Pain is complained of and perhaps a click may be felt about the elbow, and pain and a click will also be felt in the wrist at the time of the accident. The arm hangs by the side, with the elbow-joint slightly flexed and the forearm midway between pronation and supination. Flexion to an angle of less than 60 degrees and complete extension are resisted and are very painful, but movements between 60 and 130 degrees are free and painless.[1] The movements of the wrist-joint are free and painless. The elbow-joint presents no deformity. Pressure over the head of the radius causes pain. Strong pronation is painful; strong supination is very painful, and there seems to be a mechanical obstacle to its performance. Forced supination develops a distinct click at the head of the radius, and causes pronation and supination to become natural and free from pain. The condition will be reproduced if the parts are not immobilized for a time. The nature of the lesion is not understood, and various conditions have been thought to exist by different observers. Among them may be mentioned the following: a slight anterior displacement of the head of the radius; a slight posterior displacement; locking of the tuberosity of the radius behind the inner edge of the ulna; dislocation of the triangular cartilage of the wrist; intracapsular fracture of the radial head; painful paralysis from nerve injury; displacement by elongation, the return of the bone being prevented by collapse of the capsule; and the slipping up of the margin of the orbicular ligament over the rim of the head of the radius.

Treatment.—In order to reduce, place the forearm at a right angle to the arm and make forcible supination. Apply an anterior angular splint, and have it worn for four or five days, or put the part in Jones's position for an equal period.

Dislocation of the Inferior Radio-ulnar Articulation.—See page 634.

Dislocation of the Ulna Backward.—This is caused by forcible pronation, for instance, wringing clothes. The wrist is pronated and extended, the fingers are extended or semiflexed and almost powerless, supination is impossible, the hand is adducted and the head of the bone is prominent posteriorly on the radius. This is reduced by separating the two bones with the thumbs and pushing on the ulna while an assistant supinates the hand.

Dislocation of the Ulna Forward.—This is caused by forcible supination. Pronation is impossible. The wrist is narrowed and the ulna projects anteriorly. Reduction is secured by manipulation, extension, and pronation.

Madelung's deformity results from the strain of persistent heavy work upon the radius of one who has not yet reached puberty. The lower end of the radius becomes flexed, the ulna projects posteriorly. Slight backward projection of the ulna, the radius not being flexed, may arise from overwork in childhood. In such a case the ulna is hypertrophied and full extension is impossible.

Dislocation of the wrist is very uncommon and is caused by a fall upon the hand.

Backward Dislocation of the Wrist.—*Symptoms.*—The deformity in backward dislocation of the wrist (Fig. 501, A) resembles that of Colles's fracture (Fig. 501, B). The fingers are flexed, the wrist is bent backward, the radius projects on the front of the wrist, the carpus projects on the dorsal surface of the forearm, the relation of

[1] See the instructive article by W. W. Van Arsdale in "Annals of Surgery," vol. ix, 1889.

the styloid process of the radius to the styloid process of the ulna is unaltered (it is altered in Colles's fracture), there is rigidity, and crepitus is absent.

Forward dislocation of the wrist is very unusual and is caused by a fall upon the back of the hand.

Symptoms and Treatment.—In forward dislocation of the wrist the radius and ulna project posteriorly and the carpus projects in front. The *treatment* in both of these dislocations is reduction by extension and manipulation, the use of a Bond splint for ten days, and the employment of passive motion after five or six days.

Dislocation at the inferior radio-ulnar articulation is rare and is caused by twisting. A fracture occurs with it.

Symptoms and Treatment.—In *forward* dislocation at the inferior radio-ulnar articulation the forearm is pronated, the space between the styloid processes is diminished, and the ulna forms a projection posteriorly. In *backward* dislocation the forearm is supinated, the space between the styloid processes is diminished, and the ulna projects in front. Reduction is accomplished by extension and manipulation. Two straight splints (as in fracture of both bones) are to be applied for four weeks, and passive motion is to be made in the third week.

Dislocation of Individual Carpal Bones.—Pick says there is one weak spot, which is "between the head of the os magnum and the scaphoid and semilunar bones," and the os magnum may be forced up. It may arise in any severe wrist injury and may result from the backfire of a gas engine (Knapp in "Jour. Amer. Med. Assoc.," Dec. 9, 1922). The lesion is called by some dislocation of the os magnum backward. Some surgeons believe the condition is a dorsal dislocation of the carpus over the semilunar bone. Codman and Chase ("Annals of Surgery," March and June, 1905) regard the injury as really *dislocation of the semilunar forward*, a dislocation which may be associated with fracture of the carpal scaphoid. The injury is caused by forcible over-

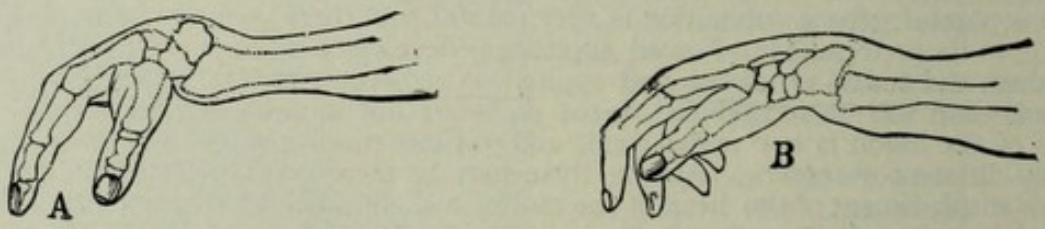


FIG. 501.—Deformity in dislocation of the wrist backward (A) and in Colles's fracture (B) (Stimson).

extension or by twisting of the wrist. According to Codman and Chase, the injury is most frequently met with in men between the ages of thirty and forty, results from violent force, immediately produces severe pain, soon followed by tenderness and ecchymosis. On examination a slight silver-fork deformity is observed, the posterior projection being the os magnum, this projection being separated from the radius by a groove which marks the former situation of the dislocated semilunar. The dislocated bone is felt under the flexor tendons of the wrist, the palm seems shorter than its fellow, the fingers are partly flexed, active or passive motion causes pain, and the *x*-rays exhibit the dislocated bone.

A trauma, even a slight one, which damages the ligament carrying the blood-supply to the semilunar, may be followed by rarefaction of that bone, and possibly fracture from slight force. Pain and swelling of the wrist persist, motion is circumscribed, and strength is lessened.

Treatment.—According to Codman and Chase, recent dislocations (even after the fifth week) may be reduced by hyperextension followed by hyperflexion over "the thumbs of an assistant held firmly in the flexure of the wrist or the semilunar" (Ibid.).

If bloodless reduction fails, the authors advise palmar incision and reduction, and if reduction fails, excision of the bone. Excision is seldom indicated. If in excising the semilunar the scaphoid is found to be fractured, the proximal part or the entire scaphoid must also be removed. The functional result from operation is excellent.

Dislocation of a metacarpal bone is seldom encountered. The first metacarpal bone is most liable to dislocation.

Symptoms and Treatment.—Dislocation of a metacarpal bone is obvious because of projection. It is reduced by extension and manipulation, a straight splint and large pad for the palm are applied (as in fracture of the metacarpus), and the splint is worn for three weeks.

Dislocation at a metacarpophalangeal articulation is unusual. Backward dislocation is the most common. The *cause* is a fall upon the hand.

Symptoms and Treatment.—A dislocation at a metacarpophalangeal articulation is obvious. Reduction is easily effected by extension and manipulation, except in the case of the thumb. A splint must be worn for three weeks.

Dislocation of the Metacarpophalangeal Joint of the Thumb.—Backward dislocation is the usual form. This dislocation is usually due to bending the thumb forcibly backward and tearing the anterior portion of the capsule. Lateral subluxations may occur. Forward luxation is very rare. There are two degrees of backward dislocation. In one the phalanx is extended. In the other vain attempts to reduce the bone bring the phalanx parallel with the metacarpal bone. In both forms the articular surface of the phalanx rests behind the head of the metacarpal bone. Cotton thinks that the usual obstacle to reduction is the interposition between the bones of a portion of torn capsule. In some cases the long flexor of the thumb gets to the ulnar side of the head of the metacarpal bone and hinders reduction (J. Hutchinson, Jr., in "Brit. Med. Jour.," Jan. 15, 1898). Farabeuf claims that the chief impediments to reduction are the sesamoid bones and glenoid ligament, which accompany the base of the phalanx in the dislocation. In cases in which reduction fails it is probable that the metacarpal bone has been caught between the tendon of the long flexor and one head of the flexor brevis (Cotton on "Dislocations and Fractures").

The *symptoms* of *backward* dislocation are as follows: The base of the first phalanx rests upon the metacarpal bone; the head of the metacarpal bone projects forward and buttonholes the muscles of the thumb; the first phalanx of the thumb is strongly extended, and the terminal phalanx is semiflexed. If attempts at reduction have been made and have failed, the phalanx may be dragged into a position parallel with the metacarpal bone. The *symptoms* of *forward* dislocation are as follows: The base of the first phalanx is felt in the palm, and the head of the metacarpal bone is felt posteriorly.

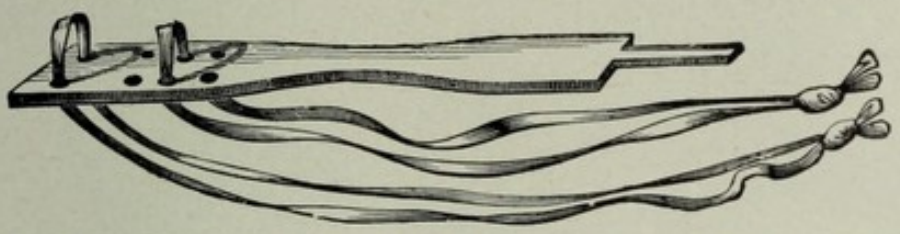


FIG. 502.—Levis's splint for reducing dislocation of thumb and phalanges.

Treatment.—In treating backward dislocation of the metacarpophalangeal joint of the thumb reduction may be difficult. Most cases can be reduced if ether is given. Hyperextend the digit and push it into place, rocking it and rotating it during the manipulation (Cotton, Ibid.). Keetley's directions are to adduct the metacarpal bone into the palm (this relaxes the flexor muscles) and to have an assistant hold it; bend the thumb strongly back, extend, pull the thumb toward the fingers, and suddenly flex. To get a firm enough grasp for these manipulations use the apparatus of Charrière or of Levis (Fig. 502). If the above maneuvers fail, it is probable that the head of the metacarpal has buttonholed between the tendon of the long flexor and a head of the short flexor. In such a case operate. Incise freely on the dorsum and reduce. Tenotomy is seldom of service. After reduction of this dislocation a splint must be worn for three weeks. In *forward* dislocation reduction may be effected by strong extension and forced flexion. If reduction fails, operate. After reducing a forward dislocation a splint is to be worn for three weeks. Lateral subluxations are put in place and treated by splints.

A **dislocation of a phalanx** may be complete or may be partial. It is most common between the first and second phalanges.

Symptoms and Treatment.—Dislocations of the phalanges are obvious. In reducing such dislocations employ extension and manipulation. Use a splint for one week.

Dislocations of the Ribs and Costal Cartilages.—The ribs may be dislocated from the vertebræ. This accident is seldom uncomplicated, and cannot be differentiated from fracture without a skiagraph. The diagnosis is rarely made, and the injury is treated as a fracture. The ribs may be dislocated from their cartilages, one or more ribs being displaced. The end of the rib forms an anterior projection, there is a depression over the cartilage, and crepitus is absent. *Treatment* is the same as that employed for fractured ribs. The costal cartilages may be displaced from the sternum,

forming an anterior projection upon this bone. Reduction is brought about by placing the patient upon a table, with a sand-pillow between the scapulæ, pushing back the shoulders and chest, and forcing the cartilage into place. The dressings are the same as those used for fractured sternum. The cartilages of the lower ribs (sixth, seventh, eighth, ninth, and tenth) may be separated. The inferior cartilage goes forward and can be felt. Pick states that reduction is brought about by causing the patient to hold the chest full of air while efforts are made to push the cartilage into place. The injury is dressed as are fractured ribs (see Fig. 348, 13).

Dislocation of the Sternum.—In dislocation of the body of the sternum the manubrium is separated from the gladiolus. The injury is a rare one, is usually associated with fracture, and is most common in the young. It is due in most cases to violent direct force inflicted by a fall or heavy blow; it may be due to indirect force, as shown in a reported case of acute tetanus. The *symptoms* and *treatment* are the same as those of fracture (see page 506). Dislocation of the ensiform process is one of the rarest

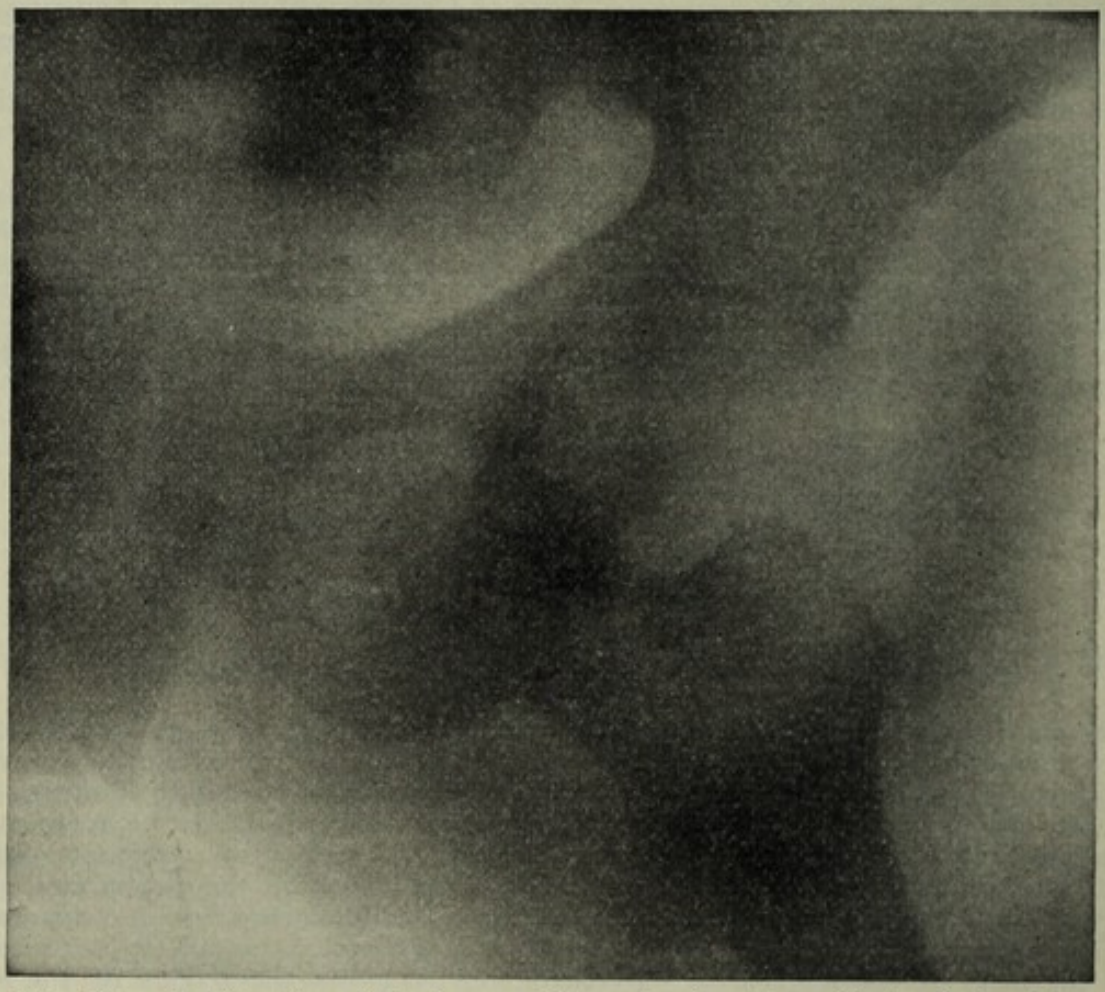


FIG. 503.—Thyroid dislocation of the femur eight weeks after the accident. Reduced by open section (Rugh).

of injuries. It is usually due to direct force, but Polaillon reports a case caused by tight lacing.

Pelvic dislocations are almost always complicated by fracture. A pubic bone can be dislocated by falls from a height or by the application of violent force to the acetabula. The condition may happen from accident while riding a horse. The dislocation may be up or down, front or back, and it may damage the urethra or the bladder. The patient cannot stand; there are great pain and recognizable deformity. Treat by molding the bones into place, by applying a pelvic girdle, and by rest in bed for four weeks. Pure separation or relaxation of the symphysis is seldom the result of injury and is usually due to childbirth. In this condition there is mobility, pain on pressure and movement, and pain on abduction of the thighs. The treatment is rest in bed and the application of a pelvic girdle. Occasionally in traumatic and also in postobstetric separation it is necessary to wire the bones. Dislocation of the sacroiliac joint may be produced by falls. It is a very rare injury. The ligaments are so

thick and strong that pelvic bones usually break rather than ligaments. In most reported cases the pelvis was also fractured. Both sacro-iliac joints may be dislocated as a complication of separation of the pubic symphysis. Double dislocation is nearly always fatal from laceration of the iliac vessels, injury of the pelvic contents, or intra-abdominal damage. Movement on the part of the patient is difficult or impossible; there is violent pain and often paralysis (from pressure upon nerves). In dislocation backward there is apparent shortening of the leg, eversion of the foot exists, and the ilium moves posteriorly and upward. In dislocation forward the anterior superior iliac spine projects and the pelvis is broadened. Sacro-iliac dislocation is reduced by holding the pelvis firm and making extension by means of a pulley. The patient stays in bed for four weeks and wears a pelvic belt as in fracture. Always examine carefully for fracture, intrapelvic damage, and intra-abdominal injury.

Dislocation of the Coccyx.—(See Fracture of Coccyx on page 511).

Dislocation of the Femur (Hip-joint).—Dislocation of this joint is not often encountered, as the hip-joint is very strong. In 23,000 surgical admissions to the Episcopal Hospital of Philadelphia, 6000 of which were surgical injuries, there were 10 dislocations of the hip (Steinke in "Annals of Surgery," 1914, lx).

It is far more common in males than in females and is most apt to occur in a young adult. It is very rare in those beyond middle life, but occasionally occurs in the early sixties. In forcible extension the head of the femur presses against the capsule of the joint, but the capsule here is very thick, and certain muscles, the rectus, psoas, and iliacus, are pulled tight and serve to strengthen it. The head of the bone cannot go directly upward because of the acetabulum (Edmund Owen). The weak point of the acetabular rim is below; the weak part of the capsule is also below; hence forced abduction is apt to push the head of the bone through the lower part of the capsule, a dislocation occurring primarily into the thyroid foramen. The signs of the dislocation depend upon the untorn portion of the capsule. The anterior portion of the capsule, including the Y ligament, usually escapes laceration. Vessels are rarely injured. Muscles are often torn. In some cases the sciatic nerve is lacerated, bruised, or caught up on the neck of the femur during the circumduction of attempted reduction. Four forms of hip-joint dislocation are usually described: (1) upward and backward, on the dorsum of the ilium; (2) backward, to the border of the sciatic notch; (3) downward, into the obturator foramen, and (4) inward, on the pubes.

All dislocations are primarily inward or outward. From these initial positions the head may be shifted to any region about the socket within reach of the remnant of untorn capsule (Oscar H. Allis). Allis rejects the old classification and suggests the following:

Low thyroid, Mid- " High " } All present abduction and outward rotation.

Reversed thyroid:

Low dorsal, Mid- " High " } All present adduction and inward rotation.

Dislocation upon the dorsum of the ilium (Figs. 504, 505) is the commonest form. One-half of all hip dislocations are of this variety. It is *caused* by a fall or a blow when the limb is flexed and abducted (as in carrying a weight upon the shoulder), by a fall upon the knee or foot, by a weight striking the back while bending, etc. Allis says rotation inward is the chief element in its production. In this dislocation the head of the femur goes upward and backward, rests upon the ilium, and is always above the tendon of the obturator internus muscle. This dislocation is secondary to thyroid dislocation, muscular action shifting the bone from its seat of displacement.

Signs.—Dislocation upon the dorsum of the ilium is indicated by the following symptoms: the buttock appears flat and broad; the great trochanter is above Nélaton's line and is deeply placed; the head of the bone can be detected in its new situation; deep pressure in front of the joint finds a hollow; the leg is shortened by about 2 or 3 inches; the fascia lata is relaxed; in some thin people the socket can be outlined; when the patient is recumbent the injured extremity can be brought to the perpendicular without flexing the leg (Allis); the knee is somewhat flexed; the thigh is slightly flexed, inwardly rotated, and adducted (Figs. 504, 506) (this is shown by the fact that the axis of the thigh of the injured side, if prolonged, would pass through the lower third of the sound thigh); when the capsule is extensively lacerated there may be no adduction and may be eversion (Allis); the heel is raised, and the great toe of the foot of the

injured side rests upon the front of the instep or the ankle of the sound side (Fig. 506); rigidity exists; voluntary movement is impossible, though some passive motion is possible in the direction of the deformity (the deformity can be made more marked). If a patient is recumbent and the knees vertical, the foot of the sound extremity is free of the bed, but the foot of the injured extremity touches the bed (*Allis's sign*).

Diagnosis.—Examine first without anesthesia. The *x*-rays are invaluable in diagnosis. If the *x*-rays are not obtainable, examine again while the patient is anesthetized. Dislocation is distinguished from intracapsular fracture by noting the inversion, the great shortening, the absence of crepitus, the age of the subject, and the nature of the force. The nature of the force, the inversion, and the absence of crepitus mark the diagnosis from extracapsular fracture.



FIG. 504.—Dr. James Kelly's case of dislocation of the femur onto the dorsum of the ilium.

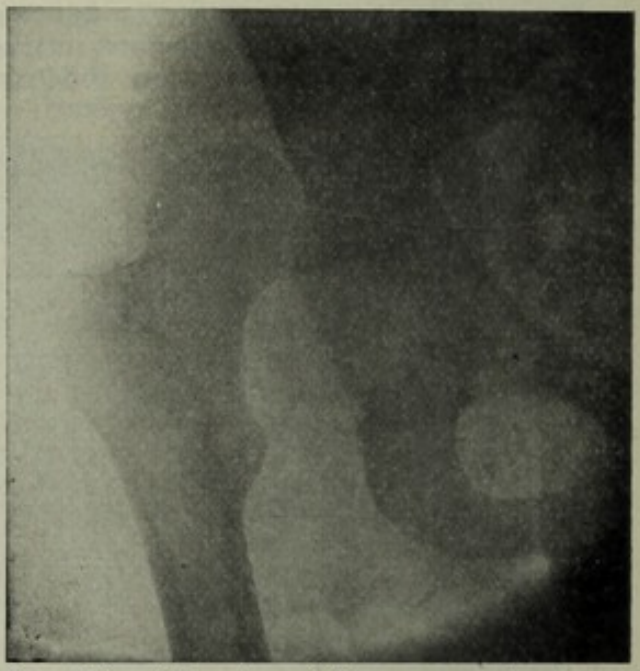


FIG. 505.—Dislocation of femur upon the dorsum of the ilium (Dr. Ohnesorg's case).

Treatment.—The chief obstacle to reduction in dislocation upon the dorsum of the ilium, Bigelow states, is the untorn portion of the capsule, especially the Y-ligament. The iliofemoral, Y, or Bigelow's ligament resembles an inverted Y, arises from the anterior inferior spine of the ilium, is inserted into the anterior intertrochanteric line, and is incorporated into the front of the capsule. To reduce a dislocation this ligament must be relaxed by manipulation or be torn by extension. Manipulation makes the head of the bone retrace its steps over the same route it took in emerging. Give ether; place the patient supine upon a mattress on the floor; flex the leg on the thigh (to relax the hamstrings), flex the thigh on the pelvis; increase the adduction over the middle line; strongly abduct; perform external rotation and extension. This treatment may be summed up as flexion, adduction, external circumduction, and extension; or, as Pick puts it, "bend up, roll out, turn out, and extend." Allis's advice is to fix the pelvis to the floor, lift the head of the bone to the level of the socket, rotate outward by carrying the leg toward the pubis, and extend the femur. If extension and counterextension are employed, make extension in the axis of the dislocated limb and obtain counterextension by a perineal band. The extension band is fastened to the thigh by a clove-hitch. After reduction put the patient to bed and use sand-bags (as in fracture of the hip) for four weeks. We may tie the knees together instead of using the sand-bags. Passive motion is made in the third week. The pulleys must not be used in reduction. They might inflict great or even fatal injury. If the surgeon fails to reduce the deformity, there are two courses open to him. He may let it alone. He may operate. If he lets it alone, the limb will almost certainly become ankylosed, though probably useful. If he determines to operate, he must recognize that tenotomy is useless. It is necessary to make a free incision in order to restore the bone.

Dislocation Onto the Border of the Sciatic Notch.—In this dislocation the head of the bone passes backward and a little upward, and rests upon the ischium at the margin of the sciatic notch (not in the notch), below the tendon of the obturator internus muscle. The *causes* are the same as those given for the previous dislocation.

The *signs* of dislocation into the border of the sciatic notch are like those of dislocation upon the dorsum of the ilium, but they are not so marked. There are flattening and broadening of the hip; ascent of the trochanter above Nélaton's line; shortening to the extent of an inch; relaxation of the fascia lata. If the knee of the injured side is vertical, the sole of the foot touches the bed. Flexion, inward rotation, and adduction exist, but the axis of the femur of the injured side passes through the knee of the sound side, and the ball of the great toe of the injured side rests upon the great toe of the sound side (Fig. 507). Other symptoms are identical with those of dislocation upon the dorsum of the ilium, but are less pronounced. Allis's signs of this dislocation are of value: if, with the patient recumbent, the thighs are brought to a right angle with the body, shortening on the affected side is materially increased; if the dislocated thigh is extended, the back arches as in hip disease.

Diagnosis and Treatment.—The signs of dislocation onto the border of the sciatic notch are similar to, but are less marked than those of dorsal dislocation, and, being a backward dislocation, the reduction and treatment are the same as for dislocation backward upon the dorsum of the ilium.

Dislocation Downward Into the Obturator Foramen (Figs. 503, 508).—Downward dislocation is the primary position of most dislocations of the hip, the bone rarely remaining in the thyroid foramen, but usually mounting up as a result of muscular



FIG. 506.—Hip-joint dislocation upon the dorsum of the ilium (Cooper).



FIG. 507.—Hip-joint dislocation onto the border of the sciatic notch (Cooper).



FIG. 508.—Hip-joint dislocation into the obturator or thyroid foramen (Cooper).



FIG. 509.—Dislocation on the pubis (Cooper).

action or of the initial violence. The *cause* is a violent abduction by falls or by stepping from a moving car.

Signs.—Dislocation downward into the obturator foramen is indicated by flattening of the hip; the head of the bone is felt in its new position and is missed from the acetabulum; rigidity exists; passive motion is only possible in the direction of deformity, and that to a slight extent; a hollow is noted over the great trochanter, which process is well below Nélaton's line and nearer than normal to the middle line. The gluteal crease is lower than is the crease of the opposite side; there is lengthening to the extent of 1 to 2 inches; the body is bent forward by the traction upon the psoas and iliacus muscles, and is also deviated to the side, thus causing great apparent lengthening; the limb is advanced partially flexed and abducted, and the foot is pointed straight ahead or is a little everted (Fig. 508); when the patient is recumbent extension is impossible, the knees cannot be pushed together without great pain, and the abductor muscles are hard and rigid. Allis's signs are absent. Unreduced dislocations usually do well, the patient obtaining a very useful hip-joint (Sédillot).

Treatment.—In treating dislocation downward into the obturator foramen give ether and effect reduction, if possible, by manipulation, and, if this fails, by extension. To reduce by manipulation flex the leg on the thigh and the thigh on the pelvis, and then perform, in the following order, abduction, internal circumduction, and extension. Allis's rule of reduction is as follows: fix the pelvis to the floor; pull the head of the femur outward and above the socket; fix the head; push the knee toward sound knee and extend the femur. If extension is made, make traction in the axis of

the limb by means of muslin fastened around the thigh by a clove-hitch. Do not use pulleys; incise rather than use them.

Dislocation upon the pubis is a very uncommon accident. The head of the bone usually rests just internal to the anterior inferior spine of the ilium. The primary position of the bone is in the thyroid foramen; the pubic dislocation, when it occurs, is always secondary, and is due to the initial force and to muscular action.

Symptoms.—In pubic dislocation the head of the bone can be felt and seen in its new position; the hip is flattened; there is a hollow over the great trochanter, this process being found below the anterior superior spine of the ilium; there is shortening to the extent of 1 inch; the limb is in abduction with eversion (Fig. 509), and the knees cannot be approximated without great pain.

In the *treatment* of pubic dislocation give ether and employ manipulation as for thyroid dislocation. If this fails, employ extension. The limb is well abducted, extension is made downward and backward, and the head of the femur is pulled outward "by a towel around the thigh, just beneath the groin" (Keetley). The after-treatment is the same as that for the previous forms.



FIG. 510.—Dislocation of left hip. Fracture of acetabulum, ischium, and pubes (right), with central dislocation of hip. Separation of pubic arch.

Central or Internal Dislocation (Fig. 510).—By this term we mean that the head of the femur has been displaced and perhaps forced through a fractured acetabulum into the pelvis. It is not a genuine dislocation. There is neither tearing nor stretching of the capsule and the acetabular floor may remain in contact with the femoral head. Skillern and Pancoast ("Annals of Surgery," Jan., 1912) point out that "the injury varies from a light depression of the floor of the acetabulum . . . to the passage of the femoral head into the pelvic cavity." For the first injury they suggest the term *fractura acetabuli perforans;* for the second, *fractura acetabuli perforata.* This injury is due to violent force. The usual cause is a fall upon the great trochanter. The symptoms vary with the degree of depression or fracture of the floor of the acetabulum. If there is only slight depression of the floor, there may be no appreciable shortening and very slight approach of the trochanter toward the symphysis pubis. The *x*-rays may be needed to make a diagnosis. If the head has perforated, shortening will be evident, there will be marked approach of the great trochanter toward the midline, and vaginal or rectal palpation will discover the displaced femoral head. In both injuries there are pain, tenderness, and impaired mobility. There may be serious damage within the pelvis. Intrapelvic hemorrhage is common. The peritoneum may be lacerated, the bowel may be damaged, the bladder injured, or the obturator nerve bruised (Skillern and Pancoast, Ibid.).

Treatment.—If complications such as are mentioned above exist at once open the abdomen and repair the injury. Reduce the deformity by extension and counter-extension. Treat by "extension in the axis of the limb in conjunction with lateral traction upon the femoral neck" (Ibid.). After a week, if there is no contraindication, apply a plaster-of-Paris dressing from the toes to the chest.

Skillern and Pancoast (Ibid.) state that the injury was first described by Callisen in 1788, and that, with their 4 cases, 55 have been reported.

Anomalous Dislocations of the Hip.—In *supraspinous dislocation* the dislocation of the hip is backward, the head of the femur resting upon the ilium above or even

anterior to the anterior superior spine. In *ischial dislocation* the dislocation is downward and backward, the head of the femur resting on the ischial tuberosity or in the lesser sciatic notch. *Monteggia's dislocation* is a supraspinous dislocation with eversion of the limb. In *perineal dislocation* the head of the femur is in the perineum. In *suprapubic dislocation* the head of the femur passes above the pubes. In *subspinous dislocation* the femoral head rests on the horizontal ramus of the pubes.

Dislocation with Catching Up of the Sciatic Nerve During Reduction.—This accident causes severe pain. The leg is flexed on the thigh and the thigh is flexed on the pelvis. Allis tells us that the task of reduction is very unpromising. We must strive to put the neck of the femur in such a position that the nerve will "drop off," and yet often the nerve cannot drop off because it is held by adhesions to the injured muscles. Allis attempts reduction by the following plan:

1. Place the patient upon his back and redislocate the femur.
2. Extend the thigh.
3. Flex the leg on the thigh.
4. Turn the ankle out until the leg is horizontal (this causes the head of the bone to look downward).
5. "Shake, shock, jar, adduct, and abduct," to disengage the nerve.
6. Rotate the head into the socket without flexing the leg (without making the nerve tense).
7. If this fails, make an incision above the popliteal space, and draw the nerve out of the wound. Detach the head of the bone from its entanglement and rotate it into the socket.[1]

Dislocation of the Head of the Femur with Fracture of the Shaft of the Bone.—We may incise, replace, and plate the fragments. We may use McBurney's hooks as in the shoulder. We may be forced to do a resection of the head.

Allis maintains that it is possible to reduce it by manipulation. He states that the upper fragment is the entire lever, and the lower fragment "is only the agent through which we apply our force." The fragments are not completely separated, but are connected at one side by material which is "partly periosteal, partly tendinous, and partly muscular." This connecting material enables us to make traction upon the upper fragment, but does not allow "rotation, circumduction, and leverage through the agency of the lower fragment." Hence "the only agency at our command is traction." If the dislocation is inward (forward), draw the head outward and have an assistant make direct pressure upon the head of the bone. If this fails, the assistant holds the head of the bone to prevent its slipping into the thyroid depression, and the surgeon makes traction inward or inward and downward. If the dislocation is outward (backward), make traction directly upward to lift the head of the bone to the level of the socket, and try to place the head over the socket by traction obliquely upward and inward. During all these manipulations an assistant presses upon the trochanter to prevent the head of the bone slipping back. Traction is now made downward and inward, and the tightened ligament may drag the head of the bone into place

Dislocation of the Knee.—It is a rare injury. There are four forms—forward, backward, outward, and inward. Any one of the four may be complete or incomplete the commonest dislocations are lateral. The *cause* is violent force, such as a fall, or in jumping from a moving train, or in being caught by the foot and dragged.

Dislocation Forward of the Knee-joint.—In the *complete* form of forward dislocation the deformity is obvious. The limb is usually extended, but it may be flexed. Much shortening exists; the condyles are felt posterior and below; the head of the tibia is felt anterior and above; the patella is movable and the quadriceps is lax; pressure of the condyles upon the contents of the popliteal space arrests the tibial pulse and causes edema and intense pain. In *incomplete* dislocation the symptoms are identical in kind, but are less pronounced.

Treatment.—Compound dislocation of the knee-joint may demand excision or amputation. In simple dislocation give ether, have one assistant extend the leg while another makes counterextension on the thigh, and the surgeon pushes the bone into place. Reduction is easy because of ligamentous laceration. Place the limb on a double inclined plane, and combat inflammation by the usual methods (see Synovitis, page 579). Begin passive motion in the third week. The patient must wear a knee support for months. Very extensive laceration of ligaments calls for incision and

[1] Allis's views will be found in "An Inquiry Into the Difficulties Encountered in the Reduction of Dislocations of the Hip," by Oscar H. Allis, M. D. This highly original and valuable treatise received the Samuel D. Gross Prize of the Philadelphia Academy of Surgery in 1895.

suturing. If the popliteal vessels are much damaged, gangrene will probably supervene and amputation will be demanded.

Dislocation Backward of the Knee-joint.—In the *complete* form of backward dislocation of the knee-joint displacement is not so great as in dislocation forward. The head of the tibia projects posteriorly and above, the femoral condyles anteriorly and below; the leg is, as a rule, partly flexed, but it may be extended, and there is moderate shortening. In *incomplete* dislocation the symptoms are less marked.

The *treatment* of backward dislocation of the knee-joint is the same as for forward dislocation.

Dislocation outward of the knee-joint is usually incomplete. The inner tuberosity of the tibia in outward dislocation lies upon the outer condyle of the femur (Pick); the inner condyle of the femur projects internally; the outer tibial tuberosity and fibular head project externally, the inner condyle having a depression below it, and the tibial head above it; the leg is semiflexed, but shortening is absent.

Dislocation inward of the knee-joint is usually incomplete. The outer tuberosity of the tibia in inward dislocation lies upon the inner condyle of the femur; the outer condyle of the femur forms an external prominence, and the inner tuberosity of the tibia forms an internal prominence. Pick cautions us not to mistake a separation of the lower femoral epiphysis for lateral dislocation (the former is reduced easily, the deformity tends to recur, and there is soft crepitus).



FIG. 511.—Old dislocation of the patella outward.

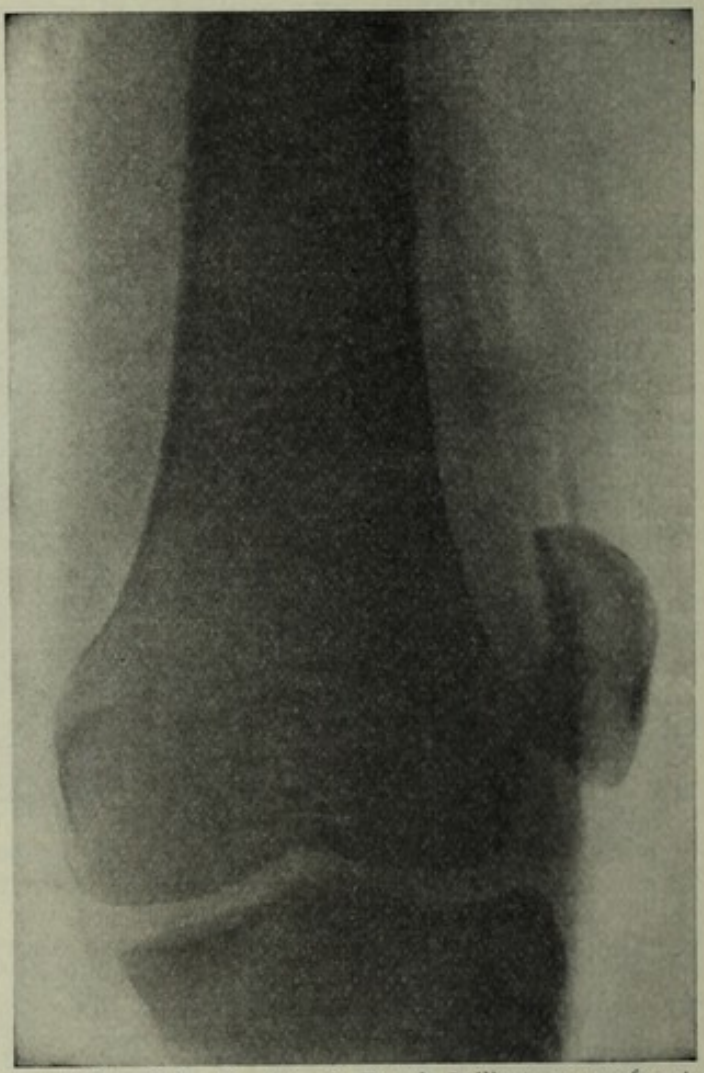


FIG. 512.—Dr. Morris Booth Miller's case of outward dislocation of the patella from direct force. Six months after the fall. Failed of reduction under ether anesthesia.

Treatment.—In treating lateral dislocation of the knee-joint, effect extension and counterextension as in anteroposterior dislocations. The leg is moved from side to side and attempts are made at rotation. The after-treatment is the same as that for anteroposterior luxations.

About 200 traumatic cases have been reported (Eisendrath in "Keen's Surgery").

Dislocation of the patella is seldom congenital. There are 35 congenital cases on record (Bajardi). There are three forms of dislocation of the patella: the

outward, inward, and edgewise. Nearly all dislocations are outward. The so-called dislocation upward is, in reality, rupture of the ligamentum patellæ (see page 674).

Dislocation of the patella outward (Figs. 511 and 512) may be due to muscular action or to direct force. It occurs particularly during efforts to avert a fall, the knee being flexed and rotated inward. It occasionally happens on a person with knock-knee. If dislocation is complete the bone lies upon the epicondyle; if incomplete, the patella is still in contact with the trochlea. The leg is partly flexed, but full flexion is impossible, and attempts at full flexion produce great agony. In the patient shown in Fig. 511 flexion became possible in an unreduced dislocation, but not until months after the accident. The knee is wider than normal. There is a hollow in front of the joint. The bone is seen and felt in its new position.

Dislocation of the patella inward is very rare. The signs are like those of dislocation outward, except that the patella rests upon the inner condyle.

Treatment of Lateral Dislocations of the Patella.—Give ether. Raise the body upon a bed-rest and flex the thigh. Grasp the patella and depress the margin which is farthest from the center of the joint (Pick). The muscles may pull the bone into place. Extend the extremity and immobilize for three weeks, and then begin passive motion. Incision may be necessary in order to effect reduction.

Dislocation of the Patella Edgewise.—The patella rotates vertically, one edge resting between the condyles. As a rule, the outer border is in the intercondyloid notch. This condition is produced by direct force when the extremity is partly flexed. Twisting and muscular action have been assigned as causes. The condition is obvious at a glance.

Treatment.—Give ether. Pick recommends "sudden and forcible bending of the knee." In some cases the bone can be pushed into place, the limb being extended and flexed as in the reduction of a lateral dislocation. In some cases incision will be necessary.

Dislocation of the Semilunar Cartilages of the Knee-joint (*the Internal Derangement of Hey; Subluxation of the Knee-joint*).—The condition was described by William Hey, of Leeds, in 1803 ("Practical Observations on Surgery," London, 1803). The interarticular cartilages of the knee-joint are attached in front of and behind the tibial spine, and the convexity of each cartilage is attached to the edge of the corresponding tibial tuberosity by means of the coronary ligament. The internal cartilage is fastened to the internal lateral ligament and has a moderate freedom of movement. The outer cartilage is not connected with the external lateral ligament and is not freely movable. The internal cartilage is the most prominent. When the joint is flexed the cartilages move backward, when it is extended they move forward. Cartilage injuries are most common in miners and athletes. To be much upon the knees predisposes (carpet layers, miners). It has been called *miner's disease*. Catching the foot and stumbling is a common cause. Direct trauma is an occasional cause. It has been stated that the outer cartilage is more frequently dislocated than the inner, but modern experience indicates that this is not true, and that the internal cartilage is the one to suffer in at least 8 cases out of 10. Sir Robert Jones, of Liverpool, finds that the internal cartilage gets in trouble seven times as often as the external cartilage. Henderson never found it necessary to remove the external cartilage ("Jour. Amer. Med. Assoc.," Feb. 3, 1917). Strahlmann and White ("Jour. Amer. Med. Assoc.," Feb. 26, 1921) find that the internal cartilage is involved five times as frequently as the external, but insist that injury of the external does occur and must not be lost sight of. The mechanism of dislocation of the internal cartilage is set forth with admirable clearness by J. K. Surls and R. B. Osgood ("Jour. of Bone and Joint Surgery," Oct., 1923). Their views are as follows: The damage is done by forced internal rotation of the femur while the knee is flexed. Normally the only rotation possible is between the cartilage and the tibia and the cartilage slides inward over the tibia as far as possible. As the force continues deep fibers of the internal lateral ligament tear, and usually near the tibial origin (with or without sprain fracture), the cartilage tears from the periphery (front or back) or fractures across or longitudinally. The anterior crucial ligament receives the strain next (may be stretched or ruptured) and the tibial spine may be torn off. The posterior crucial suffers next and finally the joint may be dislocated. Dislocation of the external semilunar is caused by external torsion.

Separation at the periphery is the most common injury of the cartilage, but the inner edge may be separated and rolled up.

A cartilage once damaged is strongly predisposed to renewed injury from trivial forces.

Symptoms.—If the injury is a limited peripheral separation, there is no locking or slight locking and the signs are not marked. When there is definite displacement the symptoms are severe. The first indication of interarticular cartilage displacement is a sudden, violent, sickening pain in the knee, which may be so severe as to cause the patient to fall to the ground. The knee is in a position of fixed semiflexion. Further flexion is possible, but extension is impossible. In some cases the patient can voluntarily make further flexion; in others the pain is so severe that he either cannot or will not do it; but increase of flexion can be obtained by passive motion. The joint is, however, blocked both to passive and to voluntary extension. Attempts at passive extension are productive of fierce pain. If either cartilage is displaced at the periphery, a prominence may be found on one or the other side of the knee-joint. If the displacement takes place toward the tibial spine a prominence may be found on one side of the ligament of the patella. Cartilage separation is rapidly followed by inflammation of the synovial membrane of the joint and inflammation of the cartilage itself; and swelling quickly masks the projection of the cartilage. This accident is frequently mistaken for the blocking of the joint by a floating cartilage; but a dislocated cartilage always remains in the same position, and a loose cartilage changes its position from time to time (Turner). Loose bodies in a joint produce pain of a shifting character and interference with both flexion and extension, or with either flexion or extension in an irregular way (Cotterill). In regard to the diagnosis Cotterill points out that in a sprain of the joint extension is not painful, but flexion is interfered with; whereas, in the dislocation of a cartilage of the joint, flexion is still possible, but extension cannot be carried out ("Lancet," Feb. 22, 1902).

The surgeon must ever bear in mind that some unrecognized disease of the articulation may have rendered the cartilage prone to dislocation and should examine and watch for the evidences of tuberculosis, syphilis, and osteo-arthritis.

Treatment.—To reduce a displaced semilunar cartilage I have used with satisfaction a method described by Henry W. Jacob ("Brit. Med. Jour.," March 7, 1908). It is not followed by severe synovitis unless the patient has walked or has made repeated efforts to reduce the displacement, and as it is a painless method ether is not required. Jacob describes it as follows:

"The patient lies on a bed or couch, the surgeon standing on the outer side of the limb affected, with his face toward the patient's foot; the patient then raises his leg off the couch in the semiflexed position, the surgeon grasps the patient's leg in both hands, and using his own thigh as a fulcrum, by means of a steady pulling movement draws the patient's leg outward while the surgeon's thigh keeps the patient's femur in a fixed position; directly this movement is effected the patient must steadily extend the limb, and the displaced cartilage will probably go back with a slight click; if the first movement of extension is not successful the maneuver must be repeated without any hurry or unnecessary force, and after a few attempts the cartilage can usually be felt to slip in without pain or inconvenience."

In treating dislocation of a semilunar cartilage of the knee it is customary to give ether and reduce by forced flexion and internal rotation of the tibia. Extension becomes possible if the cartilage is freed. During these maneuvers an assistant endeavors to push any projection of cartilage into place. Sir Robert Jones reduces the cartilage by acutely flexing the leg, abducting the knee, rotating the lower leg in the direction the hands of a clock move, telling the patient to make forcible extension by kicking and aiding him in the accomplishment of it. Reduction takes place if full extension is possible.

If this manipulation fails, reverse it in part. The formula is flexion, sudden extension, and rotation of the lower leg during extension in "a counter-clockwise direction" (Surls and Osgood, Ibid.). It is sometimes possible to obtain reduction even long after the injury. After reduction immobilize in a plaster cast for six weeks. After three weeks cut the cast down the front in order to allow massage and gentle movements. Begin weight bearing in three weeks, the foot being held straight ahead and the shoe being raised on the inner side (Surls and Osgood, Ibid.). This position saves pull on the internal lateral ligament. As recurrence of the displacement is usual, the patient should wear a knee-cap made of leather during the day for many months. A partial tear may entirely heal when thus treated by rest and support; an extensive tear will not, although even in such cases a useful but somewhat stiff joint may be obtained. If it is found impossible to unlock the blocked joint, if the

tear is extensive and redislocation is prone to occur, if pain and tenderness persist, if the joint is weak and slips or if swelling endures, an operation is advisable. Annandale in 1885 sutured the cartilage in place through a transverse incision. Freeman and others used sutures to fix the cartilage. Excision of the separated part or of the entire cartilage is just as safe and more satisfactory than suturing, and after excision recurrence of the trouble is impossible. After excision the extremity is placed upon a posterior splint. Passive motion is begun in two weeks. In a series of 76 cases (Strahlmann and White, Ibid.) the operative results were as follows: In 86 per cent. the result was satisfactory. In 7 cases there were recurrences of preoperative symptoms. In 31 per cent. of the 76 cases there was some stiffness. In 53 per cent. there was more or less weakness of the joint. Strahlmann and White (Ibid.) in considering the reasons for poor results point out that the cartilage derangement may be a symptom of "an unrecognized and sometimes undeveloped condition" (syphilis or tuberculosis), that permanent joint damage extending beyond the cartilage may have resulted from the trauma or too little cartilage may have been removed at operation (a loose portion or a fragment having been allowed to remain). For a full and admirable study of 228 patients operated on in the Massachusetts General Hospital see the paper of Surls and Osgood (Ibid.) which I have used largely.

Dislocation of the Fibula at the Superior Tibiofibular Articulation.—This injury is rare. The head of the fibula may go forward or backward. The *causes* are direct force and violent adduction of the foot with abduction of the knee (Bryant).

Symptoms.—After dislocation of the fibula the position is one of semiflexion of the knee, voluntary extension and flexion being impaired or lost. A distinct movable projection is readily noticed in front or behind, which is found to be continuous with the fibula. There is a depression over the normal position of the head of the fibula.

Treatment.—In treating dislocation of the fibula bend the knee to relax the biceps, and proceed to push the bone into place. Put a compress over the head of the fibula, apply a bandage, and put the limb on a double inclined plane. The peroneal nerve winds around the neck of the fibula and care must be taken to avoid making injurious pressure upon the nerve. At the end of three weeks put a lacing knee support upon the knee and let the patient up. As displacement is liable to recur, a knee-cap must be worn during the day for a year.

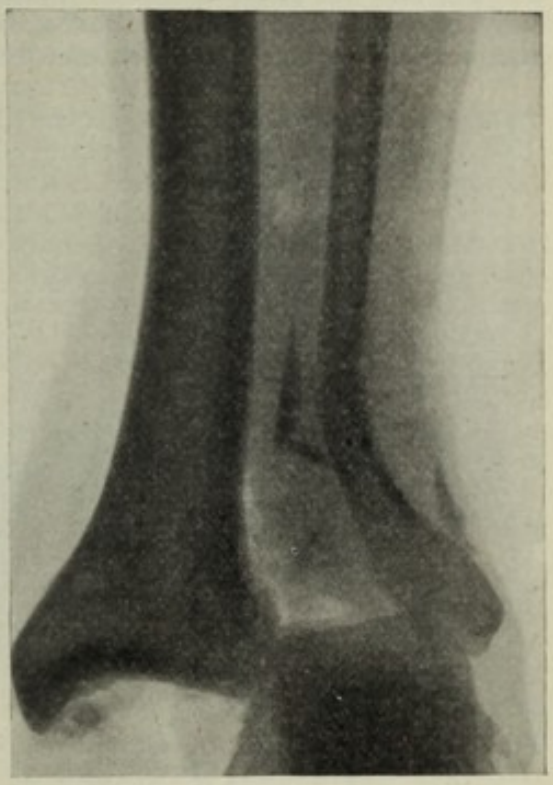


FIG. 513.—Dr. Carnett's case of dislocation of the ankle with comminuted fracture of the fibula. Medico-Chirurgical Hospital (skiagraphed by Dr. Pfahler).

Dislocation of the Ankle-joint.—This injury is not unusual. Fracture is a frequent complication (Fig. 513). There are five forms of ankle-joint dislocation—outward, inward, forward, backward, and upward.

Lateral dislocation of the ankle-joint is either outward or inward, and may be complete or incomplete. In these dislocations the astragalus rotates. In incomplete dislocation "there is no great separation of the trochlear surface of the astragalus from the under surface of the tibia, but the outer or inner margin of this surface is brought into contact with the articular surface of the tibia, and the whole foot presents a lateral twist" (Pick). The *causes* of these dislocations are twists of the joint.

Symptoms.—Incomplete outward dislocation of the ankle-joint occurs in *Pott's fracture* (see page 573). *Dupuytren's fracture* comprises complete outward dislocation of the astragalus, the articular surface of the astragalus being displaced completely outward from the articular surface of the tibia, and a fracture of the fibula existing with separation of the inferior tibiofibular articulation (Fig. 513). In incomplete dislocation the foot goes outward and upward, the fibula is fractured, and the tibiofibular ligaments

are torn off. In Dupuytren's fracture the ankle is broad, the inner malleolus projects and looks lower than natural, the outer malleolus ascends with the foot, the foot rotates outward, and crepitus can be detected. In inward dislocation which is associated with fracture of the inner malleolus there is inversion, the outer malleolus projects, and crepitus can be detected. In incomplete separation the symptoms are similar, but are not so marked.

Treatment.—In treating a case of dislocation of the ankle-joint the deformity is reduced by flexing the leg on the thigh and the thigh on the pelvis; an assistant makes counterextension from the knee; the surgeon makes extension from the foot, and at the same time rocks the astragalus into place. Dupuytren's fracture is treated in the same manner as Pott's fracture (see page 573). Dislocation inward is treated in a fracture-box for the same period as Pott's fracture.

Anteroposterior dislocation of the ankle-joint is rare. The *cause* is the catching of the foot in jumping or falling—direct violence. In dislocation forward the foot is lengthened, the heel is not conspicuous, the tibia and fibula project against the tendo achillis, and the relation of the malleoli to the tarsus is altered. In incomplete dislocation the symptoms are similar, but less pronounced. In dislocation backward the foot is shortened, the tibia and fibula project in front, the heel is prominent, and the relation between the malleoli and the tarsus is altered. In incomplete dislocation the symptoms are similar, but less marked.

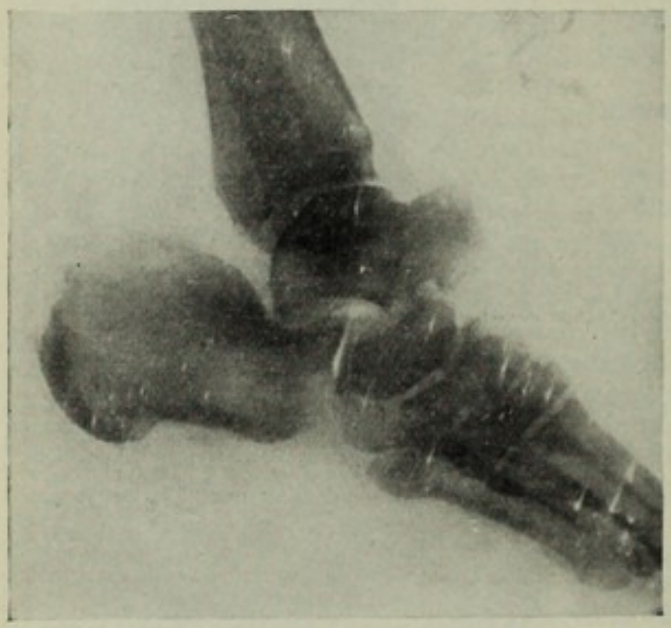


FIG. 514.—Dislocation of the astragalus forward (skiagraphed by Dr. Manges).

Treatment.—In anteroposterior dislocation of the ankle-joint reduce as in lateral dislocations. Sometimes the tendo achillis must be cut. Apply a plaster-of-Paris dressing and let it be worn for two weeks; then begin passive motion, and let the patient wear side-splints for at least two weeks longer.

Dislocation upward of the ankle-joint, or *Nélaton's dislocation,* is a very rare injury. The astragalus is wedged high between the widely separated tibia and fibula. This dislocation is usually associated with fracture. The *cause* is a fall upon the feet from a great height.

Symptoms.—Upward dislocation of the ankle-joint is indicated by the widening of the ankle and by the flattening of the foot. The malleoli are nearly on a level with the plantar surface of the foot, and there is absolute rigidity.

Treatment.—In treating upward dislocation of the ankle-joint give ether, and try to reduce by powerful extension and counterextension. Treat the injury afterward in the same manner as an anteroposterior luxation.

Dislocation of the Astragalus.—The astragalus may be displaced from the bones of the leg and at the same time be separated from the rest of the tarsus. The displacement may be forward, backward, outward, inward, or rotary.

Dislocation of the astragalus forward (Fig. 514) or **backward** is caused by falls or twists.

Symptoms.—In forward dislocation the astragalus projects strongly; there is shortening of the foot, and the malleoli approach the plantar aspect of the foot; the foot is deviated to one side or to the other, and there is absolute rigidity of the ankle-joint. In incomplete luxations the symptoms are similar, but less marked. This dislocation may be obliquely forward. In backward dislocation of the astragalus the foot is not deviated to either side; the astragalus projects between the malleoli and above the os calcis, and the tendo achillis is stretched over the projection. Rigidity is absolute. This dislocation may be obliquely backward.

Lateral and Rotary Dislocations of the Astragalus.—Lateral dislocations of the astragalus are rare, are always compound, and are always associated with fracture. In rotary dislocation the astragalus remains in its normal habitat after rotating on

its own axis, either horizontally or vertically. The *causes* of rotary dislocation are twists of the foot when it is at a right angle to the leg (Barwell). The *symptoms* of rotary dislocations are obscure. There is rigidity, but sometimes the position of the astragalus may be made out.

Treatment of Dislocation of the Astragalus.—In treating astragalus dislocation reduce under ether by flexing the knee to relax the gastrocnemius, extending the foot, and pushing the bone into place. It may be necessary to cut the tendo achillis. After reduction put up the foot and leg in a plaster-of-Paris dressing for two weeks, and then begin passive motion and apply side-splints, which are to be worn for one week more. If reduction fails, support the limb on splints, combat inflammation, and endeavor to bring about union between the dislocated bone and the tissues. Often, in unreduced dislocation, the skin sloughs over the projecting bone. Excision is demanded the moment sloughing is seen to be impending. Cases of compound dislocation of the astragalus require immediate excision.

Subastragaloid Dislocation.—This condition is a separation of the astragalus from the os calcis and scaphoid, without separation from the bones of the leg. Pick states that the usual classification for these dislocations is forward, backward, inward, and outward, but that the displacement is, as a rule, oblique, the foot passing backward and outward or backward and inward. The *cause* is twisting.

Symptoms.—In subastragaloid dislocation the astragalus projects on the dorsum; the foot is everted in outward dislocation and inverted in inward dislocation; the relation of the malleoli to the astragalus is unaltered; the ankle-joint is not absolutely rigid; the foot "is shortened in front and is elongated behind" (Pick).

Treatment.—To treat subastragaloid dislocation make extension in the direction opposite to that of the displacement. In dislocation of the tarsus backward fix a bandage around the foot, on a level with the heads of the metatarsal bones, which bandage the surgeon ties around his shoulders. The surgeon puts one knee in front of the ankle and thus fixes the leg, raises himself up to make extension upon the tarsus, and molds the bone into position. Tenotomy may be necessary. After reduction apply a plaster-of-Paris dressing and have it worn for three weeks. The ankle-joint, fortunately, is not involved, and stiffness of this articulation need not be apprehended. If reduction is impossible, take the same course as in luxations of the astragalus.

Dislocations of the other tarsal bones are very rare. Single bones may be dislocated, or the luxation may occur at the mediotarsal articulation.

Symptoms and Treatment.—Projection is an obvious *symptom* in dislocation of the other tarsal bones. The *treatment* is to reduce by extension and molding, the part being put up in plaster-of-Paris dressing for two weeks.

Dislocations of the metatarsal bones are rare.

Symptoms and Treatment.—Shortening of the toes and projection of the dislocated bone are *symptoms* of dislocation of the metatarsal bones. To *treat* these dislocations reduce by extension under ether and put up in a plaster-of-Paris dressing for two weeks. If reduction fails, the functions of the foot will not be much impaired.

Dislocations of the phalanges are very rare. The first phalanx of the big toe is the one most liable to dislocation.

Symptoms and Treatment.—Dislocations of the phalanges are obvious. The *treatment* is by reduction and fixation, as in dislocation of the thumb. Immobilize for two weeks.

Operations Upon Bones and Joints

Osteotomy.—By the term *osteotomy* the modern surgeon means literally the sectioning of a bone for the purpose of straightening a limb ankylosed in a bad posi-

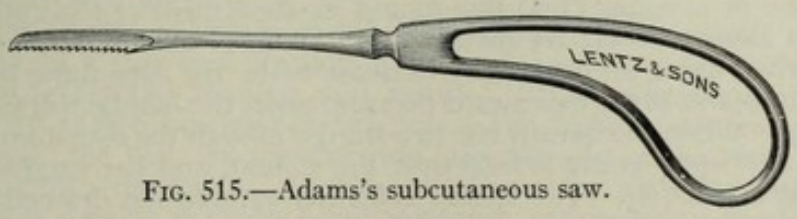


Fig. 515.—Adams's subcutaneous saw.

tion, correcting a bony deformity, or amending a vicious union of a fracture. In a *linear osteotomy* the bone is transversely or obliquely divided at one spot; in a *cuneiform osteotomy* a wedge-shaped portion of bone is removed. The operation of osteotomy may be performed with a saw (Fig. 515) or with an osteotome (Fig. 516). The saw

creates dust, draws much air into the wound, and lacerates the tissues to a considerable degree. Most surgeons prefer the chisel or the osteotome. The osteotome slopes down to an edge from each side (Fig. 516); the chisel is straight on one side and on the other is beveled to an edge.

Osteotomy for Genu Valgum, or Knock-knee (*Macewen's Operation*, Fig. 517).—Operation is never done until the subacute stage of rickets has passed and the greatest care is taken not to traumatize the epiphysis. The patient lies upon his back, being rolled a little toward the diseased side. The leg of the diseased side is partly flexed upon the thigh and the thigh upon the pelvis, and the extremity is laid upon its outer surface, a sand-bag being pushed between the extremity and the bed, opposite to the site of section. The flexion of the knee relaxes the popliteal vessels and saves them from injury. The surgeon, if operating on the right leg, stands outside of that extremity; if operating on the left leg, he stands opposite the left hip (Barker). The knife is inserted into the tissues and carried to the bone at the inner side of the knee, just in front of the adductor tubercle of the inner condyle and on a level with the upper border of "the patellar articular surface of the femur" (Barker). An incision is made upward 1 inch in length, in the direction of the axis of the femur. The knife is left in as a guide until the osteotome is inserted at the lower angle of this wound. After the insertion of the osteotome the knife is withdrawn and the blade of the osteotome



FIG. 516.—Osteotome.

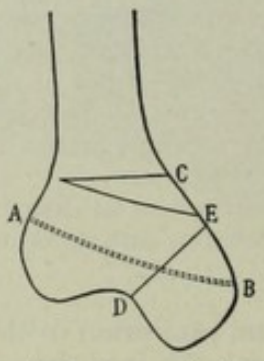


FIG. 517.—Osteotomy of the right femur in a case of knock-knee: A, B, Epiphyseal line; C, section of Macewen; D, E, section of Ogston.

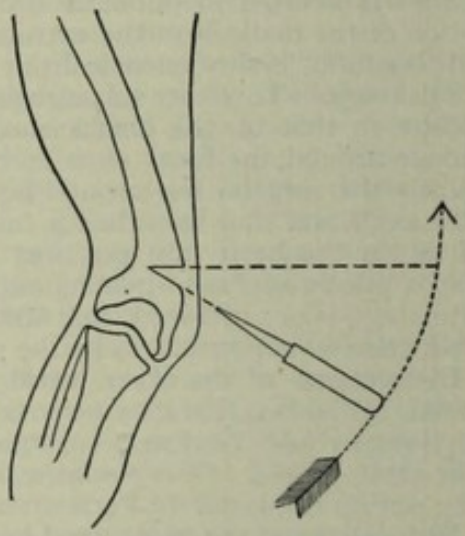


FIG. 518.—Macewen's operation for genu valgum. The chisel is held in the line for striking with a mallet; the arrow shows the direction in which the chisel is levered up and down so as to make a wide gap in the bone (after Barker).

is turned to a right angle with the shaft of the femur, ½ inch above the epiphysis (Fig. 517). The osteotome is struck several times with a mallet; the handle is moved several times toward and from the body, so as to widen the cut in the bone (Fig. 518); the osteotome is again struck with the mallet several times; it is again moved to and fro, and this process is continued until the bone is cut two-thirds through. If the osteotome become slightly fixed, it should be withdrawn and a smaller one introduced. In the soft bone of a young child this to-and-fro movement of the chisel, if carefully executed, is not liable to break the instrument. In dense bone it may break the instrument; hence, when doing an osteotomy in dense bone, the osteotome is moved to and fro across the limb and slight downward pressure upon the handle will to a great extent prevent binding. When the bone is cut two-thirds through the osteotome is withdrawn, a piece of wet antiseptic gauze is held over the wound, and the surgeon fractures the femur by strong adduction. The wound is neither sutured nor drained, but is dressed aseptically, the entire extremity is wrapped in cotton, and a plaster-of-Paris dressing is applied and carried up to the groin. The dressing is not removed for four to six weeks. This operation is scarcely ever fatal.

Ogston's Operation for Knock-knee (Fig. 517).—In this operation the internal condyle is sawed off obliquely with an Adams saw (Fig. 515)—a proceeding which

permits the straightening of the knee. The objection to the procedure is that it opens the knee-joint, and that this cavity fills up more or less with a mixture of blood and bone-dust. Macewen's operation is decidedly the safer.

Osteotomy for a Bent Tibia.—The tibia is divided transversely or obliquely (linear osteotomy), or a wedge-shaped piece is removed (cuneiform osteotomy). The oblique incision is the best. If the convexity of the tibial curve is inward, cut the bone from above downward and from in front backward; if the curve is forward, section the bone from above downward and from within outward. The fibula need rarely be interfered with. After the osteotomy the limb is treated just as it would be for a fracture.

Osteotomy for Faulty Ankylosis of the Hip-joint.—This operation is performed in order to allow straightening of a limb that has undergone bony ankylosis in a faulty or an inconvenient position. In some cases an attempt is made to obtain a movable joint, but in most cases the surgeon must be satisfied with ankylosis in extension. Osteotomy may be performed through the neck of the femur or through the shaft of the femur below the trochanters.

Osteotomy through the neck of the femur is performed (1) with a saw (Adams's operation) or (2) with an osteotome.

Adams's Operation (Fig. 519, A).—The patient lies upon his sound hip; the surgeon stands upon the side to be operated upon, and back of the patient. The knife is entered a fingerbreadth above the great trochanter, is pushed in until it strikes the neck of the bone, is then carried across the front of and at a right angle with the neck, and is withdrawn, enlarging the wound, in the soft parts as it emerges, to the extent of 1 inch. The saw is then introduced and the neck of the femur is entirely divided. After the osteotomy dress the wound antiseptically and place the extremity straight. To straighten the limb it may be found necessary to cut contracted tendons and fascial bands. After securing extension and applying dressings use the weight-extension apparatus and the sand-bags. Begin passive movements from the start if a movable joint is desired; few patients can tolerate the pain necessary to bring this about. If it is determined to aim for a stiff joint, treat the case as an intracapsular fracture would be treated.

With an Osteotome.—The position of the patient is the same as that for Adams's operation. An incision 1 inch long is made, starting just above the great trochanter, ascending in the axis of the femoral neck, and reaching to the bone. An osteotome is introduced, is turned to a right angle with the neck of the bone, and is struck with a mallet until the bone is *completely* divided. (It is not to be divided partially and then broken.) The after-treatment is the same as that for Adams's operation. The operation by the osteotome is to be preferred to that by the saw.

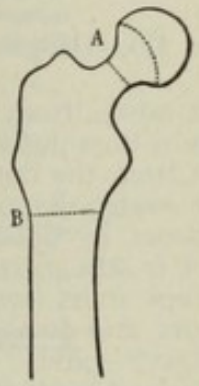


FIG. 519.—Osteotomy through the neck of the femur: A, Adams's operation; B, Gant's operation below the trochanters.

Osteotomy of the Shaft of the Femur Below the Trochanters (*Gant's Operation*).—In this operation (Fig. 519, B) the saw may be used, but the osteotome is to be preferred. The position in Gant's is like that in Adams's operation. A longitudinal incision 1 inch long is made upon the outer aspect of the femur and on a level with the lesser trochanter. The osteotome is inserted and the bone is completely divided below the lesser trochanter. The after-treatment is the same as that for Adams's operation. Gant's operation is the best method for correcting faulty position in bony ankylosis, and Adams's operation can only be employed in those cases in which the femur still has a neck which is practically unchanged.

Osteotomy for Faulty Ankylosis of the Knee-joint.—This operation is performed for bony ankylosis of a knee in a position of flexion. In these cases it is nearly always necessary to cut contracted tendons and fascia. These contractures tend to draw the tibia backward as in a posterior dislocation. The patient lies upon his back with his thighs flat upon the bed, the legs hanging over the end of the bed. The surgeon stands on the patient's right side. Just above the patellar articular surface upon the femur a transverse incision is made 1 inch in length and reaching to the bone. The osteotome is introduced and the bone is cut *nearly* through. The leg is then forcibly extended. It must not be extended too violently or the popliteal vessels may be injured. In cases in which the structures of the popliteal space are tense and have not been divided the leg must not be brought at once into full extension, but this position

should be attained gradually by means of weights. The wound is dressed aseptically, and the extremity is treated as for fracture near the knee-joint.

Osteotomy for Hallux Valgus.—In this operation a linear osteotomy is made through the neck of the metatarsal bone of the great toe, the toe is forcibly adducted, and a splint is applied to the inside of the foot and the toe. A cuneiform osteotomy may be done instead of a linear osteotomy. The osteotomy is made through the neck of the metatarsal bone. A wedge-shaped piece of bone (the base of which is to the inner side of the foot) is removed. Charles H. Mayo makes a flap of the bursal sac and capsular ligament, divides the metatarsal bone with a Gigli wire saw, sutures the flap over the bone end, closes the skin incision, and fixes the toe in the adducted position.

Osteotomy for Talipes Equinovarus (*After Barker*).—The patient lies upon his back, the thigh is semiflexed, the knee is bent, and the sole of the foot rests upon the table. The surgeon stands to the right side if it is the right limb which is to be operated upon, and to the left side if it is the left limb. He feels for the outer surface of the cuboid bone, and cuts away from over the latter a piece of skin corresponding in size with the bone-wedge intended to be removed (this piece of skin must include the bursa which forms in these cases). The foot is then turned outward, the astragaloscaphoid articulation is located, and over this an incision is made "from the lower to the upper dorsal border of the scaphoid bone" (Barker), reaching through the skin only; the foot is placed again in the first position, all the soft parts are raised from off the superior surface of the tarsus, and a triangular surface corresponding with the base of the wedge to be removed is cleared; a "kite-shaped" director (Fig. 520) is passed into the external wound and projected from the internal wound; the saw is pushed through the groove of the director nearest the toes, and is made to cut through the tarsus, from the dorsum to the sole, at right angles to the metatarsal bones; the saw is then pushed through the groove of the director nearest the ankle, and is made to cut from the dorsum to the sole, at right angles to the long axis of the calcaneum; the wedge-shaped piece of bone is grasped by sequestrum forceps and cut out by scissors, by bone-forceps, or by a blunt bistoury. The wound is well irrigated, the foot is straightened, the internal wound is sewed up, the external wound is sutured except at its lowest portion, where a drainage-tube is to be retained for twenty-four hours, and dressings are applied to the wound. The foot is put up in plaster or upon a Davy splint. Some surgeons insert the wedge of bone into the opening made by a linear osteotomy on the inner side of the foot.

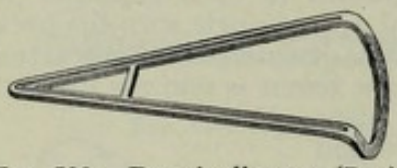


Fig. 520.—Davy's director (Pye).

Osteotomy for Talipes Equinus.—This operation is described by Mr. Davy, who devised it,[1] as follows: "Taking the line of the transverse tarsal joint as a guide, on the outer and inner sides of the foot, and immediately over the joint, two wedge-shaped pieces of skin are removed, equal in extent to the amount of bone demanded. The soft structures are freed on the dorsum of the foot in the way previously described; but, as the base of the osseous wedge for equinus cases is at the dorsum and its apex at the sole, the parallel wire director, instead of the kite-shaped varus one, is used. The saw is successively inserted in its grooves, and by keeping in mind the idea of a keystone a clean wedge of bone is cut out from the dorsum to the sole of the foot." The wedge is extracted, and the foot is straightened and is put up in plaster of Paris or is placed on a Davy splint.

Osteotomy for Vicious Union of a Fracture.—The operation is done for angular deformity. For small bones do linear osteotomy; for large bones, cuneiform osteotomy. It is wisest to divide the bone above or below the seat of fracture in order to bring together non-sclerotic surfaces and so secure the best chance for repair. It is best, when possible, to enter the osteotome upon the concavity of the bent bone, so that the periosteum will not rupture when extension is made, and the patient will, in consequence, gain a longer limb. After the operation it is seldom necessary to fix the fragments with a plate and usually the limb is encased in plaster.

The following rules laid down by Mr. William Pearson, of Dublin, are of great value ("Lancet," Jan. 19, 1924). In the lower limb rotation alone seldom demands operation.

If in fracture of the shaft of the radius the upper fragment is supinated and the lower pronated, do a simple osteotomy above the insertion of the pronator radii teres

[1] Barker's "Manual of Surgical Operations."

muscle and set the lower fragment in full supination so as to meet the supinated upper fragment.

If fracture of the upper end of the humerus has been followed by ankylosis of the shoulder joint, the arm being in external rotation, do a linear osteotomy below the insertion of the deltoid.

If there is slight overlapping in the femur no operation is required. If there is gross overlapping and the fracture is firmly united, contractures of the soft parts may forbid operation. In the upper limb shortening does not call for operation.

If the radius becomes fused to the ulna by a bridge of bone, remove the osseous bridge and interpose between the two bones a flap of fat and fascia cut from the thigh. This flap is so folded that fascia lies against each bone.

Ankylosis of the superior or inferior radio-ulnar joint requires excision.

The Question of Operation for Recent Fractures.—(See also page 491.)

Operation for Recent Simple Fracture.—Very early after the injury is a fairly safe period for operation. Lane favors very early operation. During the first week, excluding the early hours after the injury, is a dangerous period to operate because the area of injury has a low resistance to infection. About the tenth day is a safer period for operation. Very careful sterilization is imperatively necessary. Make a free incision and expose the fracture. Remove all tissue from between the bone ends. König disagrees with Lane that all blood-clot should be removed. Arrest bleeding.

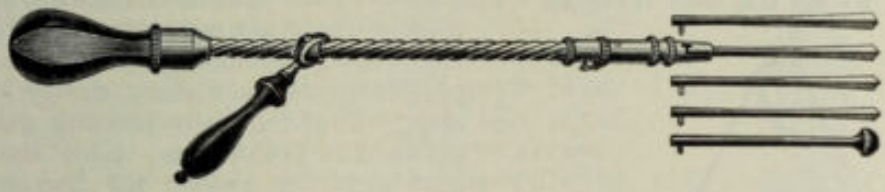


FIG. 521.—Hamilton's improved bone-drills.

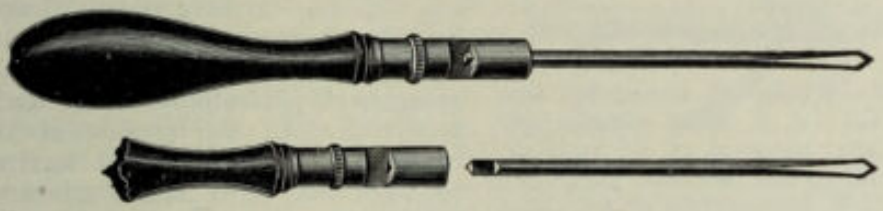


FIG. 522.—Brainard's drills with Wyeth's adjustable handles.

Bring the fragments into apposition by extension and by using powerful forceps (Fig. 327) as a lever. It is seldom necessary to use a plate and screws, and usually the part is fixed in splints or plaster. If there is a strong disposition to a recurrence of the deformity use a Lane plate (see Fig. 319).

Select a suitable place, remove the lever, fix the plate and bones by Lowman's clamp (see Fig. 328), bore the bone by a drill (see Figs. 320, 521, 522) at each screw hole, insert and fix the screws, remove the clamp, and close the wound without drainage or with a cigarette drain. The part is placed upon a splint.

Figure 328 shows Lane's plate applied. If it does not loosen and does not give trouble a plate is not removed surgically.

Recent Transverse Fracture of the Patella.—(See page 568.)

Recent Fracture of the Olecranon Process of the Ulna.—(See page 533.)

Bone-grafting, or Transplantation.—(See pages 493 and 652.)

Operative Treatment of Ununited Fracture.—A method of operation long in vogue but now seldom used except upon the patella, olecranon, and mandible, was by the use of silver wire sutures. It was performed as follows: Incise longitudinally down to the seat of fracture, retract the periosteum from the bone, drill the bones before cutting them, chisel away the material imperfectly uniting the fragments, saw through each bone end far enough from the seat of fracture to reach sound tissue, cut away the hard plug in each medullary cavity, pass large silver wire through the holes (this wire should be 1/10 inch in diameter for the femur, 1/16 inch for the patella, etc.) (Fig. 523), twist the wires a fixed number of times (two complete turns) in the direction that the hands of a watch move (this is Keen's direction; in case removal of the wires should be demanded later we know how to untwist them; of course the surgeon must remember

where he stood in relation to the limb and regard the hypothetic watch as being face up upon the part), sever the ends of the wires, and hammer their stems against the bones. The wires may never require removal. The soft parts are sutured, no drain or a cigarette drain is used, and the limb is encased in plaster of Paris. The objection to wire in fracture of a long bone is that the wire acts as a hinge and, as a consequence, alignment is apt to be disturbed. Various plans besides wiring have been employed in ununited fracture. Some surgeons unite the fragments with kangaroo-tendon instead of wire (suturing of bone); others use nails of bone or ivory; others use screws. Senn asserted that the above methods will not hold fragments in contact if these fragments have a tendency to become displaced. Senn fastened the bones together by hollow cylinders of decalcified bone or ivory, the cylinders being perforated in many places (bone-ferrules). The silver plate of Halsted and steel plate of Lane have been largely used. None of the above methods stimulate bone production and all have given way in most cases to Albee's operation of bone-grafting (see below).

Albee's Operation of Bone-grafting.—Albee has emphasized the true principle in ununited fracture. Fixation alone is seldom successful. The osteogenetic power is impaired in these injuries. Plates will fix the fragments, but will not stimulate bone production. This can be done by a bone-graft. The graft is cut from sound bone ends or from another bone on the same individual. When fixed in place a graft holds the fragments like a plate, stimulates osteogenetic power, acts as a scaffolding for new bone-cells, and at least, so Albee believes, actively participates in repair. It is far and away the best method. The method for ununited fracture is as follows: Expose the fracture, cut away fibrous union and freshen the bone ends, remove the sclerosed plug from the medullary cavity of each fragment; if there is overriding make traction, divide the periosteum, take the twin saw, and cut the groove for the insert. This groove goes through the cortex. The loose bone is removed. Drill holes through the cortex on each side of the groove. Expose the tibia and cut a groove with the twin saw. Remove the graft from the sound tibia. This graft consists of periosteum, bone, and endosteum. Insert it into the groove of the fractured bone. Kangaroo-tendons having been run through the drill holes are now tied over the graft. (See Albee, in "Amer. Jour. Surgery," 1914, xxviii, and "Bone-graft Surgery," by Albee.)

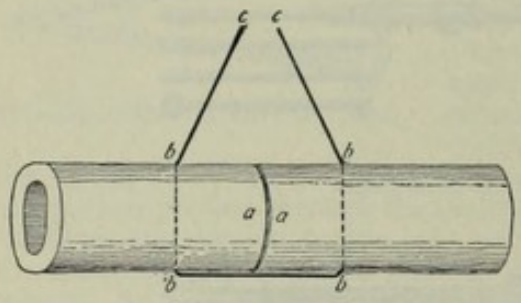


FIG. 523.—Wiring of bones for ununited fracture: *a*, *a*, Sawn surfaces approximated after removal of old material which was interposed between the fragments; *b*–*b*, *b*–*b*, perforations drilled completely across the bone; *c*, *c*, wires ready for twisting.

Ununited Fractures of the Femoral Neck.—Loreta did the first successful operation for this condition a number of years ago. The operation is not adapted to the aged, but should certainly be employed in youths and middle-aged individuals if the general condition of the patient or some particular diseased state does not forbid, and if pain is severe and disability is pronounced.

Leonard Freeman advises an anterior incision beginning below and external to the anterior superior iliac spine and extending downward, external to the sartorius, for 3 or 4 inches ("Annals of Surg.," Oct., 1904). When the fragments are exposed, the connective tissue between them is cut away by means of scissors, the surfaces of the fragments are freshened by a chisel or a curet, oozing is arrested by pressure and hot water, and loose osseous splinters are removed (Freeman). Some surgeons have fixed the fragments together by nails, screws, or pegs of bone or ivory, access to the trochanter being best obtained for this purpose by making a second incision over the outer portion of that bony process. As Freeman points out, however, the head is often so very soft that none of these appliances will secure fixation.

Freeman has devised a clamp for this purpose. In about eight weeks the extension is removed and the patient is allowed about on crutches. I succeeded in one case by simply nailing the fragments together without attempting to freshen their faces. A silver nail was used. A bone peg may be the best method. Good results have been obtained in certain cases by surgical impaction which, of course, causes some shortening. The procedure is to freshen the ends, sharpen the narrower fragment, and drive it into the other.

In some ununited intra-articular fractures excision is necessary.

Ununited Fracture of Patella.—Ten days before operating inject the knee-joint with 15 c.c. of a 2 per cent. solution of formalin in glycerin. This will produce a chemical inflammatory reaction, which coffer-dams the lymph-spaces and strengthens immunity to infection (John B. Murphy in his "Surgical Clinics," vol. iv). A semilunar incision through the skin and superficial fascia is made about the fragments, the convexity pointing up or down (this avoids the prepatellar bursa), or an incision is made in the long axis of the limb, over the middle of the space between the fragments, from well above the upper fragments to well below the lower piece. The soft parts are retracted, but the periosteum is undisturbed; each fragment is bored (Fig. 524, 1) in one or two places; the surfaces of the fragments are sawed straight across, through sound bone; all old reparative material is cut away; the wires are passed through the perforations, twisted, cut off, and hammered down (Fig. 524, 2). If the bone fragments cannot be approximated, it may become necessary to incise the muscle around and above the patella or partially to separate the tuberosity of the tibia and bend this process upward. In some cases the quadriceps tendon is greatly shortened and it is necessary to lengthen it. This is best done by the method of Bennett, of Baltimore (Figs. 452–454). (See "Jour. of Bone and Joint Surg.," April, 1922.) A bone-graft is used in some cases instead of wire fixation. The limb is put upon a Macewen splint.

Treves's Operation for Caries of the Lumbar and Last Dorsal Vertebræ, with Abscess in the Psoas Magnus or Quadratus Lumborum Muscle.—The patient lies upon the opposite side, with the knees drawn up and a sand-bag under the other loin. The surgeon stands behind the patient (Barker). An incision is made at the outer border of the erector spinæ mass, reaching from the last rib to the iliac crest and going down at once to the lumbar fascia. The lumbar aponeurosis is opened, the erector spinæ muscle is retracted inward, and the anterior portion of the erector spinæ sheath is incised. The quadratus lumborum muscle is next cut, and then the anterior leaflet of the lumbar aponeurosis is slit. The abscess is thus reached and opened and tuberculous pus flows out. The abscess cavity is irrigated with quantities of warm corrosive sublimate solution (1 : 5000). The cavity is filled, the fluid is allowed to flow out, its exit being aided by pressure in front and changes of posture; the cavity is filled again, and so on, and, after all loose débris has been removed, the bodies of the vertebræ are carefully examined with the finger and diverticula are opened. Loose pieces of bone are removed by spoons or forceps, and cavities are thoroughly but lightly curetted, as in some places the wall is very thin. By means of properly shaped spoons carious bone can be removed even from the anterior surface of the column (Treves). Thus Volkmann's membrane is completely removed. Finally, all débris is washed out by irrigation with mercurial solution; any mercurial solution which might remain is washed out by warm water or salt solution, and the interior of the cavity is wiped dry. At this stage most operators introduce iodoform emulsion. Whether or not this is done, "the wound is closed by a series of silkworm-gut sutures, passed sufficiently deep to include the greater part of the muscular and tendinous structures with the skin" (Treves's "Operative Surgery"). Treves's operation gives a considerable mortality.

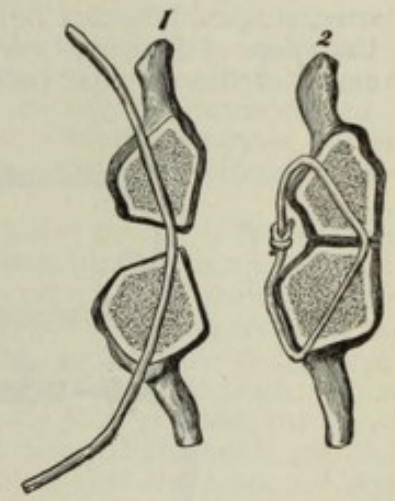


FIG. 524.—Wiring of the patella: 1, Fragments cut and cleaned and the wires passed; 2, wires twisted and hammered down upon the bone (after Barker).

Aspiration of Joints.—In certain cases of joint effusion from inflammation, tuberculous or otherwise, and sometimes in hemorrhage into a joint, it is desirable to remove the fluid by aspiration. The pneumatic aspirator (Fig. 525) is used. The trocar and cannula are thoroughly asepticized and the joint is prepared as for a set operation. The needle is entered at a point free from large vessels. The directions for using an aspirator are as follows: insert the stopper firmly into a strong bottle (preferably a clear glass one), then attach the short elastic hose to the stop-cock *B* of the tube projecting from the stopper, and attach the other end of the same elastic hose to the exhausting or inward-flowing chamber of the pump. Next, attach one end of the lower elastic hose to the stop-cock *A* projecting from the stopper and fix the other end of the tube to the needle. Care should be taken that all the fittings or attachments are inserted firmly into their respective places. Now close the stop-cock *A* and

open the stop-cock *B*. By giving from thirty-five to fifty strokes of the pump a sufficient vacuum can be produced to fill with the fluid from the joint a bottle holding from a pint to a quart. After having formed the vacuum, close the stop-cock *B*, and insert the needle into the joint. When the stopcock *A* is opened, suction through the needle draws the fluid from the joint. The trocar may be used to inject antiseptic agents, but Fig. 69 shows a better instrument. After the completion of aspiration the part is dressed antiseptically and the extremity is put at rest upon a splint.

Excisions of Bones and Joints.—The ancients practised excision and resection for compound dislocations and fractures. For centuries surgeons removed pieces of diseased bone from joints. The operation of excision was set forth as a definite procedure, and was first formally advised as a substitute for amputation in joint disease by Mr. Park, of Liverpool, in 1781. In 1782 the elder Moreau, of Bar-sur-Ornain, independently devised a like operation. The terms "excision" and "resection" are usually employed as synonymous, but such a use is not strictly accurate. According to the elder Ashhurst, the term *excision* means "the removal of an offending part without that total ablation of the affected portion of the body which is implied by the term 'amputation.' Hence we speak of excisions of tumors, of joints, of the eyeball, etc." *Resection* has a more restricted meaning; it signifies "an operation which takes away a middle portion and brings the ends together again, and is thus in strict surgical language limited to partial excisions of the long bones" ("International Encyclop. of Surgery," edited by John Ashhurst, Jr.). Excision of a joint is the removal of the articular portions of the bones of the joint, and also the cartilage and

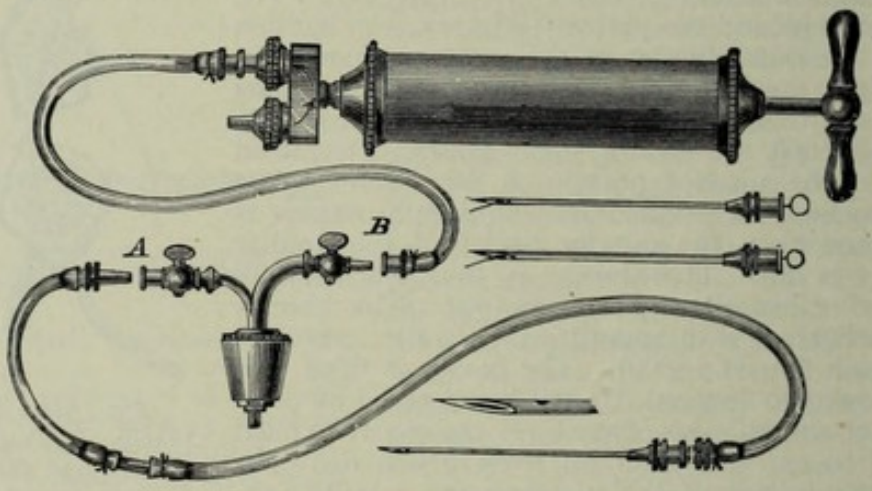


FIG. 525.—Aspirator and injector.

synovial membrane. In the hip-joint and shoulder-joint only the head of the long bone may require removal, and not the articular surfaces of both bones. In partial excision of a long bone, excision (resection) for bone disease, enough bone is known to have been removed only when the remaining bone bleeds. *Complete excision* of a bone is the removal of an entire bone. *Partial excision* or *resection* is the removal of a portion only of a bone. Excision is a conservative operation which often averts amputation.

Excision may be performed by the *open* method, in which the periosteum is not preserved, or it may be performed by the *subperiosteal* method, in which the periosteum is carefully separated by a rugine and the capsular ligament is preserved. This method was devised by Ollier, of Lyons. *Arthrectomy*, or *erasion*, is the excision of the diseased synovial membrane and ligament, and also small foci of disease of bone and cartilage.

Excision may be employed for compound dislocation, and in compound dislocations of the elbow and the shoulder it is usually performed. Excisions for compound dislocations in other large joints are very dangerous; they are rarely attempted in battlefield practice, and are to be avoided even in civil practice unless the patient is young and vigorous and every advantage can be given him during the operation and convalescence. Excision for deformity is rarely performed except upon the hip, the knee, and the shoulder, and these excisions must not be employed if the patient's condition leads one to fear the result of a protracted convalescence. Excision of the elbow, however, is usually a safe operation. In excising for deformity always con-

sider the patient's trade and the demands of habitual position which it makes upon him.[1]

Excision is largely employed for joint disease, especially for tuberculous joints. Bell states that attempts to preserve the limb without excision are more justifiable in the lower than in the upper limbs, because operation in the lower extremity is more dangerous than in the upper, and because a cure without operation in the lower limbs, if this cure can be brought about, gives as good a result as a cure by excision. In the upper extremity the danger from operation is less than is the danger from waiting. In a young subject an excision may remove the epiphysis, and thus lead to permanent shortening, which is productive of less inconvenience and deformity in the arm than in the leg. A danger of excision operations is that the section may be made through cancellous bony tissue; hence, if infection takes place, disastrous suppuration, phlebitis, osteomyelitis, septicemia, or pyemia will follow; further, in excision, if the cut is made through diseased tissue, failure or a protracted convalescence is inevitable. Amputation is certainly effected through healthy tissue, and the convalescence is short. Excision, however, when successful, gives the patient a very useful limb.

Erasion, or Arthrectomy.—This operation was suggested by Cross, of Bristol, and was perfected and established by Wright, of Manchester, between 1881 and 1888. *Erasion* is the complete removal of diseased synovial membrane, ligaments, and small foci of disease in bone and cartilage. This operation seeks to remove a depot of infection in an early stage of tuberculous synovitis, and it possesses the conspicuous merit of not interfering with the epiphysis. The term "erasion" is also used by some to designate the operation of removing healthy synovial membrane, ligaments, etc., for the purpose of producing fixation of a flail-joint due to infantile paralysis, but in such cases *arthrodesis* is the proper term for the operation. Erasion is oftenest practised upon the knee-joint.

Erasion of the Knee-joint.—The patient lies upon his back; the leg is flexed, with the sole of the foot planted upon the table, and an Esmarch bandage is applied at a point well up on the thigh. The surgeon stands to the right of the patient. The incision is begun in the midline of the thigh (on the side opposite to that occupied by the surgeon), about 3 inches above the patella; it is carried down across the ligament of the patella and up to a corresponding point on the opposite side of the thigh. This incision goes down to the bone; the flap is turned up and the joint exposed; the knee-joint is strongly flexed, and the synovial membrane and diseased ligaments are dissected away with scissors and forceps, great care being taken that the posterior ligaments (which, fortunately, are rarely implicated early in the case) are not divided and that the contents of the popliteal space remain intact. After removing the diseased ligaments and synovial membrane the cartilage is examined and any diseased portion is removed. The bone is then examined and any tuberculous foci are gouged away. Exposed vessels are ligated. The wound is irrigated with salt solution, the extremity is straightened, and the ends of the ligamentum patellæ are sutured, a drainage-tube is inserted at each angle of the wound, the skin is sutured, and antiseptic or sterile dressings are applied. The limb is placed upon a posterior splint for a few days, then the drainage-tubes are removed, the dressings are changed, and a plaster-of-Paris cast is applied, trap-doors being cut on each side, and the joint is kept immobile for two or three weeks. This operation is only suited to early synovial cases in which the lesion involves chiefly or purely the synovial membrane and ligaments, and in these cases it frequently gives a good result, some capacity for motion being not unusually preserved.

Excision of the Shoulder-joint.—Bent, of New Castle, performed the operation in 1771 ("Manual of Operative Surgery," by Sir Frederick Treves). Syme really established the operation in surgical confidence. In the shoulder-joint *partial* excision is often performed, the head of the humerus being removed and the glenoid being undisturbed; but some patients require complete excision, the entire glenoid depression, as well as the head of the humerus, being removed by the surgeon. Excision of the shoulder-joint is made, if possible, an intracapsular operation, the capsule being opened, but the capsular attachment to the anatomic neck of the humerus not being interfered with. In advanced cases, however, the capsular attachment must be destroyed. Excision of the shoulder-joint for trauma is a far less common operation in civil than in military practice. It is performed for gunshot wounds, compound dislocations, tuberculous disease, and tumors of the head and upper portion of the humerus.

Operation by Anterior Incision.—The patient lies supine; a pillow is placed beneath

[1] Joseph Bell in his "Manual of Surgical Operations."

the shoulders, and a sand-pillow is put beneath the shoulder to be operated upon. The arm is held to the side with the outer condyle forward and the bicipital groove inward (Barker's directions). The surgeon stands by the affected side. An incision 3 or 4 inches in length is made from just external to the coracoid process of the scapula, running straight down the humerus (Fig. 526, A). This incision divides the border of the deltoid muscle and brings into sight the long head of the biceps. The tendon of the biceps is retracted inward unless it is diseased, in which case it is resected. The knife is carried up the groove and opens the capsule of the joint. The periosteum is lifted from the neck of the bone while an assistant rotates the elbow to make the muscles tense. In some places, if the periosteum tears, muscular insertions must be cut with a knife. The head of the bone is sawn off while the bone is in place, or the elbow is strongly pulled back, and the head of the bone is forced out of the wound, and is then sawn off at the point required. In ordinary cases only the articular head is removed; in other cases the section is made just above the surgical neck; in

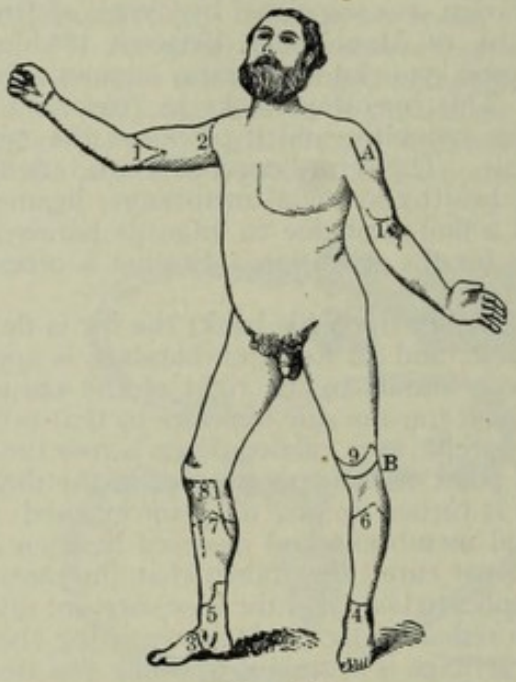


FIG. 526.

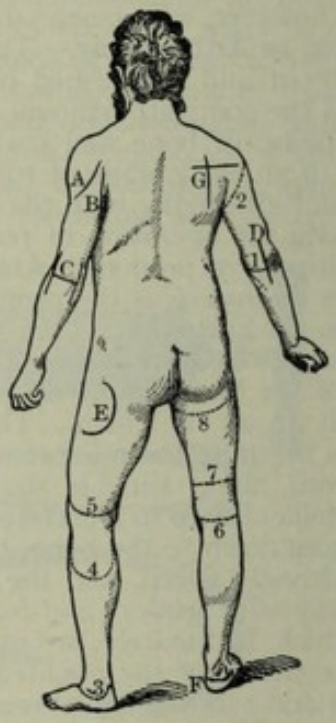


FIG. 527.

FIG. 526.—1–9, AMPUTATIONS AND EXCISIONS (Joseph Bell): 1, 1, Of arm by double flaps; 2, at shoulder-joint; 3, at ankle-joint by internal flap (Mackenzie's); 4, 5, of leg just above the ankle-joint (Syme's); 6, 7, below the knee (modified circular); 8, through condyles of femur (Syme's); 9, at lower third of thigh (Syme's); A, excision of head of humerus; B, of knee-joint (semilunar incision).

FIG. 527.—1–8, AMPUTATIONS AND EXCISIONS (Joseph Bell): 1, At elbow-joint (posterior flap); 2, at shoulder-joint, posterior incision (first method); 3, at ankle-joint (Mackenzie's); 4, through condyles of femur (Syme's); 5, at lower third of thigh (Syme's); 6, at knee (posterior incision); 7, of thigh (Spence's); 8, at hip-joint. A–G, Excisions: A, Excision of shoulder-joint (deltoid flap); B, of shoulder-joint (posterior incision); C, of elbow-joint (H-shaped incision); D, of elbow-joint (linear incision); E, of hip-joint (Gross's); F, of os calcis; G, of scapula.

still others a portion of the shaft must also be cut away. If the glenoid cavity is found slightly diseased, the dead bone must be removed by the gouge and mallet or by the cutting forceps. If the cavity is seriously diseased, the entire glenoid should be removed. Scrape away all damaged tissue; ligate bleeding points; irrigate the wound with normal salt solution; swab it out with a solution of chlorid of zinc (20 gr. to 1 oz.); dust with iodoform; close the upper portion of the wound and insert a drainage-tube in the lower angle; dress the wound antiseptically; place a small pad in the axilla; apply the second roller of Desault; and put the patient in bed with a pillow under the affected shoulder. In seven days the hand-sling is substituted for the bandage, and with the elbow hanging free the patient is permitted to get up and is advised to move his arm frequently. Drainage is maintained until the wound is well healed from the bottom. Decided limitation of movement inevitably follows a shoulder-joint resection.

Excision by the deltoid flap is performed when the head of the bone is much enlarged

(as by a tumor) or when the tissues are thick and indurated. The deltoid flap is in the shape of a U or is semilunar (Fig. 527, A). Raising this flap exposes the head of the bone most satisfactorily. Bell states that when the glenoid cavity is chiefly involved the incision should be posterior (Fig. 527, B).

Senn's Method.—Senn[1] described an incision which does not damage important vessels, muscles, tendons, or nerves, and which is followed by good functional results. A semilunar skin-flap is formed, the incision running from the coracoid process to the posterior border of the axillary space. The flap is turned up, exposing the upper half of the deltoid muscle. The acromion is sawn off and turned down with the attached deltoid. The capsule is now freely exposed; it is opened, and either arthrectomy or excision is performed, according to conditions. In closing the wound it is not necessary to bore the acromion and pass silver wires to join the fragments; it is enough to suture the periosteum with catgut.

Excision of the Elbow-joint.—This operation was suggested by Park in 1782, but the first employment of it was by Moreau in 1794. It is performed for wounds, faulty ankylosis, and chronic articular disease. Excision must be complete. Endeavor to make a subperiosteal resection; this maintains the shape of the articulation and gives the best chance for a movable joint. The patient lies "supine, but inclining to the sound side, the affected arm being held almost vertical, with the forearm flexed and nearly horizontal" (Barker). The incision is made on the posterior surface of the joint. A single posterior incision is usually employed (Fig. 527, D). The cut is made a little internal to the long axis of the olecranon, beginning 2 inches above and terminating 2 inches below the tip of the olecranon. This incision goes down to

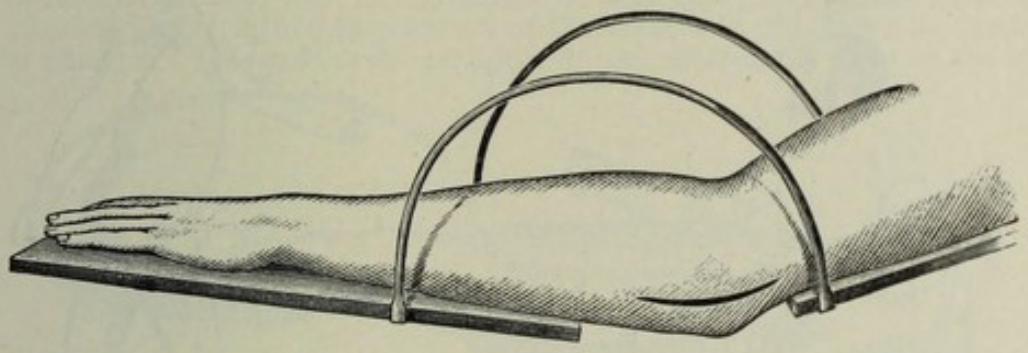


FIG. 528.—Esmarch's splint for the treatment of a limb after excision of the elbow-joint.

the bone, and throughout the entire operation the surgeon must guard and shield the ulnar nerve. The periosteum and soft parts are well separated; the olecranon is sawn off; forced flexion exposes the joint cavity freely, and enables the surgeon to lift the periosteum and soft parts from the humerus; the humerus is sawn through at the beginning of its condyloid processes; the radius and ulna are cleared and are sawn at a level below that of the base of the coronoid process of the ulna. Diseased tissues are cut and scraped away; the wound is irrigated, sutured, drained, and dressed. In some cases an H-shaped incision is employed (Fig. 527, C), but the cicatrix of a transverse cut will limit flexion of the limb.

After excision of the elbow the patient is put to bed and the arm is laid upon a pillow, the elbow being placed midway between a right angle and complete extension, the forearm being placed midway between pronation and supination. No splint is used, as a rule. Esmarch used the splint shown in Fig. 528. The aim in treatment is to obtain a freely movable joint. Passive motion is begun in one week, at which time the patient gets up. The hand is carried in a sling for a time after healing of the wound is complete.

Excision of the Head of the Radius.—This operation is practised for irreducible dislocation of the radius. An incision is made through the supinator longus muscle down to the head of the radius, and the neck of the bone is divided by means of a Gigli saw or bone-cutting forceps. The musculospiral nerve lies to the inner side. Some bone is always taken from the external condyle in order to make a sufficient gap to prevent subsequent ankylosis ("The Operations of Surgery," by Jacobson and Rowlands).

Excision of the Wrist-joint.—This operation was first performed by Moreau in 1794. Bell states that, whatever method of excision is chosen, three cardinal rules

[1] "Phila. Med. Jour.," Jan. 1, 1898.

must be borne in mind: (1) Remove all the diseased bone, including the portions of the radius, ulna, carpus, and metacarpus which are covered with cartilage; (2) interfere with the tendons to the least possible degree, and (3) begin passive motion of the fingers very early. Many surgeons prefer the simple gouging away of diseased foci and the scraping of sinuses instead of a formal resection of the wrist, amputation being employed in severe cases or when scraping fails after several trials. Formal excision is not frequently performed, and the results cannot be regarded as very favorable.

Lister's Open Method of Excision.—Break up adhesions as completely as possible by forcible movements. Apply a tourniquet or an Esmarch apparatus. The patient lies upon his back, the arm and the forearm being brought, from stage to stage, into the most desirable positions. Begin an incision over the middle of the dorsum of the radius, on a level with the styloid process; carry it downward in the direction of the inner edge of the articulation of the first phalanx of the thumb with the first metacarpal bone, and when the knife reaches the radial side of the second metacarpal bone alter the direction of the incision and carry it downward in the long axis of the metacarpal bone to about its middle (Fig. 529, A). This is known as the *radial incision*, and the only tendon divided is that of the extensor carpi radialis brevior muscle. The tissues upon the radial aspect of the incision are dissected up, the tendon of the extensor carpi radialis longior muscle is divided at its point of insertion (Bell), and all the soft structures are retracted outward, exposing the trapezium, which is cut off from the rest of the carpus, but which is left in place, as its removal at this stage endangers the radial artery (Barker). By extending the hand the tendons are loosened and the carpus is cleared in the direction of the ulnar border of the hand.



FIG. 529.



FIG. 530.

FIG. 529.—1–18, AMPUTATIONS AND EXCISIONS (Joseph Bell): 1, Amputation at wrist-joint (dorsal incision); 2, at wrist-joint (palmar incision); 3, at forearm (dorsal incision); 4, at forearm (palmar incision); 5, at elbow-joint (anterior flap); 6, at arm (Teale's); 7, at shoulder-joint (first method); 8, 9, of metatarsus (Hey's); 10, 11, at ankle (Syme's); 12, 13, of leg, posterior flap (Lee's); 14, at knee-joint (Carden's); 15, of thigh (B. Bell's); 16, of thigh (Spence's); 17, of thigh in middle third; 18, 18, at hip-joint; A, excision of wrist (radial incision); B, of wrist (ulnar incision).

FIG. 530.—1–10, AMPUTATIONS AND EXCISIONS (Joseph Bell): 1, Of lower third of forearm (Teale's); 2, at shoulder-joint by large postero-external flap (second method); 3, at shoulder-joint by triangular flap from deltoid (third method); 4, 5, through tarsus (Chopart's); 6, 7, at knee-joint; 8, by single flap (Carden's); 9, 10, of thigh (Teale's); A, excision of hip; B, B, of ankle-joint (Hancock's incision).

Another incision is made, starting upon the inner surface of the wrist, 2 inches above the articular surface of the ulna, and midway between the ulna and the flexor carpi ulnaris tendon. This incision, which is known as the *ulnar incision*, is carried down until it is opposite the middle of the fifth metacarpal bone in the palm (Fig. 529, B). "The dorsal lip of this incision is raised" (Bell), and the extensor carpi ulnaris tendon is divided and dissected from its depression, but is not separated from

the integument. The extensor tendons are lifted; the ligaments upon the dorsum and sides of the wrist-joint are cut; the flexor tendons are raised from the carpal bones; the pisiform bone is cut from the carpus, but is not yet removed; and the unciform process of the unciform bone is cut with forceps. The anterior radiocarpal ligament is divided, the carpometacarpal articulations are cut through, and the carpus is pulled out with bone-forceps. The ends of the radius and ulna are forced out of the ulnar incision. All that portion of the ulna which is crusted with cartilage is to be removed, the saw-cut is to be oblique, and the base of the styloid process is to be left behind. A thin section is to be sawn from the radius, and the tendon grooves are not to be impinged upon. The articular surface of the ulna is cut away by pliers (Bell). If foci of disease are discovered beyond these points, they are to be gouged out. The ends of the metacarpal bones are sawn off, and their articular facets are cut away by means of pliers. The trapezium is dissected out, the end of the first metacarpal bone is sawn off and its facet is cut away with forceps, and a portion of the pisiform bone is removed (the entire bone being removed if it be diseased). The wound is irrigated, vessels are tied, the radial incision is closed, the ulnar incision is partly closed, a drainage-tube is inserted by way of the ulnar incision, the wounds are dressed antiseptically, and the Esmarch apparatus is taken off. I place forearm and hand upon a splint which immobilizes the wrist and leaves the fingers semiflexed. Passive motion of the fingers is begun after thirty-six hours. The splint is worn for many months until the wrist-joint is immobile and solid. Esmarch uses the splint shown in Fig. 531.

Excision of Metacarpal Bones and of Phalanges.—Excision of a metacarpal bone, except in cases of necrosis with the formation of large quantities of new bone, usually leaves a useless finger; hence amputation of the bone with the finger is usually preferred to excision. This rule does not apply to the metacarpal bone of the thumb,

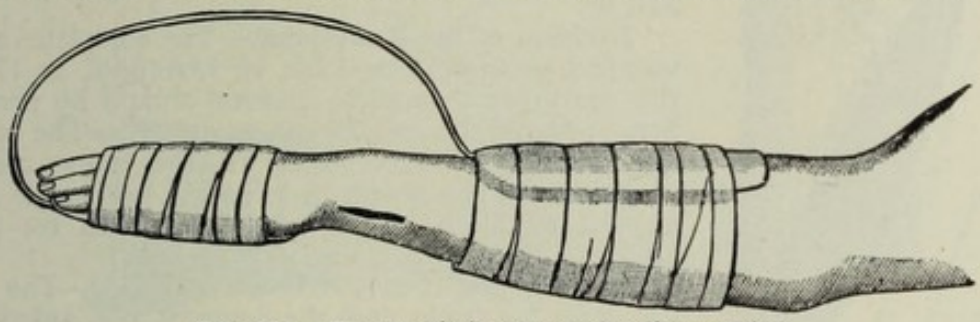


FIG. 531.—Esmarch's interrupted splint applied.

which is occasionally excised. The incision for this operation is made upon the dorsum, and is straight. Excision of the proximal phalanx of the thumb is sometimes performed. Excision for disease is rarely performed upon the finger-joints, amputation being preferred, though the operation is sometimes undertaken for compound dislocation. In the metacarpophalangeal joint of the thumb excision, if it can be performed, is preferred to amputation. The incision for resection of this joint is placed upon the radial aspect.

Excision of the Hip-joint.—Treves and Jonathan Hutchinson, Jr. ("Manual of Operative Surgery"), tell us that the operation was first performed by Anthony White, of the Westminster Hospital, in 1818. Sir William Fergusson established the operation in surgical confidence. Some surgeons advocate this operation; others, notably Marsh, are emphatically opposed to it. Excision should be performed in the early stage of tuberculous disease *if less radical treatment has failed*. In this stage the usual position of the limb is one of flexion, abduction, and eversion. In cases of long duration, especially where dislocation exists, excision is an easy and a comparatively safe operation; in recent cases it is difficult and carries with it decided dangers, but the peril of delay may be greater than the peril of an early excision. In cases of hip disease with involvement of the acetabulum the mortality is 50 per cent., whether operation is or is not attempted. Excision is performed especially for tuberculous disease and for gunshot injuries.

Operation by Anterior Incision (Fig. 532—*Barker's Operation*).—In this operation the patient is supine, with the thighs extended as thoroughly as circumstances permit. The surgeon stands to the right of the patient. An incision is begun ½ inch below and ½ inch external to the anterior superior iliac spine, and it is carried downward and a little inward for about 3 inches (Fig. 532, D). If dislocation exists, the incision need

not be so long. This incision is carried at once deeply between the muscles, and the capsule of the joint is opened. The neck of the bone is divided from its upper surface downward by a saw or an osteotome, and without dislocating the bone through the wound by forcible extension and eversion. The head of the bone is removed. All tuberculous foci must be scraped away, and the flushing gouge (Barker's spoon) is used upon tuberculous areas of the acetabulum. All sinuses should be thoroughly scraped. Bleeding is arrested, the wound is irrigated with normal salt solution, mopped with chlorid of zinc solution, and dusted with iodoform. A drainage-tube is inserted at the lower angle of the incision, and the upper portion of the cut is closed. The wound is dressed antiseptically. Extension is made by the extension apparatus until healing has obtained good headway, when a double Thomas splint is applied, so that the patient may be taken out daily in the air and sunlight. As a rule rigid ankylosis results from resection of the hip, but occasionally a joint results with a small range of movement.

Operation by Lateral Incision (*Langenbeck's Operation*).—In this operation a straight incision 2 inches in length is made in the direction of the axis of the femur, and passing downward from the apex of the great trochanter. From the beginning of this incision a curved incision is carried toward the head of the bone, the convexity of the curve being backward (see Fig. 530, A). Bell advises the use of the saw after bringing the head of the bone into the wound by abduction and eversion of the thigh. Barker applies the saw with the bone *in situ*, and strongly opposes wrenching the bone out of the incision because of the danger of peeling off the periosteum, which, if it takes place, favors necrosis.

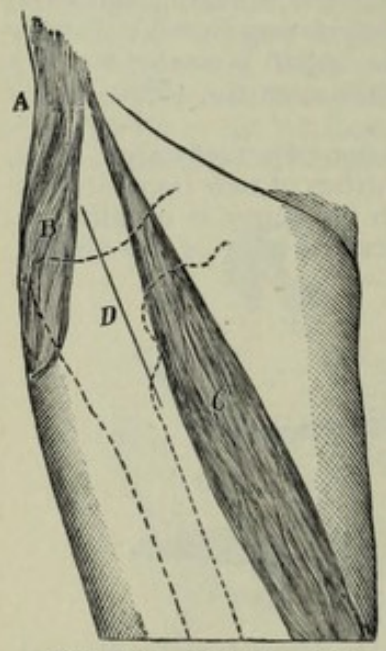


FIG. 532.—Excision of the hip-joint: A, Gluteus muscle; B, tensor vaginæ femoris muscle; C, sartorius muscle; D, anterior incision.

Incision of Gross.—In Gross's operation a semilunar flap is made with the convexity backward (see Fig. 527, E).

Excision of the Knee-joint.—The complete operation was first performed by Park, of Liverpool, in 1781. In this operation a complete excision should be performed. Some remove the patella, others do not. The operation is performed for tuberculous disease, some compound fractures and compound dislocations, and some cases of angular ankylosis. It is rarely employed for gunshot injuries.

Operation by Anterior Semilunar Flap.—The patient lies upon his back, and the joint, if not ankylosed in extension, should be semiflexed. The surgeon stands to the right side. An incision is made which at once opens the joint. The incision begins at one condyle and reaches the other condyle by a curve which passes through the ligamentum patellæ midway between the tuberosity of the tibia and the inferior margin of the patella (see Fig. 526, B). The flap is dissected up, the knee is thrown into forced flexion, the lateral ligaments and crucial ligaments are cut, and the end of the femur is well cleared. The blade of Butcher's saw is passed beneath the femur, which is sawn from below upward (Ashhurst). The end of the tibia is cleared and a portion is sawn off. If, after sawing, diseased foci are discovered, another section can be sawn off or the foci can be gouged away. The elder Ashhurst, who had a vast experience with this operation, insisted that in sawing through the femur the natural obliquity of the bone must be borne in mind and the section must be made in "a line parallel to that of the free surface of the condyles." If the section is made transverse to the axis of the femur, "the limb, after adjustment, will be found to be markedly bowed outward." The same surgeon said that the epiphyseal line is somewhat higher on the front than it is on the back of the femur, and in consequence the following rule is formulated for section of the condyles: the section of the condyles should be "in a plane which, as regards the axis of the femur, is oblique from behind forward, from below upward, and from within outward." Ashhurst advocated section of the tibia "in a plane transverse to the long axis of the bone, with a slight anteroposterior obliquity, so as to correspond with that of the section of the condyles," and he further said that the patella must be removed whether it is diseased or not, and quotes Péniére's observations to the effect that excision of the patella diminishes the risk of death one-third, and its retention doubles the probability of an amputation becoming

necessary in the future. Many surgeons prefer to retain the patella. When this is done the posterior portion of the patella and portions of the front of the femur and tibia are denuded. The denuded patella is applied as a bone-graft to the denuded tibia and femur. The graft aids in fixation and early solidification.

The diseased synovial membrane is clipped away with scissors and all sinuses and diseased territories are well curetted. The posterior ligament of the joint is not removed unless it is diseased; its retention prevents displacement and guards the popliteal space. In some cases tenotomy is required to permit extension. In children the fragments should be wired together; in adults this need not be done. After hemostasis, irrigate by salt solution, insert a drainage-tube, suture, dress antiseptically, and adjust the limb upon Price's splint or Ashhurst's bracketed wire splint. Instead of the bracketed splint a long fracture-box may be used. Many surgeons use a fenestrated or interrupted plaster-of-Paris splint, which is employed until the parts have become apparently firm and solid (Fig. 533). If the femur tends to project anteriorly, use an anterior splint. If there be a tendency to outward bowing, adopt Ashhurst's expedient of carrying a strip of adhesive plaster around the outside of the limb and fastening it to the inner side of the splint. The splint is kept on until bony union is complete, as in this operation a movable joint is never sought. Even for many months after the parts have apparently become solidly united, bending may occur. How long fixation should be used has been much debated. In order to avoid the danger of flexion or other deformity, fixation by some form of apparatus should be maintained for "at least a year and probably nearly two years after excision" (J. Torrance Rugh, "Amer. Jour. Orthopedic Surgery," Feb., 1909).

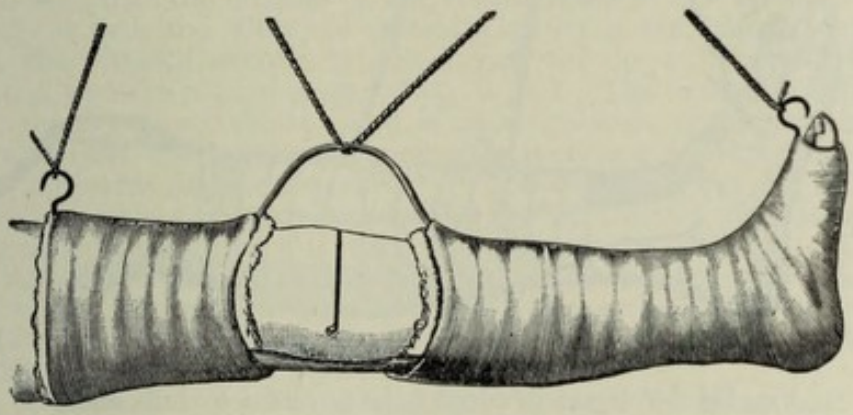


FIG. 533.—Watson's plaster-of-Paris swing splint.

Excision of the Ankle-joint.—Excision of the ankle was first performed by Moreau in 1792. This operation is performed chiefly for gunshot wounds, compound dislocations, and in some cases of tuberculous joint disease. Excision of the ankle is an operation which is seldom performed.

Operation by Hancock's Method.—In this operation the patient lies upon his back, the foot rests upon its inner side, and the surgeon stands to the outer side of the damaged limb. Begin an incision just behind and 2 inches above the external malleolus, and carry it across the front of the joint to a corresponding point above and behind the internal malleolus (see Fig. 530, B); this incision goes through the skin only, and the flap thus marked out is reflected. "Cut down upon the external malleolus, carrying the knife close to the edge of the bone both behind and below the process, dislodge the peronei tendons, and divide the external lateral ligaments" (Joseph Bell). Cut the fibula 1 inch above the malleolus by means of pliers; divide the tibiofibular ligament; turn the foot upon its outer side; dissect from their habitat back of the inner malleolus the tendon of the posterior tibial muscle and the tendons of the flexors of the toes; carry the knife around the inner malleolus close to the bony edge; separate the internal lateral ligament, and dislocate the lower end of the tibia through the wound by turning the sole of the foot downward; saw off the lower end of the tibia and the articular process of the astragalus, sawing away from the tendo achillis, and removing the fragments by bone forceps. Cut away diseased synovial membrane, and curet all sinuses and tuberculous areas. Arrest bleeding, irrigate, and drain. Sew up the wound, insert a tube at the outer angle, and cause it to emerge at the inner angle. Apply antiseptic dressings, and put up the foot in fixed dressing or in splints at a right angle to the leg (Fig. 534). In Langenbeck's operation the excision

is subperiosteal. If, in an excision of the ankle-joint, the astragalus is found extensively diseased, remove the entire bone.

Excision of the Os Calcis.—In caries limited to the os calcis most surgeons prefer to gouge away the dead bone, leaving the periosteum and, if possible, a shell of healthy bone, and draining thoroughly. Others advocate excision in some cases. Extensive disease limited purely to the os calcis is rare, and most surgeons advise gouging for limited caries, and Syme's amputation in the event of the disease extending beyond the periosteum or reaching adjacent bones.

Operation by Subperiosteal Method.—In this operation the position assumed by the patient is supine, with the leg extended and the foot resting on its inner side. The incision, which cuts the tendo achillis and reaches the bone at once, is begun at the upper border of the os calcis and the inner margin of the tendo achillis, and is taken outward and horizontally forward to a point in front of the calcaneocuboid articulation (see Fig. 527, F). A vertical incision is begun near the forward termination of the initial incision, is carried across the outer edge and plantar surface of the foot, and terminates at the external margin of the inner surface of the os calcis. Some surgeons carry the vertical incision a little upward, toward the dorsum. The periosteum is entirely stripped by an elevator, the os calcis is removed, the cavity is packed with iodoform gauze, the wound is stitched, a drain is inserted posteriorly, the foot is dressed antiseptically, is placed at a right angle to the leg, and plaster of Paris is applied, trap-doors being cut for drainage. Later the drain is removed and the packing of gauze is changed daily.

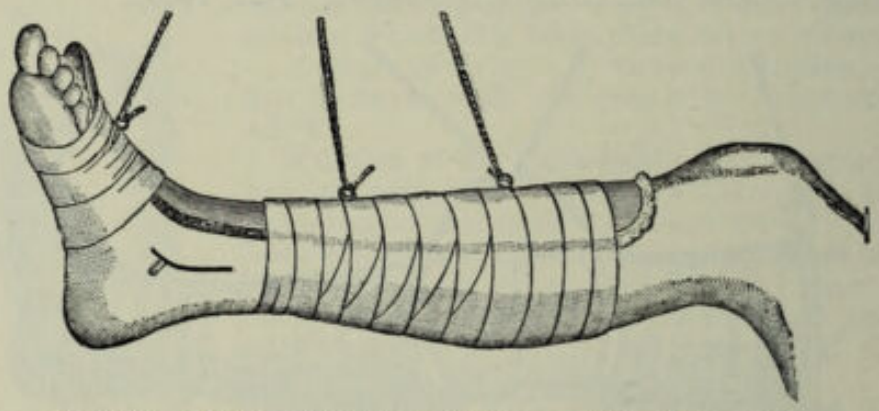


FIG. 534.—Volkmann's dorsal splint for excision of the ankle.

Astragalectomy, or **excision of the astragalus,** is not infrequently performed. Astragalectomy is employed occasionally for relapsed and inveterate cases of club-foot. The indications are pointed out by Willard ("International Clinics," vol. iii, 12th series): "(1) Adults with great bony deformity; (2) neglected children of five to fifteen years, who have markedly distorted their tarsi by locomotion; (3) relapsed cases which have resisted the milder forms of operation, or which have been neglected by parents after previous operation; (4) only occasionally, young children in whom from infancy the bones of the foot have been exceedingly rigid and unyielding, and where there is practically but little motion either at the ankle-joint or in the tarsus."

Operation by the Subperiosteal Plan.—Barker advises an incision going at once to the bone, from the "tip of the external malleolus forward and a little inward, curving toward the dorsum of the foot." The foot is extended and turned inward, the periosteum is lifted, the astragalus is removed, and the wound is treated and the foot is dressed as is done after excision of the os calcis.

In cases of *paralytic calcaneus* Whitman ("Orthopedic Surgery") recommends removal of the astragalus through a curved external incision; freeing the malleoli and making new sockets for them beside the cuboid and scaphoid bones. He puts the foot in marked plantar flexion and holds it by plaster of Paris.

Excision of the Metatarsophalangeal Articulation of the Great Toe.—In this operation make a lateral incision and cut off or saw off the proximal end of the first phalanx and the distal third of the first metatarsal bone. (See Mayo's Operation for Bunion, page 650.)

Excision of the Metatarsal Bone of the Great Toe (*Butcher's Method*).—In this operation a lateral straight incision is made, the periosteum is elevated, and the shaft is sawn from each extremity and removed.

Excision of the fourth metatarsal bone is done to relieve crowding of the metatarsal bones in obstinate cases of metatarsalgia (Morton's toe).

Excision of the clavicle may be required for dislocation, caries, necrosis, gunshot wound, tumor of this bone, as a preliminary to ligation of the artery and vein in certain cases of amputation at the shoulder-joint, or in cases of removal of the entire upper extremity. In excision of the clavicle the position of the patient is the same as that for ligation of the third part of the subclavian artery (see page 431). An incision is made down to the bone from the sternoclavicular joint to the acromioclavicular articulation. If the case is suitable, the periosteum is stripped and the bone is sawn and removed; if not, the bone is sawn and each half is separately disarticulated. In a case of sarcoma do not leave the periosteum. The wound is sutured and dressed, and the limb is put up in a Velpeau bandage. McCreary, of Kentucky, in 1811 performed the first complete excision of the clavicle.

Excision of the Scapula.—Complete excision of the scapula is usually performed for tumors. Partial excision requires no detailed description. In excision of the scapula the patient lies upon his sound side. Treves suggests the following incisions: one outside the vertebral border of the scapula, from its superior to its inferior angle; another from over the acromioclavicular joint, along the acromion process and spine of the scapula, to meet the first incision. Syme used an incision carried transversely inward from the acromion process to the vertebral border of the scapula, and another cut directly downward from the center of the first incision (see Fig. 527, G). In the method of Treves[1] the upper flap is reflected and the trapezius muscle is divided; the lower flap is reflected and the deltoid muscle is divided. The patient's hand is placed on the sound shoulder; the muscles of the vertebral border are divided, the posterior scapular artery is tied, and while the vertebral border of the scapula is pulled toward the surgeon, the serratus magnus muscle is cut, the upper border of the shoulder-blade is cleared, and the suprascapular artery is tied. The hand is now brought down to the side; the acromioclavicular joint is disarticulated; the conoid and trapezoid ligaments are divided; the muscles of the coracoid process are cut; the capsule is incised, with the supraspinatus and infraspinatus, the subscapularis, and the scapular origins of the biceps and triceps muscles; and finally the teres major and minor muscles are divided, the subscapular artery is tied, and the bone is removed. The wound is stitched, a drain is introduced, and antiseptic dressings are applied. The patient lies upon his back until healing is well under way, when the arm is placed in a sling. The drainage-tube may be removed in twenty-four hours. Langenbeck, of Berlin, in 1855 performed the first complete excision of the scapula.

Excision or Resection of a Rib (Fig. 714).—In *caries* the gouge and rongeur may remove the disease. In other cases excision is performed. In this operation the patient lies upon his sound side unless the operation is performed for empyema, in which case he lies on his back or only partly on the sound side. (See Empyema, Operation for.) The surgeon faces the patient. Make an incision down to the bone, in the long axis of the rib. The periosteum, if not diseased, is lifted from the bone, and the intercostal artery is lifted out of the way with the periosteum and is thus saved from being cut. After dividing the bone beyond the limits of disease, remove it. During the sawing a metal retractor is held beneath the rib, between the rib and the periosteum. It is better to saw it than to cut it with ordinary biting forceps, because the latter splinters the bone. The author usually uses a forceps known as a *costotome*, which cuts the rib without splintering. If the periosteum is diseased, remove it after tying the intercostal artery. It should be removed in a case of empyema, otherwise bone formation may interfere with drainage. In *empyema*, after removing the periosteum, open into the pleural cavity, allow pus to flow out slowly, remove fibrinous masses, employ a finger to feel if there are adhesions and if the lung will probably expand, and insert a drainage-tube. In resection for rib disease curet sinuses and pack with iodoform gauze for some days. Sew up the wound except at one end. Dress antiseptically and apply a binder. (See Operations Upon the Chest and Estlander's Operation.)

In *removing a cervical rib* make an incision along the posterior edge of the sternocleidomastoid, avoid the pleura, subclavian vessels, and brachial plexus, and remove the periosteum with the rib in order that the bone will not be reproduced.

Complete Excision of One-half of the Upper Jaw.—The whole upper jaw has been removed, but in what follows only resection of one-half the jaw will be described. This operation is performed for malignant tumors of the superior maxillary bone or

[1] "Manual of Operative Surgery."

its antrum. Up to 1826, at which time Lizars, of Edinburgh, suggested the operation, tumors of the antrum were treated by scraping them away with a sharp spoon. Gensoul, of Lyons, in 1827 performed the first operation for resection of the upper jaw. Heyfelder, in 1844, removed both superior maxillary bones. Excision of a superior maxillary bone is not justifiable except as a palliative measure, if the orbit is invaded, if the skin and subcutaneous tissues are infiltrated, or if the disease extends widely beyond the superior maxillary and palate bones. The mortality is about 15 per cent. Half the sarcoma cases which recover from operation will show no return in a year. One-third of the recoveries show no return in three years. Carcinoma almost invariably returns, and quickly.

Some surgeons ligate the external carotid artery or compress it temporarily. In a number of excisions of the upper jaw I have always found the hemorrhage readily controllable as soon as the bone has been removed, and have never felt it necessary to resort to preliminary ligation or compression.

Operation by Median Incision.—The patient, whose face has been shaved, is placed in the Trendelenburg position, thus avoiding the possible need of instant tracheotomy; or, what is even better, he lies horizontal or with the head a little raised and takes ether by intratracheal insufflation (see page 1205). The surgeon stands to the right side of, and faces, the patient. The central incisor tooth on the diseased side is pulled out.

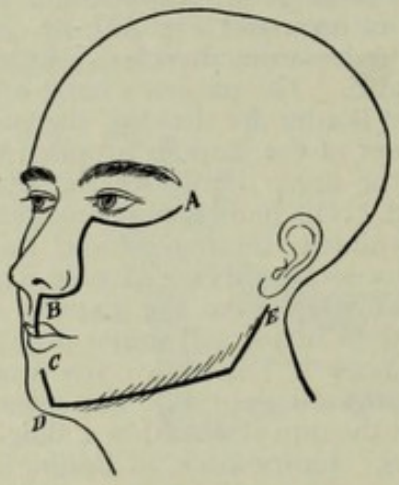


FIG. 535.—*A–B*, Incision of the soft parts preliminary to excision of the upper jaw; *C–D–E*, incision of soft parts preliminary to excision of the lower jaw.



FIG. 536.—1, Excision of the upper jaw: A–B, Section of the nasal process; B–C, section of the orbital plate; D, section of the malar bone and orbital plate; E, section of the alveolus and hard palate. 2, Excision of the lower jaw: G, Section of the inferior maxillary; H, section of the ramus in partial resection.

The incision, which is really Weber's incision (called by some Nélaton's, by some Fergusson's, by some Liston's) is begun ½ inch below the inner canthus of the eye, and is carried along the side of the nose, around the ala of the nose, by the margin of the nostril, and through the middle of the lip. While the lip is being incised the assistant arrests hemorrhage by grasping the corners of the mouth, and after the lip has been divided the coronary arteries are at once ligated. Some operators approach the mucous membrane cautiously and ligate the vessels before opening the cavity of the mouth. The upper portion of the wound having been compressed by another assistant during these manipulations, pressure is now removed and bleeding points are ligated. Another incision is now carried outward from the beginning of the first incision, along the orbital margin to well over the malar bone (Fig. 535). The flap is lifted from the periosteum, and the bleeding from the infra-orbital artery and the small vessels is restrained by pressure. The nasal cartilage is separated from the bone, and the nasal process of the superior maxillary is sawn (line A–B, Fig. 536). The orbital periosteum is lifted up, and the orbital plate is cut by forceps from the saw-cut in the superior maxillary bone to the sphenomaxillary fissure (line B–C, Fig. 536). The malar bone is sawn or is bitten through about its center, the cut running into the sphenomaxillary fissure and taking a downward and outward direction (line C–D, Fig. 536). The soft parts covering the hard palate are incised in the median line, a corresponding incision is made along the floor of the nose near the septum, and the soft palate is separated from the hard palate by a transverse cut. The saw is

introduced through the nose, and the palate is sawn (line E, Fig. 536). The upper jaw bone is grasped by Fergusson's lion-jaw forceps and removed, the removal being aided by the use of the scissors and bone cutters; the latter are used to separate the upper jaw from the pterygoid process (Treves). The moment the bone is out plug the cavity with a hot, moist towel. On removing the plug search for bleeding. Every vessel that can be seen is tied, and severe bleeding from bone is arrested by antiseptic wax. Oozing is controlled by hot water and pressure or by Paquelin's cautery. Examine carefully to see if all the diseased area has been removed; if it has not been, use the gouge, scissors, chisel, and saw until healthy tissue is reached. The wound is packed with iodoform gauze, and the end of the strip is so placed as to be accessible through the mouth. The wound is sutured (the mucous membrane of the lip must be stitched, as well as the skin) and is dressed antiseptically (the eye being protected by aseptic gauze), and a crossed bandage of the angle of the jaw is applied. After this operation it is common to have the eye sink to a lower level (causing double vision), to have persistent swelling of the lower lid, and to have tears flow over the lid instead of down the duct. This may be prevented in some cases by making a hammock for the orbital contents from a flap of the temporal muscle with a bit of the anterior portion of the coronoid process.

Excision of One-half of the Lower Jaw.—In some rare instances the entire inferior maxillary bone is removed. The lesions necessitating removal of the lower jaw are of the same nature as cause us to remove the upper jaw. The names of many surgeons are connected with this operation, viz., Deadrick, White, Dupuytren, Sir Astley Cooper, and Valentine Mott.

In this operation the patient is placed in the same position as for excision of the upper jaw, the chin having heen previously shaved. A vertical cut is made through the chin tissue, starting below the margin of the lip and reaching to below the border of the jaw (C–D, Fig. 535). From the point D an incision is carried outward below the border of the jaw and then back of the ramus, as shown in the line D–E (Fig. 535). Treves's advice is to carry this incision down to the bone, except at the line of the facial artery, at which point it must go through the skin only. The facial artery is now to be sought for, tied in two places, and divided. Except in malignant cases the periosteum is lifted from the external surface of the bone, from the symphysis outward. Hemorrhage is arrested. The buccal mucous membrane is cut from the alveolus. A lateral incisor tooth is pulled, and the bone is sawn in the line G (Fig. 536). The bone is grasped in a lion-jaw forceps and is drawn outward. The mylohyoid insertion is cut; the internal pterygoid muscle is cut and the periosteum at this spot is lifted; the inferior dental artery is cut and tied; the jaw is pulled down; the insertion of the temporal muscle upon the coronoid process is cut away, and the external pterygoid muscle is divided. The capsule of the joint is opened, and the bone is separated from the ligaments which still hold it in place. Bleeding is arrested, the wound is sutured, a tube is introduced in the posterior portion of the wound and retained for twenty-four hours, and antiseptic dressings and a Gibson or a Barton bandage are applied. Partial excisions of the alveolus may be performed through the mouth by means of chisels and rongeur forceps, and Wyeth has thus removed half of the jaw; but if any considerable part of the body of the jaw is to be removed, it is usually best to make an incision below the inferior maxillary.

Partial Excision.—This operation is frequently made necessary by epithelioma involving the periosteum or bone. After this operation, unless means are taken to prevent deformity, there will be asymmetry of the two portions of jaw bone remaining and malrelation of the teeth. Various attempts have been made to fill up this gap at the time of operation by some material, or to hold the two portions of the mandible in symmetric relation by the insertion of trusses of silver wire, or by fastening each piece of bone to a metal plate.

John B. Murphy suggested the use of a bridge of silver wire. All of my trials with such a bridge failed. It always ulcerated out and usually through the skin, but did some good by keeping the bone ends further apart than they otherwise would have been.

Stanley Stillman ("Annals of Surgery," July, 1912) advocates bone-grafting as the only proper method in order to prevent contraction during healing after the removal of the jaw bone. "When the teeth on the sound side are numerous and firm enough to stand the strain, they may be prepared beforehand with the aid of a dentist, so that a few days after the operation they may be clamped firmly to those of the upper jaw" (Ibid.). When the wound heals Stillman separates the flap,

freshens the bone ends, and wedges a section of rib between them. The clamps are left in place until the bones unite, which requires six to eight weeks. In cases in which the teeth cannot be used to clamp the lower to the upper jaw a silver bridge is inserted, which is left in place until the parts are ready for the insertion of the bone.

Operation for Dislocation of the Internal Semilunar Cartilage of the Knee-joint.—(See Surls and Osgood in "Jour. of Bone and Joint Surg.," Oct., 1923.)

Prepare thirty-six hours before the operation and repeat the process twelve hours before. Apply an Esmarch and sterilize the parts again. The leg of the patient hangs over the end of the bed and his heel rests in the thigh of the seated surgeon. The cut starts opposite the middle of the inner side of the patella. It is 3 inches in length, runs downward and curves forward (V shaped). The coronary ligament is separated from the presenting cartilage and all of the cartilage is removed. Spare the crucials and the internal lateral ligament. Remove hypertrophied synovial tabs. Suture the synovial membrane with fine silk. Next suture the lateral expansions of the quadriceps next the skin. Extend the leg over a pillow and support with sandbags. Active motion, if painless, can be made very early. In ten days more active motion can be practised and light weight bearing should be ordered. In two or three weeks get the patient up on crutches.

Arthroplasty of a Joint.—In some cases free resection will give more mobility than will arthroplasty. If there is firm ankylosis in useful position and no pain, do not operate. Existing infection forbids arthroplasty, most cases of tuberculosis are unsuitable for operation, osteo-arthritis is unfavorable. The best results are obtained in traumatic cases with bony ankylosis and with bones and muscles normal. Toxic muscular atrophy and a great amount of scar tissue in the chief muscles forbid operation (see the very valuable article by Groves in "Brit. Jour. Surg.," Oct., 1923). The best results are obtained in the elbow. The operation is forbidden if the bones are still growing.

The details of the operation and the selection of cases are of immense importance (Groves, Ibid.). If too much bone is cut away a flail-joint will be obtained; if too little, there will be renewed ankylosis. Shape the bone ends so that one end has a definite concavity. Some surgeons insert a foreign membrane (for instance chromicized pig's bladder), but much inflammatory material forms and hence adhesions take place. Many prefer a pedicle flap of muscle or fascia. Groves (Ibid.) points out that this is liable to slip, may be too tense, and cause much inflammatory exudation. It is best to use a free flap of fascia lata to cover both ends. The flap is fixed to a bone end by sutures through the bored bones, by nails, or by ivory pegs.

If rapid healing is obtained, if the bone ends are held asunder by traction, and if voluntary motion is permitted early, a bursa forms between the bones.

During or after a mobilization operation it may be necessary to repair the ligaments. This is true particularly in the knee.

I find the following rules by Groves (Ibid.) extremely useful. In the shoulder, if the scapula is movable, arthrodesis is preferred to mobilization.

In the ankle astragalectomy and in some cases amputation is better.

In the elbow no operation is necessary if there is no pain and the arm is useful. Excision gives a good result, but mobilization is better.

In the hip it is hard to obtain a firm and movable joint by operation. If the hip is ankylosed in a faulty position or if both hips are ankylosed we must operate.

Osteotomy of the neck is done first in simple ankylosis. In massive ankylosis a new joint is made below the trochanter. In osteo-arthritis mobilization is accomplished by excision and the insertion of flaps. The knee gives a very uncertain prospect and mobilization is practised only when there is ankylosis in faulty position or when both knees are involved. In the latter case only one knee should be operated upon (see Ernest W. Hey Groves, of Bristol, in "Brit. Jour. of Surg.," Oct., 1923).

Operation for Congenital Dislocation of Hip.—*Lorenz's Bloodless Method of Reduction.*—The method of reducing by manipulation a congenital dislocation of the hip was advised by Paci and modified and improved by Lorenz. It has long been known that reduction is easy at birth because an acetabulum, though probably a shallow one, exists, and the head of the bone is not firmly held in its new situation. In an older child the problem is far more difficult, because, even if reduction is effected, the acetabulum may be extremely shallow or absent, and redislocation may readily occur. Lorenz aims to effect thorough reduction and then fixes the limb in abduction for months, so that the acetabulum will deepen and the bone will become firm in its proper socket. This operation is rarely successful in children over six years of age.

The child is anesthetized and an attempt is made to draw the femoral head into line with the acetabulum. If the child has never walked, this is readily accomplished. If it has walked, the procedure may be very difficult, and it may be necessary to make extension by a fillet fastened above the knee, and counterextension by a screw and a perineal band. The drawing down of the head is made easier by stretching and massaging the adductor muscles. The next step is to flex the thigh, strongly rotate it a trifle internally, and then abduct it while flexion is maintained. This causes the head of the femur to pass around the posterior margin of the acetabulum and frequently produces reduction. "Full abduction being kept up, the thigh is rotated out, thus forcing the head of the femur more firmly into the socket." (See the description of the Lorenz method in J. Jackson Clark's "Orthopedic Surgery.") The strongly abducted limb is put up in plaster of Paris. In about three months the plaster is removed, the abduction is diminished, the plaster is reapplied, and is retained for another three months. During the continuance of immobilization of the hip the child crawls about, with the knees bent. When the plaster is finally removed, manipulation, massage, and exercise strengthen the muscles and give freedom to the joint. In a double dislocation one joint may be cured before the other is operated upon, or both may be operated upon at the same séance. In double dislocation plaster must be worn more than six months. The Lorenz operation is safe when applied to very young children, but has elements of danger which increase with the years of the subject. A patient may suffer grave lacerations of muscles and ligaments, and even vessels and nerves. Death may result from shock, and extensive deep-seated hemorrhage may occur. In fact, it is a mistake to call it a bloodless method. The blood flows, though we do not see it. An untrained man may do fearful mischief by this operation, and it should only be attempted by an experienced, skilful manipulator and upon properly selected cases, when it is a very successful procedure. I am satisfied that, except in the case of a very young child, in whom reduction is easy, one who performs the Lorenz operation should be something more than skilful and experienced. He should be physically strong, so that traction and abduction will be powerful and steady. A weak man will jerk, will throw his weight upon the part, and will be apt to tear structures instead of stretching them. Sudden forcible movements are apt to break the bone.



FIG. 537.—Lorenz method. Unilateral congenital dislocation of hip (reduced). Cast applied with leg in "frog position."

Hoffa's Cutting Operation.—Make the external incision of Langenbeck to open the joint (see page 660). The capsule is incised at its insertion into the neck, and the periosteum and muscles are lifted from the great trochanter. Hoffa claims that in children less than five years of age the head of the bone can be readily replaced into the acetabulum by flexing the thigh and making direct pressure upon the head of the bone. After replacing the femoral head it is held in place while an assistant extends the leg in order to stretch the muscles. In children over five years of age cut with a tenotome the muscles which spring from the ischial tuberosity and also the adductors; cut the fascia lata and muscles which arise from the anterior superior iliac spine; open the joint and liberate the head of the bone; remove the ligamentum teres; scrape out the acetabulum, removing "cartilage, fat, and considerable spongy tissue" (Tubby); and replace the head of the bone in the acetabulum. The limb is maintained in inversion, abduction, and extension for several weeks, when it is straightened. Massage and passive motion are begun in the fifth week. The patient now gets about, wearing for many weeks an apparatus which permits the head of the bone to move in the socket, but prevents redislocation.

Lorenz's Cutting Operation.—This is a modification of Hoffa's. The muscles inserted into the greater and the lesser trochanter are not cut; the sartorius, the hamstrings, and the external portion of the fascia lata are cut (Tubby).

The incision of Lorenz is longitudinally from the anterior superior spine. Another incision is carried inward from this at the level of the lesser trochanter. The capsule is opened by a crucial cut; the acetabulum is enlarged; the head of the bone, if it remains, is inserted into the acetabulum; if there is no true head, a new one is shaped and inserted into the cavity. The limb is immobilized in a position of moderate abduction. Massage and passive motion are begun in the fifth week, and are continued for months.[1]

Reduction by Means of Mechanical Appliances.—As the chief factor in the reduction of a congenital dislocation is thorough stretching of the muscles and ligaments before attempting replacement, numerous forms of levers have been devised to accomplish this. The best-known one is that of Bartlett, of Boston. It consists of a pelvic rest with perineal support, rods to fix the pelvis, and traction rods to make extension. Great care is necessary in the use of all such appliances because of the danger of injuring vessels and nerves or of fracturing bony parts. After the parts have been thoroughly stretched replacement is accomplished by manipulation, as in the usual methods of manual reposition.

XIX. DISEASES AND INJURIES OF MUSCLES, TENDONS, AND BURSÆ

Myalgia, or **muscular rheumatism,** is a painful spasm of the voluntary muscles and a painful condition of the fibrous and periosteal areas to which they are attached. The term "muscular rheumatism" is not strictly correct. It is probable that in some cases the muscular structure is torn or inflamed, but it is certain that in some cases the pain is distinctly neuralgic. Muscular rheumatism may be due to cold and wet, to overexertion and strain, to acute infectious disorders, to syphilis, to chronic intoxications (lead, mercury, and alcohol), and to disturbances of the circulation. Gouty and rheumatic persons are especially predisposed, men being more liable to the disease than women. The disease is usually acute, but it may be chronic.

Symptoms.—Muscular rheumatism is apt to come on suddenly. The pain, which may be very acute and lancinating or dull and aching, is in some cases constantly present; in other cases it is awakened by muscular contraction only, and it is frequently relieved by pressure, though there is often some soreness. The skin above the muscle is sometimes tender to light pressure. The disease usually lasts for a few days, but it tends to recur. There is little, if any, fever.

Lumbago is myalgia of the muscles of the loins. Suddenly, during movement of the parts (coughing, sneezing, twisting, lifting), there is a feeling as if something had torn above the iliac crest and the spinal muscles become the seat of spasm and violent pain. Any attempt at use of the back muscles causes a pain so violent that it at once inhibits effort. *Rheumatic torticollis* is myalgia of the muscles of the neck. Usually one side of the neck is attacked. The chin is turned from the affected side and the neck is stiff. *Pleurodynia* is myalgia of the intercostal muscles. The pain is very severe, is aggravated by deep respiration, by coughing, and by yawning, there may be tenderness, and the patient tries to limit chest movement. In *intercostal neuralgia* the pain is limited, is not constant, but occurs in distinct paroxysms, and is linked with the presence of the tender spots of Valleix. Pleurodynia lacks the physical signs of pleurisy. *Cephalodynia* is myalgia of the muscles of the scalp. The muscles of the shoulder, upper dorsal region, abdomen, and extremities may also be attacked by myalgia. Myalgia must not be confused with the pains of locomotor ataxia.

Treatment.—Remove any obvious cause. Treat any existing diathesis, such as gout or rheumatism. Rest is of the first importance. For lumbago put the person to bed. For pleurodynia strap the side of the chest. A hypodermic injection of morphin and atropin into the affected muscles at once allays the pain, and a deep injection of distilled water is sometimes curative. Relief may be afforded by painting the surface with 30 drops of a mixture of equal parts of guaiacol and glycerin and covering the painted area with cotton. The introduction of four or five aseptic needles into the muscles, and their retention for a few minutes, sometimes acts most favorably. Ironing the skin above the painful muscles with a very warm iron, a piece of flannel being interposed, is a useful domestic remedy. Vigorous rubbing of the area with a piece of ice allays the pain. Hot poultices do good. In lumbago an injection into the muscle of a 1 per cent. solution of quinin and urea hydrochlorid will relieve the painful spasm (H. S. Souttar in "Brit. Med. Jour.," Nov. 17, 1923). If the pain is widely

[1] I have drawn upon the very lucid description of these operations in A. H. Tubby's treatise upon "Deformities."

diffused, alters its seat, or is very obstinate, order hot baths or Turkish baths and administer diuretics. In chronic cases employ blisters or counterirritation by the cautery, give iodid of potassium and nux vomica, and have the patient take a Turkish bath every week. The constant electric current finds advocates. In an ordinary severe case order a hot bath, put the patient to bed with a hot-water bag over the part, and administer 10 gr. of Dover's powder; the next morning order to be taken four times daily a capsule containing 5 gr. of salol and 3 gr. of phenacetin until the pain disappears. Citrate of potassium, citrate of lithium, aspirin, chlorid of ammonium, or the salicylate of colchicin may be ordered instead of salol and phenacetin.

Infective myositis is a wide-spread inflammation of the voluntary muscles due to an unknown infective cause. It is a disorder accompanied by pain and stiffness, by cutaneous edema, and by various paresthesiæ. Myositis resembles trichinosis, and can be distinguished from it only by spearing out a bit of muscle and examining it microscopically. Occasionally diffuse suppuration occurs.

Ordinary myositis arises from injuries, from syphilis, or from rheumatism, and it presents the usual inflammatory symptoms. Contraction and adhesions may follow. I operated upon a case of myositis of the rectus abdominis in a boy of eight. There was a large mass like a full bladder. There had not been an attack of typhoid and there was not hereditary syphilis. Caseation existed. The condition was possibly tuberculous, although no bacilli were found.

Treatment of Myositis.—Infective myositis is treated by anodynes, stimulants, nutritious food, hot applications, and rest. If pus forms, it should be evacuated. Rheumatic myositis calls for the administration of the salicylates, the alkalies, or salol. Syphilitic myositis is treated with mercury and iodid of potassium. The remedies employed for myalgia are used in traumatic myositis.

Hypertrophy of the muscles may arise from their increased use. In *pseudohypertrophic paralysis* the muscle is greatly augmented in bulk, but it contains less muscle structure and more fat or connective tissue.

Atrophy of the muscles arises from want of use, from injury, from continuous pressure, from interference with the blood-supply, from disease of the nerves or their centers, or from lead-poisoning.

Degeneration of Muscles.—The muscles may undergo granular degeneration, waxy degeneration, fatty degeneration and calcareous degeneration, and may become pigmented.

Local Ossification and Myositis Ossificans.—It is not unusual for a small portion of bone to form in the periosteal insertion of a muscle which is subjected to frequent strain. In persons who ride many hours a day there not infrequently develops the *riders' bone*, which is an area of ossification in the adductor muscles of the thigh.

Myositis ossificans traumatica is a circumscribed ossification of muscle due to a single severe closed injury. It does not follow open injuries (O. M. Shere in "Jour. Amer. Med. Assoc.," 1915, lxv). The usual cause is a contusion and laceration of muscle by a dislocated bone or a rupture of muscle may be followed by the ossifying process. The bone formed is cancellous. The nature of the process is uncertain. Some observers believe the process is inflammatory, a real myositis. Many believe that the osteoblasts come from the periosteum or that a bit of periosteum was pulled off by the muscle. Oliver ("Jour. Amer. Med. Assoc.," 1914, lxiii) says the process is not a myositis, but is a metaplasia of connective tissue or a periosteal growth. The treatment is early excision. This treatment is particularly important when we remember that the condition may be mistaken for, and perhaps may sometimes be, sarcoma.

I operated upon a traumatic case by removing an ossified area in the thigh muscles. The laboratory report was myositis ossificans. Growth quickly recurred after operation, but the new growth showed very little ossification. The laboratory report was spindle-cell sarcoma. This case and also another one reacted to Coley's fluid. It seems possible that local myositis ossificans may, in some cases at least, be a sarcoma in which rapid ossification occurs.

Myositis ossificans progressiva (Fig. 538) is a wide-spread ossification of the muscles arising during the first ten years of life and much more common in males than in females. The cause of this rare condition is unknown. It is probably due to congenitally defective organization. The thumbs and great toes are commonly short (microdactylia). This is due to imperfect development of the proximal phalanges or of the metacarpal and metatarsal bones. There may be osteomata of the skull, scapula, and other bones. The disease usually begins about the back, shoulders, and neck. There are stiffness, local cyanosis, and a feeling of doughiness. The areas later become hard.

Most of the muscles may suffer (the tongue, heart, diaphragm, muscles of deglutition, and the sphincters are never attacked). Involvement of the masseters locks the jaws. The *x*-rays show the bone. Death takes place usually before the twentieth year, in most cases from bronchopneumonia. No treatment is of even the slightest avail.

Tumors of the Muscles.—Primary tumors of the muscles are rare. Among those which may occur are sarcoma, fibroma, lipoma, myoma, osteoma, angioma, myxoma, and enchondroma. Many cases of supposed primary sarcoma of muscle are, in reality, cases of syphiloma (Esmarch).

Syphilis may cause inflammation. Gummata may form or gummatous infiltration may take place.

Trichinosis or **trichiniasis** (Fig. 539) is a disease due to the embryos of the Trichina or Trichinella spiralis. Sir James Paget recognized the nature of the previously known encysted or larval form. It was long believed that the Trichina spiralis was a harmless parasite, but in 1860 Zenker, of Dresden, proved that it might be responsible for dangerous epidemics. The trichina is normally a parasite of the rat. Man is infected by eating flesh which contains trichinæ and has been insufficiently cooked. The flesh of

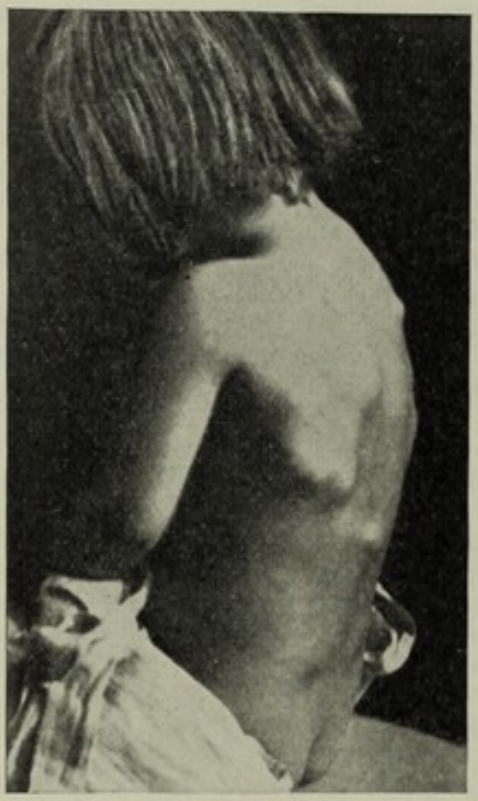


FIG. 538.—Myositis ossificans progressiva (author's case).

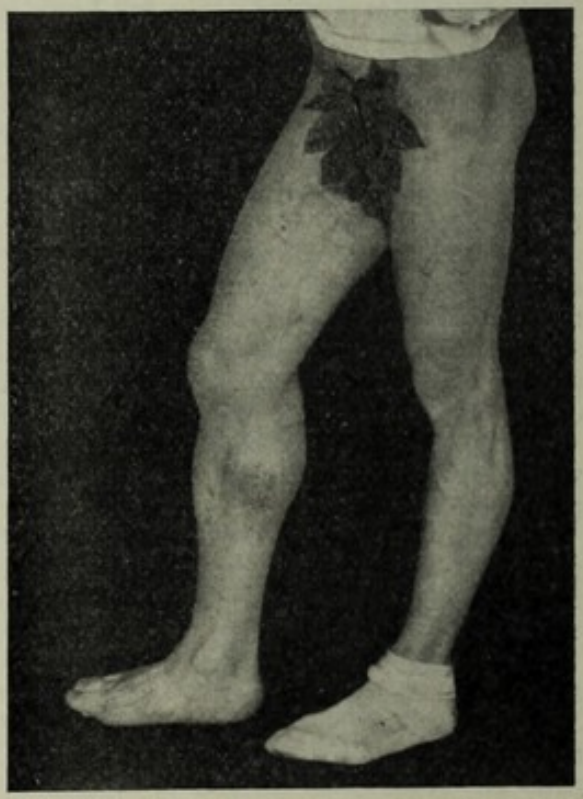


FIG. 539.—Author's case of trichinosis of right leg.

the pig is the medium of infecting man. The pig becomes infected by eating rats suffering from the disease or offal and slaughter-house refuse containing trichinallized flesh. Dr. Joseph Leidy discovered the trichina in pork. People are most commonly affected by eating raw sausage, smoked sausage, or underdone pork. Imperfectly boiled ham may be responsible. Albert reported 14 cases from eating boiled ham. W. Gilman Thompson found records of 52 sporadic cases occurring in New York City during six years ("Amer. Jour. Med. Sciences," Aug., 1910). These nematodes are carried into the intestine, there to develop and multiply. In from seven to nine days a horde of embryos develop in the bowel, and leave the alimentary canal by passing through the peritoneum or by means of the blood, and finally reach the connective tissue of the muscles. From the connective tissue the embryos migrate into the primitive muscle-fibers, where they dwell and enlarge. Myositis develops, and in the course of five or six weeks the parasites become encapsuled and develop no further. The cyst walls may calcify and the worms may become calcified, or may live for years. The eating of infected meat is not inevitably followed by the disease, and a few embryos lodged in muscle may cause no symptoms.

The **symptoms** of trichinosis often appear in a day or two after eating infected meat.

The symptoms of acute gastro-intestinal catarrh or of cholera morbus are common, but in some cases no gastro-intestinal manifestations usher in the disease. In from seven to fourteen days after the infected meat is eaten the migration of the parasites develops obvious symptoms. A chill may be noted; there is usually fever; muscular pain, tenderness, swelling, and stiffness are complained of. This condition may be wide-spread. Involvement of the muscles of mastication interferes with chewing; of the larynx, with talking and respiration; of the intercostals and diaphragm, with respiration. Skin edema and itching are marked. In some cases delirium exists. The writer saw in the Philadelphia Hospital one fatal case which was mistaken for erysipelas because of the high fever, the delirium, and the edematous redness of the face and neck. Dyspnea is frequent. Mild cases get well in a week or two; severe cases may last many weeks. The mortality varies in different epidemics from 1 to 30 per cent. (Osler). The diagnosis is made by spearing out a piece of muscle, which is then examined for trichinæ under a microscope; or the worms may perhaps be detected in the feces by means of a pocket lens. In a case under the care of the author, in St. Joseph's Hospital, there was no record of any attack of gastro-intestinal disturbance and the first manifestation was enlargement of the calf of the left leg. In most cases of trichinosis there is eosinophilia, but in the author's case, previously referred to, eosinophilia was not present.

Treatment.—To treat trichinosis employ purgatives (senna and calomel) early in the case, and give glycerin, and also santonin or filix mas. When muscular invasion has taken place, sedatives, hypnotics, nourishing diet, and stimulants are indicated.

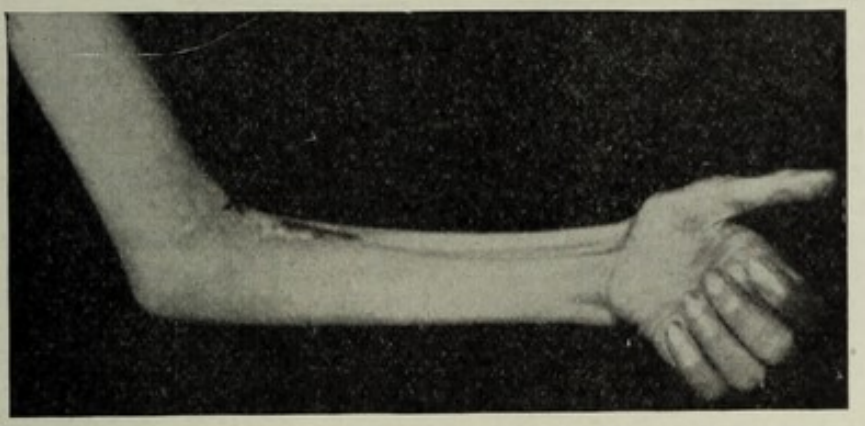


FIG. 540.—Volkmann's contracture (Dr. A. J. Davidson).

Ischemic Myositis, or Volkmann's Contracture (*Volkmann's Paralysis; Volkmann's Syndrome; Ischemic Paralysis; Ischemic Muscular Atrophy, with Contractures and Paralysis*, Fergusson calls it).—It is occasionally noticed, particularly in children, after prolonged fixation of the forearm, especially after prolonged fixation of the elbow-joint by some appliance that impedes the freedom of circulation in the part. Contractures of the fingers occur and perhaps rigidity and flexion of the wrist. In 1881 Richard von Volkmann, professor of surgery in Halle, described severe contractures of the hand observed in some cases as a result of the use of tight bandages to hold splints in place in treating fractures of the arm. He believed that the condition was due to deprivation of arterial blood, that the muscles perished for want of oxygen, and that rigor mortis occurred. He pointed out that paralysis and contracture occur simultaneously, whereas in primary nerve lesion paralysis precedes contracture. The condition may come on after the application of an Esmarch band, after a severe injury in the neighborhood of the elbow-joint, may follow ligation of the main artery of a limb, arterial embolism, venous thrombosis from injury or infectious disease, Raynaud's disease, or exposure to cold. One of Sir Robert Jones's cases followed a rapidly developing traumatic myositis ossificans; two followed crushes; in one an elastic tourniquet had been kept on a child's arm to prevent bleeding after an operation for webbed fingers; in one pad pressure had been maintained for twenty-four hours to check bleeding ("Amer. Jour. Orthop. Surg.," April, 1908). A case of mine resulted from embolism of the brachial artery. There are two forms, one due to almost complete arterial ischemia, lasting for several hours at least; another due to interference with venous return. Volkmann's contracture is due to muscular degeneration, infiltration, induration, and contraction, the result of marked and prolonged arterial ischemia, or interrupted venous

return, and it is frequently spoken of as ischemic myositis (Dudgeon, "Lancet," Jan. 11, 1902). In some cases distinct neuritis with paralysis also exists. Leriche considers the condition to be muscular necrosis due to pressure upon the periarterial sympathetic. One characteristic of ischemic contracture is the rapidity with which it comes on. Dudgeon points out that in half a day, or even in less time in some cases, the symptoms appear, these symptoms being paralysis of the part with contracture. Pain is unusual unless the nerves are seriously involved, and then it is violent. In some cases the fingers and hand swell and become discolored. The absence of pain frequently prevents the recognition of the condition; therefore the causative splint or bandage pressure may be maintained for days after the trouble has become serious. When the splints and bandages are removed and the forearm is examined there is almost always tenderness over the muscles and the nerve trunks; and in the majority of cases in which a splint has been the cause a portion of the skin will have sloughed. Dudgeon points out the characteristic position of the deformity as follows: When the wrist is extended, the metacarpophalangeal joints are also extended; but the interphalangeal joints of the fingers and the terminal joint of the thumb are so strongly bent that the tips of the fingers touch the palm, and this position cannot be corrected by any justifiable amount of force. As soon as the wrist-joint is bent to a right angle the interphalangeal joints can readily be extended. In a very severe case the wrist itself will become markedly flexed, and it will be impossible to extend it. The forearm is usually semiflexed and the hand pronated. The ulceration or sloughing so frequently present causes a *splint-sore*. There is always marked induration about a splint-sore. The flexor muscles themselves are indurated and usually wasted. The condition of sensation depends upon the state of the nerves of the part. When neuritis is absent sensation will be normal; but in accordance with the amount of neuritis and degeneration there will be hyperesthesia, partial anesthesia, or complete anesthesia. A curious feature of these cases that is dwelt upon by Dudgeon and commented upon by Turner is the fact that in young children there is a cessation of growth of the bone. Sir Robert Jones (loc. cit.) reports that 19 cases out of 40 were associated with fracture. In 13 of the 19 cases there was pronounced malunion.

Treatment.—The old view of this condition was that it was practically hopeless. Anderson and Dudgeon, however, maintain that restoration may usually be obtained, the treatment consisting in regular, active motion, passive movements, massage, and electricity. Forcible extension under ether is of no benefit whatever.

Jones's plan of treatment is very beneficial ("Amer. Jour. Orthop. Surg.," April, 1908).

Operative procedures on arms that necessarily have deficient circulation are hazardous, and Jones has discontinued all operative correction and relies upon purely mechanical and manipulative routine, as follows:

Five splints are cut out of zinc, tin, or sheet wire, to fit each finger and the thumb. The wrist is forcibly flexed and held while each finger is separately splinted. It will be observed that in the fully flexed position of the wrist the fingers are all relaxed.

When the finger splints have been applied the wrist is released, and the patient is directed to systematically extend the metacarpophalangeal joints. In a few days the second splinting may usually be employed by embedding the entire hand to the wrist and the already splinted fingers in plaster of Paris, while the wrist is again flexed. Several days are devoted to systematic voluntary efforts at extension of the hand in a manner similar to that employed for the metacarpophalangeal joints.

The third splinting embraces that already employed and, in addition, embraces the wrist in the fullest extension possible, which in a few days may be increased until full extension is obtained. The latter position of full extension of wrist, hand, and fingers is maintained for some weeks until all contractible elasticity has disappeared.

It is usually observed that when the hand can be held in hyperextension without tendency to relapse, the circulation will almost invariably improve and the fingers resume their normal function and appearance except in cases of nerve destruction. Jones has found that in many cases in which the nerves had lost their function during contracture the extension of the hand was the starting-point of recovery.

In making any splint pressure to straighten the fingers the greatest care must be exercised. The skin of the dorsum of the fingers will not endure prolonged pressure. I have used Rugh's splint with much satisfaction (Figs. 541, 542). It is best in the beginning to apply the splint for five or ten minutes twice a day. The time of each séance is gradually increased as the tissues develop resistance. Frequent bathing with alcohol aids the skin to bear pressure.

R. H. Sayre ("Volkmann's Ischemic Paralysis and Contracture," "Amer. Jour. Orthop. Surg.," Nov., 1908, p. 221) advocates the Jones method in all cases, inasmuch as cutting operations may be employed later if the results of Jones's treatment are not entirely satisfactory. The improvement in the circulation and function obtained by Jones's method will make the operative field more capable of rapid recovery.

In a persistent and long-continued case an operation may be necessary. The operation may consist in dividing in the forearm the flexor muscles of the fingers, as advised by Davies Colley, and then, at a later period, dividing the flexor tendons. The objection to his procedure is that it destroys permanently the capacity to flex the fingers. Another suggestion has been to excise a piece from both the radius and the ulna, and wire the fragments together. This operation shortens the forearm and adjusts it to the shortened muscles. The best surgical treatment is probably exposing the nerves, separating them from adhesions, stretching them, and then doing tendon lengthening, but this should not be done until all the improvement it is possible to secure by conservative treatment has been obtained. Conservative treatment should be tried for at least three months.



FIG. 541.—Dr. Rugh's splint for Volkmann's contracture. Splint applied. Looking at the palmar surface.

Wounds and Contusions of the Muscles.—*Wounds* of muscles may be either *open* or *subcutaneous*. In an open longitudinal wound the edges lie close together, and hence drainage must be provided for by the surgeon. In a transverse wound the edges separate widely, and catgut stitches must be inserted. *Contusions* of muscles, like contusions of other tissues, vary in extent and in severity. There are pain (which is increased by attempts to use the muscle), loss of function, swelling beneath the deep fascia, and discoloration, which may appear at once because of superficial damage from the initial injury, or which may appear in dependent parts after many days because of gravitation of blood and blood-stained serum. As a result of contusion, suppuration, inflammation, or atrophy may arise.

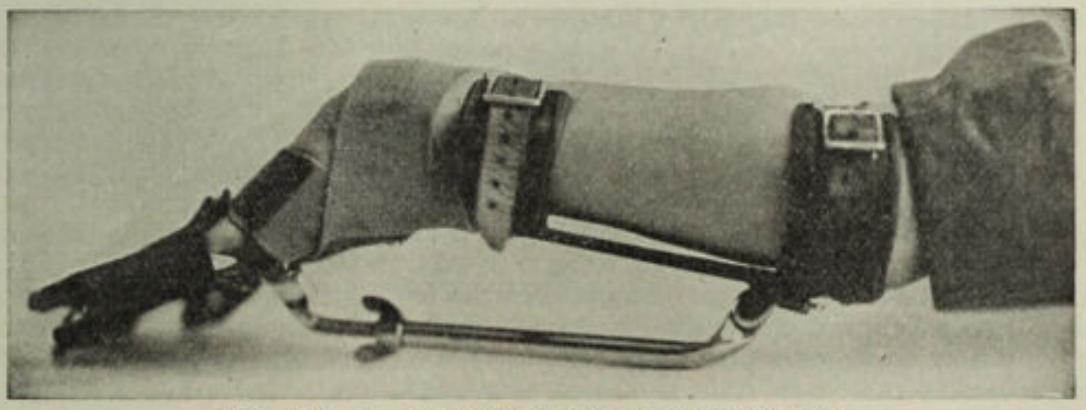


FIG. 542.—Lateral view of splint shown in Fig. 541.

Treatment.—In a longitudinal wound, drain; in a transverse wound, suture the muscle. The further indications in wounds and contusions of muscles are to obtain rest by means of splints and to secure relaxation. Limitation of swelling is secured

by bandaging. Inflammation is combated first by the ice-bag or lead-water and laudanum; later by iodin, blue ointment, ichthyol, and intermittent heat. To prevent loss of function employ, as soon as the acute symptoms subside, massage, passive motion, and stimulating liniments, and, later in the case, electricity (galvanism if the reactions of degeneration exist; faradism, if they are absent).

Strains.—A muscular strain is a stretching of a muscle with rupture of a few fibers. It is caused by traction in the long axis of the muscle. The muscle becomes swollen, tender, stiff, weak, and sore, and attempts at motion produce sharp pain. A strain of a tendon is a trivial or partial rupture. It leads to the development of acute thecitis, with fluid swelling and pseudocrepitation. Strains are common in the deltoid, the ham-string muscles, the back, the calf, the biceps, and the great pectoral. *Strain of the psoas muscle* causes pain on voluntary flexion of the thigh, and is associated with tenderness in the iliac fossa. Strain of the right psoas may be mistaken for appendicitis, but it lacks the intense local tenderness, the abdominal rigidity, and the constitutional symptoms. *Lawn-tennis arm* is a strain of the pronator radii teres muscle. *Riders' leg* is a strain of the adductor muscles of the thigh. A strain of the long head of the biceps flexor cubiti produces the condition called by ball players a *glass arm.* A strain may be the only injury, or may be associated with some other condition (fracture of bone, dislocation, sprain, contusion, etc.). A strain may be followed by periostitis at the point of insertion of the muscle. Atrophy of the muscle occasionally follows a strain.

A strained muscle is usually rigid, is tender, and pains greatly when an attempt is made to use it. The skin over it, especially over its point of insertion, is usually tender.

A *strain of the back* is a very common accident, which is often associated with sprains of the vertebral articulations. There is great pain when the patient voluntarily straightens up. If the vertebral ligaments are not damaged, the patient can be straightened by passive motion without pain. The skin is tender in certain areas. The muscles are often rigid. There may be unilateral rigidity. In a back injury make a careful examination to be sure no damage has been inflicted upon the vertebræ or cord.

Treatment.—Relaxation by suitable position; rest by the use of splints or by putting the patient to bed; bandages for compression; hot fomentations or a hot-water bag, and ichthyol. As soon as acute symptoms subside, employ friction and massage. Strapping with adhesive plaster is of service in strain of the back and of the calf. If there is severe pain after a strain, administer Dover's powder or even morphin.

Rupture of Muscles and Tendons.—Rupture of a muscle is announced by a sudden and violent pain and by loss of function, arising during powerful muscular contraction or strong traction in the long axis of a muscle. The rupture may be announced by a clearly audible snap (A. Pearce Gould). A distinct gap is felt between the retracted ends of the torn muscle; great pain develops on movement; there are tenderness, loss of power, and swelling. Rupture may be followed by atrophy, so may a contusion. Among the muscles which occasionally rupture we may mention the quadriceps, biceps, triceps, deltoid, plantaris, etc.

Rupture of the biceps flexor cubiti or its tendon is not very common; 72 cases have been collected by W. W. Keen ("Annals of Surgery," May, 1905). Alexander collected 74 cases and added 8 ("Annals of Surgery," 1915, lxi). It is much more common in men than in women. Loos's table of 66 cases contains records of only 2 women (Doane in "Jour. Amer. Med. Assoc.," May 16, 1908). The rupture may be where the muscular belly passes into the lower tendon, through the muscular belly, in the muscular part passing either to the long or short head, or at the part where the muscular belly joins the long or short head. The tendon of the long head may be torn through or the long head may be torn from the glenoid cavity. The muscular portion is far more often injured than the tendinous. In rupture of the muscle belly a part of the muscle, in rupture of the long head the entire muscle, becomes soft and relaxed. In rupture of the belly there is a gap between the two portions and each portion causes a lump. In rupture of the tendon there are not two lumps with a gap between, but there will be a single muscular lump. In rupture of the long head the muscular belly is much nearer the elbow than in health (Figs. 543, 544). If rupture takes place at the lower part of the belly, the muscle passes toward the shoulder. *Rupture of the long head of the biceps* allows the humerus to pass somewhat forward and upward.

Flexion with the forearm supinated is much less powerful than flexion with the forearm pronated (*Hüter's sign*).

In a case of my own in the Philadelphia Hospital the accident had occurred while

carrying a heavy bucket. Forearm flexion was possible, but it was slow, feeble, partial, and incomplete. On flexion the short head contracted, but the muscular "bunch" of the belly was nearer the elbow than normally. *Rupture of the plantaris muscle* (*coup de fouet; lawn-tennis leg*) is an injury which is frequently not diagnosticated. It occurs during exercise (walking, bicycling, jumping, playing tennis) or is first complained of after exercise. It produces sudden pain in the middle of the calf, swelling, and often ecchymosis and inability to walk except with a rigid ankle and everted toes. *Rupture of the quadriceps extensor femoris tendon* results occasionally from the sort of force which in other cases fractures the patella. The rupture is just above the patella. The patient cannot extend the thigh and cannot walk or stand and there is severe pain. A gap can be felt just above the patella, unless it is hidden by effusion, and the muscle is bunched above. *Rupture of the extensor longus pollicis tendon* (*drummer's paralysis*) may take place when the tendon has become necrotic from injury or weakened by repeated traumatism. Sometimes it occurs, apparently spontaneously, a number of weeks after the occurrence of Colles's fracture.

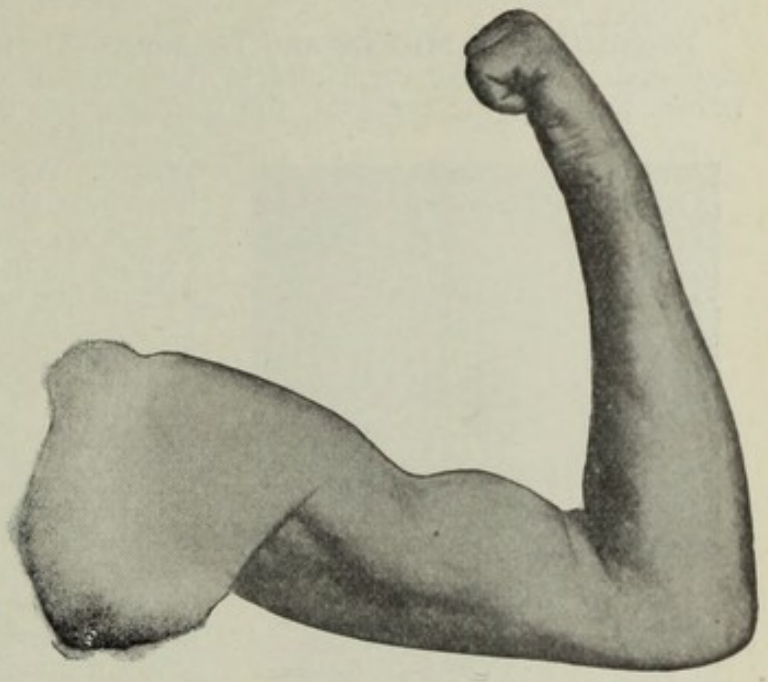


FIG. 543.—Author's case of rupture of the long head of the biceps.

Treatment. — In limited rupture treat as a severe strain. In treating extensive rupture of an important muscle, when the ends are widely separated, expose by incision, unite the divided ends by sutures of chromicized catgut (Fig. 77), and sew up the skin with silkworm-gut. Treat the part in any case by rest and relaxation and combat inflammation by appropriate means. Passive motion and massage are employed as soon as union is firm. In rupture of the quadriceps extensor femoris operation should be undertaken, because mechanical treatment frequently gives a bad result and confines the patient to bed for weeks. *Rupture of the biceps* requires incision and suture. In a case in the Philadelphia Hospital (Figs. 543, 544) I operated and found that the long head with a portion of periosteum had been torn from the glenoid cavity. A portion of the upper end of the tendon was cut away and the tendon was fastened to the short

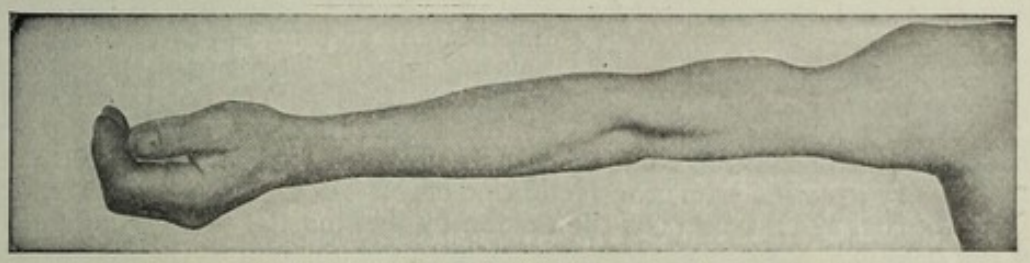


FIG. 544.—Author's case of rupture of the long head of the biceps.

head by splitting and suture. Nine months later the result was perfect (Keen in "Annals of Surgery," May, 1905). In Alexander's table of 82 cases only 10 were operated upon (Ibid.). *Rupture of the plantaris* is treated at first by rest on a posterior splint and compression and later by massage and the use of an elastic bandage. The patient is allowed to walk with the aid of a cane in one week, but he should not raise the heel for several weeks. Rupture of the quadriceps is treated by suturing. In rupture of the extensor longus pollicis tendon the torn ends may be freshened and sutured, or, as Heineke recommends, the peripheral end can be fastened to the extensor tendon of the index-finger or to the tendon of the long extensor of the carpus.

Hernia of Muscles.—When a tear takes place in a muscular sheath a portion of the muscle protrudes.

The **treatment** is incision, restoration or extirpation of the protruding mass of muscle, and suturing of any muscle wound and of the sheath.

Contractions of muscles may result from injury, from joint disease, from malposition of parts (as in old dislocation or torticollis), or from diseases of the nervous system.

The **treatment** in some cases is sudden extension, in other cases gradual extension, tenotomy, or myotomy. Macewen recommends the making of a number of V-shaped incisions in the muscle. In some cases of spasmodic contraction nerve-stretching is of value.

Dislocations of Muscles and Tendons.—The long head of the biceps is oftenest displaced. The flexor carpi ulnaris, the peroneus brevis, the peroneus longus, the tibialis posticus, the sartorius, the plantaris, the quadriceps extensor femoris, and the extensors back of the wrist may be dislocated. What is known as dislocation of the latissimus dorsi, a condition in which that muscle no longer lies upon the angle of the scapula, is, in reality, paralysis of the serratus magnus (see page 706). Most of these accidents are associated with chronic disease or with fracture, but displacement may exist as a solitary injury. *Dislocation of the long head of the biceps* may occur tolerably early in the progress of rheumatoid arthritis of the shoulder-joint, and the displaced tendon may be absorbed.

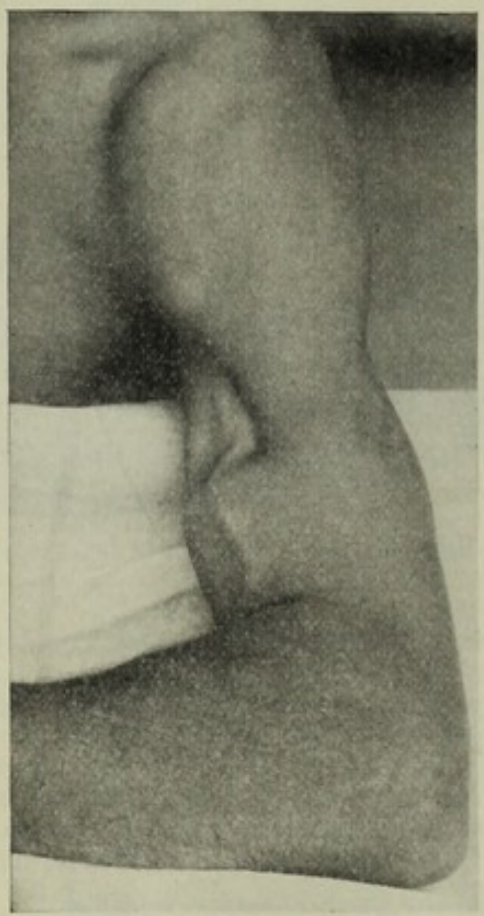


FIG. 545.—Dislocation of the long head of the biceps (proved by operation).

Symptoms.—After dislocation of a tendon the muscle of the tendon can still contract, but it acts at a disadvantage; thus the corresponding joint exhibits partial loss of function. The displaced tendon can be felt, and a hollow exists where it normally resides.

When the muscle contracts the tendon is felt to slip from its groove. When the tendon of the biceps is dislocated the head of the bone passes forward (so-called *subluxation of the humerus*).

Treatment.—In tendon dislocation reduction is easy, but the displacement is apt to recur because of laceration of the sheath. The treatment usually advised is to effect reduction by relaxation of the limb and manipulation of the tendon, to place the part upon a splint so that the muscle belonging to the tendon will be relaxed, and to apply pressure over the point of injury. This treatment generally fails, and if the tendon does not become firmly anchored in its proper situation in four weeks we should operate. In some tendons it is enough to incise, freshen the edges of the torn sheath, and sew up with kangaroo-tendon or chromicized catgut. In a tendon lying in a long groove make a halter for the tendon by incising the periosteum and suturing it over the tendon.[1] Passive movements are begun at the end of the first week. Even if the tendon will not remain reduced, a useful joint will probably be obtained.

Wounds of Tendons.—Subcutaneous wounds of tendons are usually inflicted by the surgeon, and they heal well. Open wounds require rigid antisepsis and suturing of the tendon. In wounds of the wrist especially always suture the divided tendons (see Fig. 78), and be sure to bring the proper ends into apposition.

Rupture of Tendons.—A violent muscular effort may rupture a tendon, and as the accident occurs a snap may often be heard.

The **symptoms** are sudden pain and loss of power, fulness of the associated muscle from retraction, and absolute inability to bring the tendon into action. A gap may often be felt in the tendon.

[1] Walsham's case of dislocation of the peroneus longus, "Brit. Med. Jour.," Nov. 2, 1895.

Treatment.—The best procedure in treating rupture of a tendon is exposure by incision and the introduction of sutures. Some surgeons relax the parts and apply splints.

Thecitis, or **tenosynovitis,** is inflammation of the sheath of a tendon.

Acute thecitis may arise from a contusion, from a wound, from repeated overaction in working or while engaged in some sport, from rheumatism, from gonorrhea, from pyogenic infection, from influenza, from a continued fever, or from syphilis. In early syphilis certain tendon sheaths may rapidly develop effusion because of hyperemia of the sheaths (Taylor).

Symptoms.—In *non-suppurative* cases of thecitis the symptoms are pain, swelling, tenderness, and moist crepitus along the tendon sheath, due to inflammatory roughening. The crepitus disappears as the swelling increases, but it reappears as the swelling diminishes. In *suppurative* cases (*phlegmon of the tendon sheaths*) the symptoms are great swelling, pulsatile pain, dusky discoloration, inflammation spreading up the tendon sheaths, and often the constitutional symptoms of sepsis.

Treatment.—In treating non-suppurative thecitis employ splints, use the hot-air oven, and apply locally iodin, blue ointment, or ichthyol, and administer suitable remedies to combat any causative constitutional disease. In the suppurative form inject 1 c.c. of formalin-glycerin (2 per cent.) after withdrawal of part or all of the exudate. If this fails, make free incisions, irrigate, drain, dress with hot antiseptic fomentations, and employ Bier's method (see page 44). (See Felon, page 679.)

Palmar Abscess.—We mean by this term an abscess beneath the palmar fascia and not a superficial collection of pus. Palmar abscess may arise after wounds, abrasions, burns, or inflammations of the skin of the palm. A thecal abscess in a flexor tendon of a finger travels rapidly upward and may produce a palmar abscess. A thecal abscess of either the index-, ring, or middle finger is usually arrested at the lower end of the palm, but suppurative thecitis of the thumb or the little finger conducts pus along the tendon sheath and up into the forearm (Fig. 546). If the theca ruptures, pus is diffused over the palm. Abscess produces great swelling of the hand and fingers, the dorsum being swollen as well as the palm. The fingers become flexed and rigid. Violent pulsatile pain and decided constitutional disturbance exist. Discoloration is late in appearing. Related lymph-glands enlarge. Palmar abscess is a most serious affection. The pus may dissect up all the structures of the palm, may pass between the bones and reach the dorsum, or may pass beneath the anterior annular ligament into the connective-tissue planes of the forearm. In some cases it leaves a clawed, stiff, and useless hand.

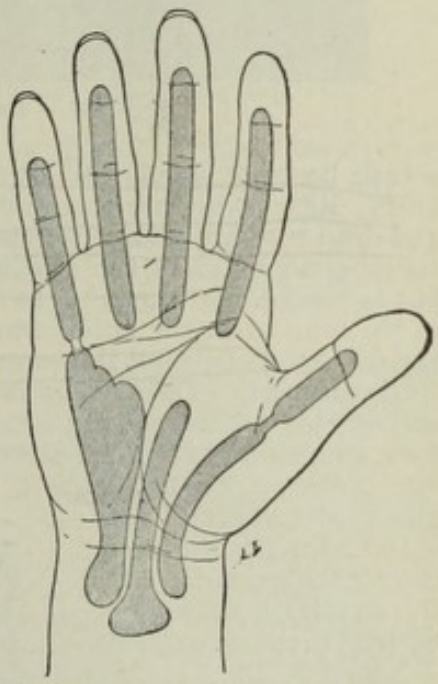


FIG. 546.—Palmar synovial sheaths (vaginæ tendinum), normal adult type (Poirier and Charpy).

Treatment.—A palmar abscess demands radical treatment at the earliest possible moment; delay will be responsible for stiff and contracted fingers and hyperesthetic skin, a damaged and perhaps a useless hand. The patient should be placed under the influence of ether. The incision is made in the line of the metacarpal bone and, if possible, below the palmar arches. A line in the transverse axis of the palm and in line with the palmar surface of the fully extended thumb is distal to both the palmar arches. In an incision above this line try not to cut either arch; but if one should be cut, at once take means to arrest the hemorrhage (see page 397). In a severe case it may be necessary to make several palmar incisions, to open the tendon sheaths on the flexor surface of the forearm above the wrist, and to make counteropenings in the back of the hand, and it is sometimes necessary to introduce tubes, and drain through and through the hand. After operation, if the patient will consent to enter the hospital, use Dakin's fluid. If the patient refuses to enter the hospital, apply hot antiseptic fomentations and put the part upon a splint. Bier's passive hyperemia is useful. When granulations begin to form, dry dressings are substituted for hot moist dressing. It may be necessary to give morphin for pain, and stimulants may be needed. There is great danger of stiffness of the fingers occurring, the tendons

becoming adherent to their sheaths. Hence passive movements are inaugurated as soon as granulations begin to form.

Chronic thecitis may follow acute thecitis, but may be due to injury, to rheumatism, to gummatous infiltration, to rheumatoid arthritis, or to tuberculous inflammation of a tendon sheath. Chronic thecitis is commonest in the tendons at the wrists, the ankles, and the knees; it may spread to a joint or it may arise from a tuberculous joint. This condition causes very little pain. In ordinary non-tuberculous thecitis the part is weak, tender, painful and stiff, crepitates on motion, and is swollen. In *tuberculous thecitis* there is at first distention of the tendon sheath with serum. The serum contains *rice*, *riziform*, or *melon-seed* bodies, and the wall of the tendon sheath is here and there thickened and caseating. Later in the case the interior of the tendon

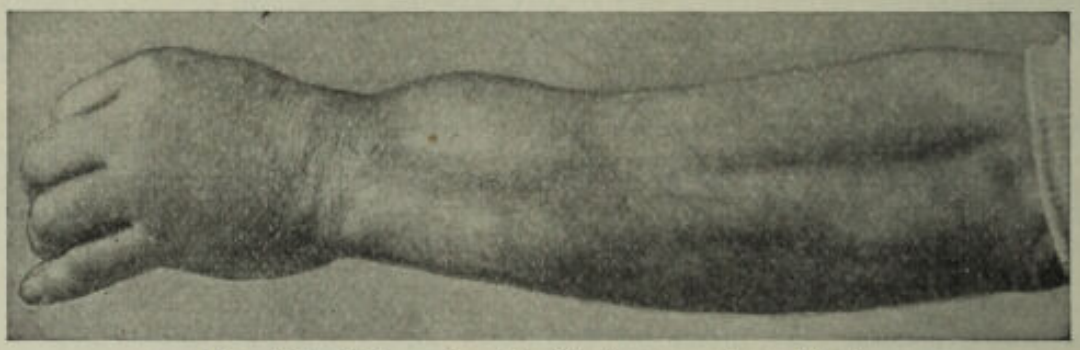


FIG. 547.—Tuberculous thecitis (compound ganglion).

sheath becomes lined with tuberculous granulations and a tuberculous abscess may form. Rice bodies are sometimes fibrinous masses, are sometimes pieces of separated and dead recently formed fibrous tissue, and are sometimes masses of proliferating cells. In tuberculous cases the swelling is firm or doughy when due to granulation tissue, but is fluctuating when due to fluid. Grating is marked. Tubercle bacilli are present in the fluid or in the granulation tissue. Tuberculous thecitis is most common about the wrist, constituting the so-called *compound ganglion* (Fig. 547).

Treatment.—*Tuberculous cases* are treated as follows: If there is a fluid effusion and no rice bodies, make a small incision, wash out with salt solution, introduce iodoform emulsion or formalin-glycerin, and close the wound. In cases in which there are rice bodies, open the sheath, evacuate the contents, scrape the walls thoroughly, inject iodoform emulsion or formalin-glycerin, and close the wound. (If the annular ligament requires division, stitch it before closing the wound—Fig. 548.) In cases with extensive thickening apply an Esmarch bandage, make a large incision, and remove all infected tissue from the sheath, around the sheath, and from the tendon. In tuberculous thecitis Bier's method (see page 44) may be of service and so may the *x*-rays. In *ordinary traumatic thecitis* use for the first few days rest associated with applications of ichthyol. Later employ hot and cold douches, massage and passive movements, strapping of the part, inunctions of ichthyol, and the hot-air bath. If effusion is persistent or rice bodies exist, make an incision and scrape the interior of the tendon sheaths.

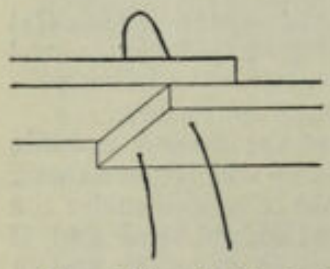


FIG. 548.—Method of suturing the annular ligament of the wrist.

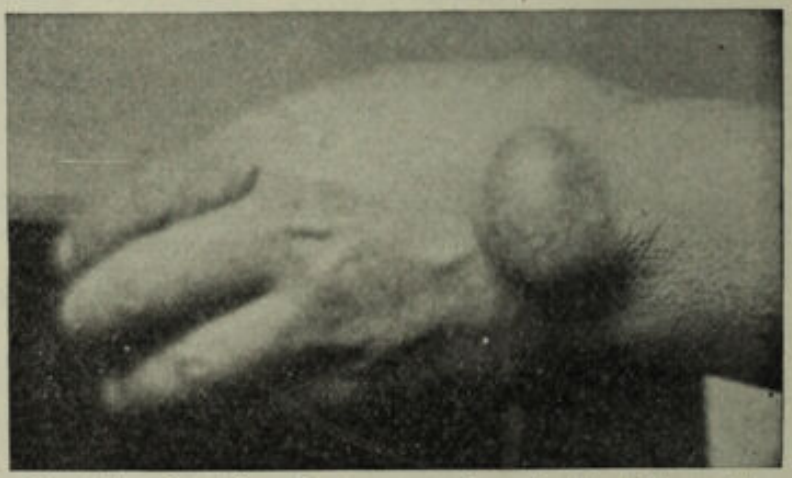


FIG. 549.—Ganglion of extensor tendon sheaths of the wrist.

In rheumatic cases give antirheumatic remedies and employ the hot-air bath. In syphilitic cases administer mercury and iodid of potassium.

Simple Ganglia (Figs. 549, 550).—In connection with tendon sheaths and joints simple ganglia may develop. They are small, tense, round swellings, which are firm, grow progressively though slowly, are painless when uninflamed, and contain a fluid of the appearance and consistence of glycerin-jelly (Bowlby). Ganglia are commonest upon the dorsum of the wrist and they occur especially in those who constantly use the wrist



FIG. 550.—Ganglion of wrist (case of Dr. Jopson in Presbyterian Hospital).

muscles. Ganglia are occasionally seen on the dorsum of the foot. Paget states that a *simple* ganglion is due to cystic degeneration of a synovial fringe inside a tendon sheath, and that the fluid of the ganglion does not communicate with the fluid of the tendon sheath. Other pathologists have maintained that a simple ganglion is a hernia of synovial membrane through a rent in a tendon sheath, all communication between the herniated part and the tendon sheath being soon obliterated. The belief is now general that a ganglion is due to cystic degeneration of an area of connective tissue adjacent to a joint or a tendon, this area of tissue having been rendered extremely cellular by traumatism. A number of minute cysts form and they coalesce into one cyst. The cyst may form a secondary communication with the interior of a tendon sheath or joint. Ganglia occasionally diminish in size or even disappear spontaneously.



FIG. 551.—Deep felon, with sloughing of soft parts and necrosis of bone.

Treatment.—A ganglion is treated by aseptic puncture with a tenotome, evacuation, scarification of the walls, antiseptic dressing, and pressure. An old-time method of treatment was subcutaneous rupture brought about by striking with a heavy book. The superstitious preferred the family Bible. Duplay treats a ganglion by injecting a few drops of iodin through a hypodermic needle. The cyst is not evacuated before injection. The parts are dressed antiseptically, and cure is obtained in one week. Recurrent ganglia, very large ganglia, and ganglia with very thick contents should be dissected out.

Felon, or whitlow (Fig. 551), is a primary, violent, rapidly spreading pyogenic inflammation beginning in "the connective-tissue space which is situated on the palmar surface of the last phalanx of the fingers" (George M. Dorrance in "Annals of Surg.," Dec., 1916—Figs. 552, 553). Kanavel pointed out that the epiphysis of the distal phalanx is supplied by a branch of the digital artery before that vessel has entered "the connective-tissue space" (Fig. 552). G. B. Mower White seems to have first de-

scribed the fibrofatty pad in this situation ("Brit. Med. Jour.," Feb. 24, 1906). The diaphysis gets its blood-supply from another vessel which reaches the bone after it has passed into the connective-tissue space (Fig. 552). Dorrance (Ibid.), in an admirable study, describes the connective-tissue space. It lies beneath the dense corium of the

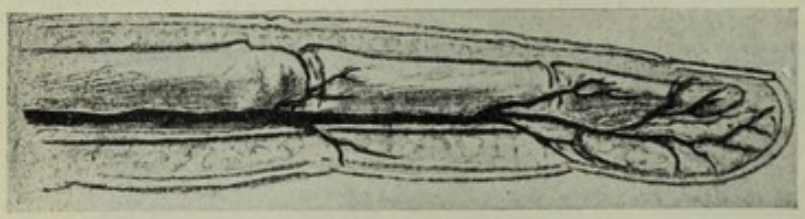


FIG. 552.—Note the fact that the diaphysis receives its blood-supply only after the artery has passed through this connective-tissue space. In order to bring this point out more clearly we injected a mixture of red lead and turpentine into the radial and ulnar arteries of a cadaver and had *x*-ray pictures made (George M. Dorrance in "Annals of Surgery").

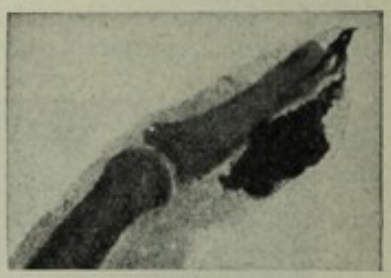


FIG. 553.—Connective-tissue space injected with red lead (George M. Dorrance in "Annals of Surgery").

last digit, has beneath it the insertion of the long flexor and the periosteum, contains loose areolar fatty and connective tissue, and is surrounded by fibrous tissue. An infection in this space is infection in a closed box. The artery which supplies the diaphysis passes through the space before it enters the bone, hence interference with blood-

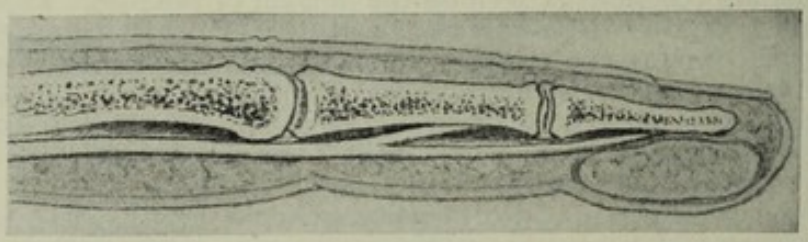


FIG. 554.—Note the fact that this distended space is walled off from the remaining subcutaneous tissue of the rest of the finger (George M. Dorrance in "Annals of Surgery").

last supply is early and when it takes place necrosis of the distal phalanx ensues (Figs. 552, 555). Dorrance points out that a puncture into and infection of the space is the cause of felon.

Felons are very rare in infants, but may occur in children. Women are more liable to them than men because they are more apt to be pricked by pins and needles.

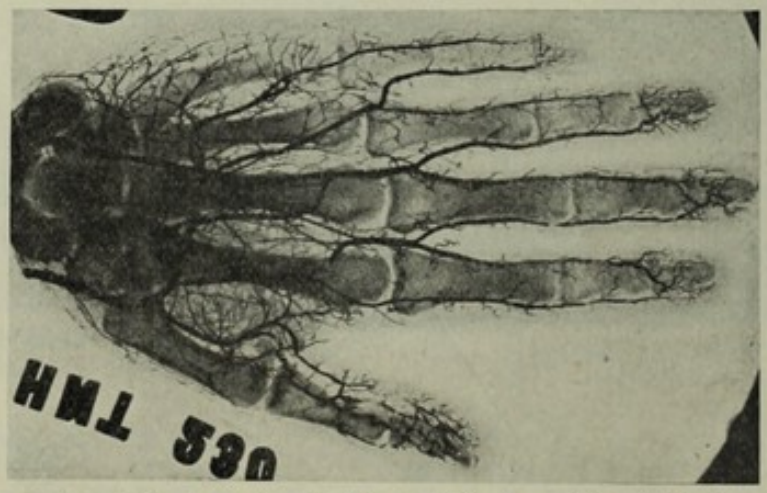


FIG. 555.—Blood-vessels. Note how clearly this point is brought out in the *x*-ray plate (George M. Dorrance in "Annals of Surgery").

The fingers are much more prone to infection than the toes, because they are more exposed to injury. Whitlow is most apt to occur and is most severe in persons broken down by disease, alcoholism, overwork, or worry. A felon is limited to the connective-

tissue space early in the case (superficial felon). The bone is involved later in the case (deep felon). In certain cases of neuritis painless suppuration may arise. In syringomyelia *painless felons* are common, and they are apt to be associated with necrosis of bone. Painless and destructive whitlows constitute a characteristic part of *Morvan's disease.*

There are two forms of felons, the *superficial* and the *deep.*

Superficial Felons.—One form of superficial suppuration is between the cuticle and the true skin and is rarely followed by involvement of deeper parts. The infection is in the skin. The point of infection becomes dark red, swollen, painful, and tender. The epidermis is lifted up into a pustule by the seropus which forms, and a considerable area may be attacked before the spread of the process is arrested. Such a condition is not really a felon. The commonest form of superficial felon is subcutaneous suppuration, the pus collecting in the fibrofatty pad at the palmar surface of the last digit (G. B. Mower White in "Brit. Med. Jour.," Feb. 24, 1906). This form often spreads deeply. There is severe pulsatile pain, increased by motion, pressure, and a dependent position. Swelling and discoloration are early and marked. Pus forms in from twenty-four to thirty-six hours. In about thirty-six hours pain abates for a time, a bad sign and not a good one. It means beginning gangrene of tissue in the space and perhaps also necrosis of bone. *Paronychia*, or *ring around*, is cellulitis starting at the end or side of the digit, and involving the parts around and below the nail. The pus organisms obtain entrance by means of an abrasion, a puncture, or an ulcerated "step-mother." In paronychia pain is throbbing and violent; is increased by motion, pressure, or a dependent position; the skin is dusky red, but the swelling is slight. In about forty-eight hours pus forms in the superficial parts, the epidermis being lifted into pustules or blebs, and pus may also form under the nail. A portion of the nail or the entire nail may be lost.

Deep Felons.—The swelling from exudation and the blocking of venous return which occur in every felon permit each pulse-beat to compress the nerve and hence the pulsatile pain. Soon the artery will be blocked and then necrosis is inevitable. Necrosis is the element of a deep felon (*bone felon*). A deep felon may cause the loss of the distal phalanx, may be associated with spreading cellulitis, ascending thecitis, sloughing of subcutaneous tissue and tendon (Fig. 551), or gangrene of the finger. The pain is dreadful, is pulsatile, is greatly aggravated by a dependent position, the surface is dusky red, and the tenderness is dreadful.

In suppurative thecitis of the three middle fingers the process seldom reaches the palm; in suppurative thecitis of the theca of the thumb or little finger the pus may pass above the wrist and a true palmar abscess may form (see Fig. 546). The pain is agonizing, entirely preventing sleep, pulsatile in character, associated with excruciating tenderness, greatly aggravated by motion or a dependent position, and often extending up the hand and forearm. The skin is dusky red and edematous, and the part is enormously swollen.

In deep whitlow lymphangitis of the forearm and arm is not unusual, adenitis of the axillary glands is common, and almost always there is fever. In superficial felon constitutional symptoms are slight or absent, and lymphangitis and adenitis arise in a minority of cases.

Treatment.—In a subcuticular suppuration, after cleansing, soften the parts well in an antiseptic fluid and then pare off the cuticle with a very sharp knife. This plan of Mower White's is an excellent one; it gives vent to pus and prevents the inoculation of the deeper tissues which may follow incision. In subcutaneous suppuration incise the abscess, but be careful not to open the tendon sheath or periosteum, as this would diffuse infection (White in "Brit. Med. Jour.," Feb. 24, 1906). In neither of the above instances is it necessary to give an anesthetic. After operating, the parts must be irrigated, dressed with hot antiseptic fomentations, the hand must be placed upon a splint, and Bier's passive hyperemia is to be induced daily.

Treatment of True Felons.—Waste no time on poultices. Do not be deceived by the usual temporary abatement of pain in from twenty-four to thirty-six hours. Incise at once. Delay of a few hours may be responsible for necrosis or even ascending infection. Give gas and oxygen. The incision starts at the base of the nail on one side and is carried "in the line of the furrow of the tip of the finger, down on the other side to a point on a level with the beginning of the incision" (Dorrance's incision—Figs. 556, 557). A flap is made by this cut. Drainage is inserted and the flap is left open. This operation drains the connective-tissue space and exposes the bone. Drainage is removed on the third day. The dressing is gauze moistened frequently with warm salt solu-

tion. Splint the hand. For a number of days the wound looks ugly and distorted, but most satisfactory healing occurs. If dead bone forms it must be removed. If there are signs of ascending infection above the last digit proceed as follows as directed in a very valuable article by G. B. Mower White ("Brit. Med. Jour.," Feb. 24, 1906). I immediately put in practice the common-sense suggestions in this valuable article and have seen a surprising improvement in results. The chief points in White's plan of treatment are as follows: To plunge a knife through an area of infection into a tendon sheath, if that sheath is not infected, will lead to infection, and the way to be sure whether it is or is not infected is to look through a carefully made incision and see. After careful sterilization, anesthetize, drain the extremity of blood by elevation, and apply an Esmarch band to the arm. This enables us to see what we are doing. Slowly and carefully make an incision by the side of the tendon sheath, and on reaching it see if it be distended. If in doubt, insert a hypodermic needle and withdraw fluid. If we get turbid serum, the theca is infected. If the theca be not infected, do not open it, but incise the subperiosteal area of suppuration if it exists. If the theca be infected, remember that this infection has surely ascended more or less, and we must not only open at the lower point, but must also incise at the upper point. Do not incise the theca over the length of the tendon, as sloughing will follow. If one of the three middle fingers be involved, incise the distal end of the theca and also the proximal end over the head of a metacarpal bone in the midline, wash from opening to opening, and drain.

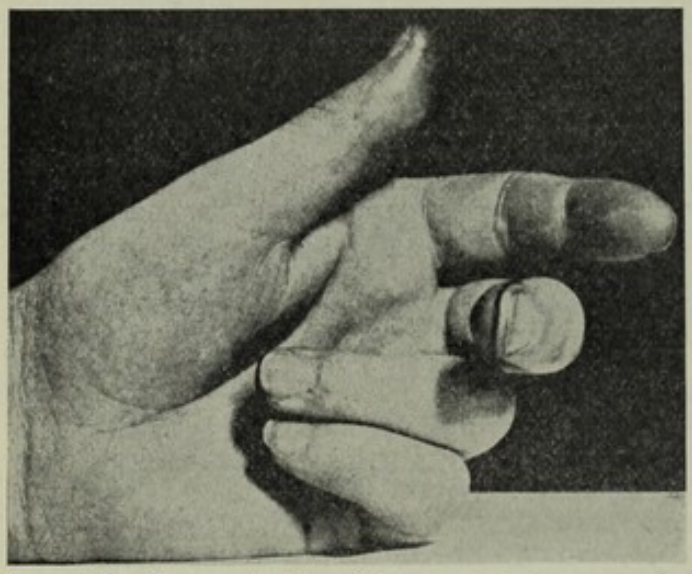


FIG. 556.—Proper incision (George M. Dorrance in "Annals of Surgery").



FIG. 557.—Flaps with drainage (George M. Dorrance in "Annals of Surgery").

If the theca of the thumb or little finger be involved, open distally and then proximally above the wrist. To reach the proximal end of the theca of the thumb cut at the radial side of the tendon of the flexor carpi radialis. Also open the palmar sac of the flexor longus pollicis, making the cut along the inner border of the outer head of the flexor brevis pollicis.

To reach the proximal end of the theca of the little finger begin an incision at the upper margin of the annular ligament and carry it up along the inner border of the flexor sublimis. Retract the tendons and pus will usually be found between the tendons of the superficial and deep flexor. Look beneath the profundus tendons for the bursa and open it. Then open the palm by an incision in the line of the axis of the ring-finger. Thus three openings are made in either case, and the theca can be thoroughly washed and drained. If either the thumb or little finger bursa be found infected, the other must be exposed and examined, as they usually communicate at their proximal ends or a communication may form as a result of suppuration. Rupture of either bursa may diffuse pus widely. White, in order to prevent secondary hemorrhage, ligates the radial artery in two places and removes 1½ inches of it (if operating on the thumb bursa); and ligates the superficial arch and removes 1 inch of it (if operating on the palmar expansion of the little finger theca). These arterial ligations seem a serious and perhaps unnecessary addition to the operation and I have not *practised* them. After thorough irrigation apply antiseptic fomentations, splint the extremity,

and induce Bier's passive hyperemia daily. If the patient cannot sleep, give morphin. See that the bowels are moved once a day. Give quinin, iron, and milk-punch. As soon as granulations begin to form, use dry dressings and make passive motion daily. If bone undergoes necrosis, remove it. Amputation is sometimes necessary.

Bursitis is inflammation of a bursa. *Acute bursitis* arises from strain, from traumatism, or from infection. The symptoms of acute bursitis are pain, limited swelling (*hygroma*), moist crepitus, fluctuation, and discoloration in the anatomic position of a bursa. In *chronic bursitis* there is intermittent pain, tenderness, and progressive, fluctuating swelling. *Bursitis of the retrocalcaneal bursa* (*Albert's disease*) is a painful affection which is often overlooked. It is rather common in storekeepers who rise often on the toes to reach shelves, in motormen who use a foot gong, in street-car conductors, and in clerks who stand at desks. It may follow gonorrhea and may be tuberculous. Walking causes great pain in the heel. Raising up on the toes is exceedingly painful. It is usually associated with flat-foot. In these cases osteophytes often form within the bursa. There are numerous bursæ about the hip. Some anatomists count twenty-one.[1] The two most important bursæ and the ones usually affected are the iliac and the deep bursa over the great trochanter.[2] Inflammation of the *iliac* or *iliopsoas bursa* produces below Poupart's ligament a swelling which is tense, but exhibits fluctuation on careful examination. Often the swelling attains large size. In some cases the sac can be emptied by pressure, the fluid passing into an adjacent bursa or into the joint. The swelling is beneath the femoral artery and consequently lifts that vessel (F. B. Lund in "Boston Med. and Surg. Jour.," Sept. 25, 1902). The enlargement often presses on the anterior crural nerve and causes spasmodic pain throughout the nerve's trajectory. The limb, according to Zuelzer, is usually slightly flexed, abducted and rotated outward, and movement in an opposite direction causes pain. Inflammation of the bursæ about the hip may produce symptoms resembling those of incipient coxalgia, but in bursitis the symptoms do not remit, as in hip disease. Iliopsoas bursitis occasionally results from gonorrhea. The bursa is sometimes involved in joint disease. In inflammation of the iliac bursa flexion is not so marked as in coxalgia, and the trochanter is never above Nélaton's line. In inflammation of the deep trochanteric bursa the position is the same as in iliac bursitis, and resembles that of coxalgia. In coxalgia, however, there is pain on pressure upon the front of the joint or directly on the trochanter or on tapping the sole of the foot. These manipulations do not cause pain in bursitis (Zuelzer). In inflammation of the *gluteal bursæ* there is moderate pain back of the thigh and knee, which disappears when the patient is at rest; there are a marked limp, limitation of motion, and an area of deep fluctuation in the buttock (Brackett).

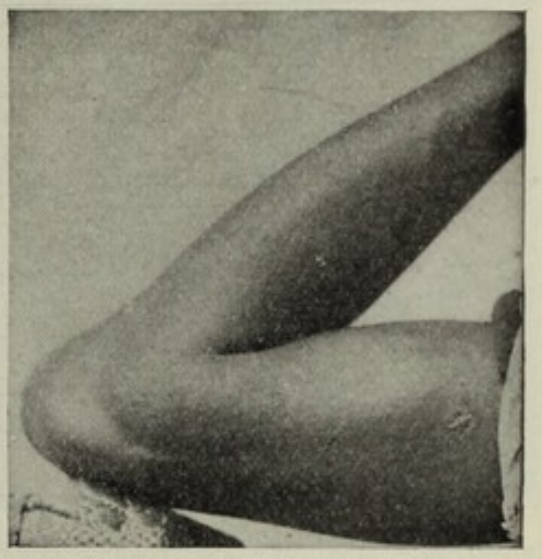


FIG. 558.—Olecranon bursitis (miner's elbow).

It is difficult to differentiate between inflammation of a deep bursa and synovitis; indeed, in bursitis the joint is apt to be secondarily affected. This difficulty is especially vexatious in distinguishing between joint injury and injury of the bursa beneath the deltoid. In subdeltoid bursitis there is a tender spot over the bursa when the arm is by the side. When the surgeon abducts the patient's arm the bursa slips up under the acromion and no tender spot can be found. Suppuration may take place in a bursa. Direct force may rupture a bursa. The bursa beneath the deltoid is frequently ruptured. When this accident happens, there are pain, marked swelling, a large area of moist crepitus, and later extensive discoloration from blood. Chronic bursitis may follow acute bursitis, or the disease may be chronic from the start. It may be due to tuberculosis (*tuberculous bursitis*). Bursæ particularly apt to become tuberculous are those about the hip, the subdeltoid, the olecranon, the prepatellar, and the retrocalcaneal. In tuberculous bursitis during the first stage the bursa is distended by fluid due to oversecretion, the walls are thickened here and there, and perhaps contain caseous foci, and rice bodies are found in the bursal fluid. In a more advanced stage

[1] Synnestvedt, of Sweden. [2] Zuelzer in "Zeit. f. Chir.," vol. l.

the bursal wall is lined with caseating granulation tissue and the bursa may become a tuberculous abscess, the walls may give way with diffusion of the process, or mixed infection with pyogenic organisms may occur. In some cases of tuberculous bursitis tending to cure the bursal walls become enormously thickened by fibrous tissue. Chronic bursitis may result from acute bursitis, but it may be chronic from the start. Some cases are due to repeated trivial injury, some to tuberculosis, some to syphilis (*syphilitic bursitis*). Years ago Verneuil discussed *luetic bursopathy*. Churchman ("Amer. Jour. Med. Sciences," 1909) showed that bursitis can occur in hereditary as well as in acquired syphilis, and discussed secondary hygroma and tertiary hygroma. In the latter the bursa is in the depths of an ulcerating gumma.

The **symptom** of chronic bursitis is swelling, but little or no pain unless acute inflammation arises. The Wassermann test and the therapeutic test enable us to make the diagnosis of syphilitic bursitis. Chronic inflammation of the olecranon bursa is called *miner's elbow* (Fig. 558). Chronic bursitis of the prepatellar bursa is known as *housemaids' knee* (Figs. 559, 560). Chronic bursitis of the subhyoid bursa is known as *Boyer's cyst*. There are six bursæ about the ham, the largest of which is the bursa

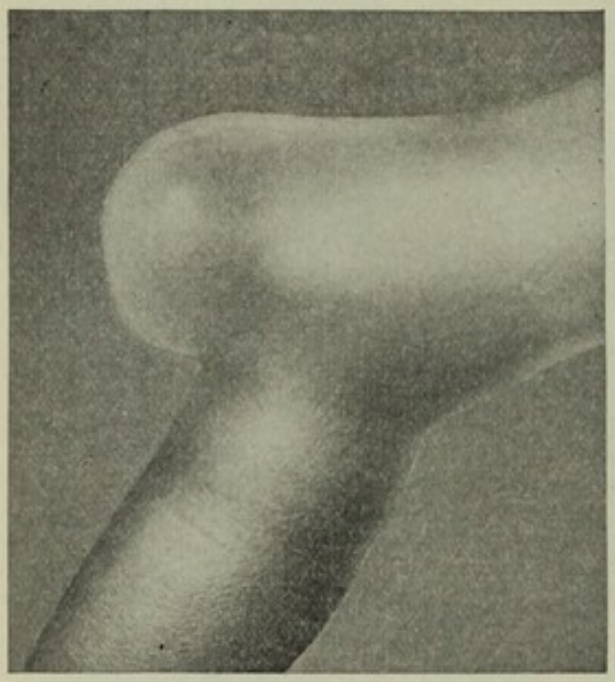


FIG. 559.—Prepatellar bursitis (housemaids' knee).

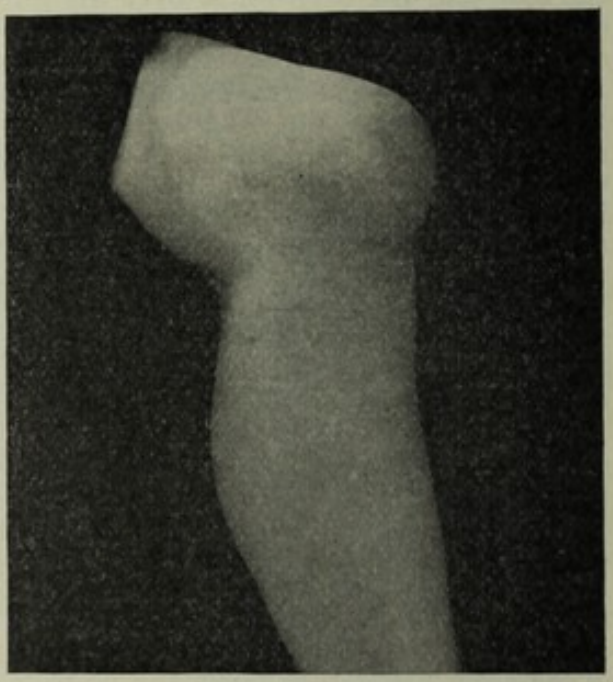


FIG. 560.—Housemaids' knee (Dr. Richard Harte, Pennsylvania Hospital).

of the semimembranosus muscle. Inflammation of the gluteal bursæ has been called *weaver's bottom* and *bargeman's bottom*.

Treatment.—Acute bursitis is treated by rest, pressure, and the application of iodin, blue ointment, or ichthyol. If the swelling persists, aspirate and apply pressure, or incise the sac and remove it partly or completely. If pus forms, incise, paint the interior of the sac with pure carbolic acid, and pack with iodoform gauze. Chronic bursitis may be cured by the use of pressure, the application of blue ointment, and with treatment of any causative diathesis, but most cases require incision and packing, and some, excision. Syphilitic bursitis calls for specific treatment. A ruptured bursa is treated as an acute bursitis. In bursal tuberculosis the best treatment is excision. If we are dealing with a very deep bursa the proper treatment is incision, scraping with a sharp spoon, mopping with carbolic acid, and packing with iodoform gauze.

Bursitis of the subacromial bursa (Figs. 561, 562) has been considered by A. E. Codman ("Boston Med. and Surg. Jour.," Oct. 22, 29, Nov. 5, 12, 19, 26, and Dec. 3, 1908), who points out that the deltoid and the subacromial bursa are one and the same thing. When the arm is abducted, the entire bursa is subacromial; when it is adducted, a large portion of the bursa is subdeltoid. Codman describes three types of conditions associated with inflammation of this bursa, first: The acute, or spasmodic type, in which there is local tenderness on the point of the shoulder, just below the acromion process and outside the bicipital groove. In some cases Dawbarn has shown

that the tender point, which is the base of the bursa, disappears under the acromion when the arm is abducted. Codman goes on to show that in attempting abduction about 10 degrees of motion can be obtained without moving the scapula. Then the scapula is locked by spasm and moves with the humerus. This spasm may be temporary in mild cases. Sometimes pain prevents the patient from voluntarily raising the arm, though it may be raised by passive motion. The pain may run down the outer side of the arm, even into the hand; the patient frequently locates the pain about the insertion of the deltoid, and may be able to note swelling of the bursa.

Codman describes type two, the subacute or adherent type, in which there are adhesions between the roof and floor of the bursa and a definite mechanical hindrance to abduction and external rotation. There may or may not be local tenderness, but Dawbarn's sign is absent, owing to the presence of the adhesions. Abduction is limited to such a great degree that, as a rule, the tuberosity will not pass beneath the acromion. Any movement in abduction beyond 10 degrees causes the scapula to move. The pain is located as in type one, and frequently also passes into the neck. In some cases it is very severe.

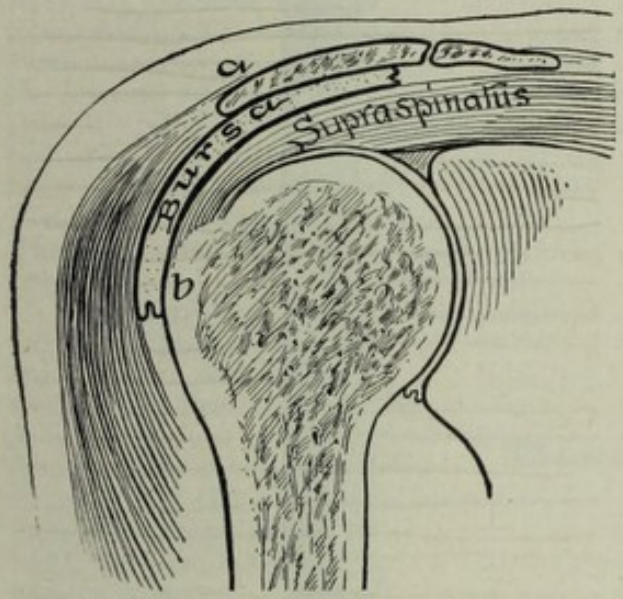


FIG. 561.—Diagram from a frozen section. Notice the deltoid and its origin, from the edge of the acromion. Notice the subdeltoid or subacromial bursa with its roof made by the under surface of the acromion and by the fascia beneath the upper portion of the deltoid. Its base is on the greater tuberosity and the tendon of the supraspinatus, which separates it like an interarticular fibrocartilage from the true joint (Codman).

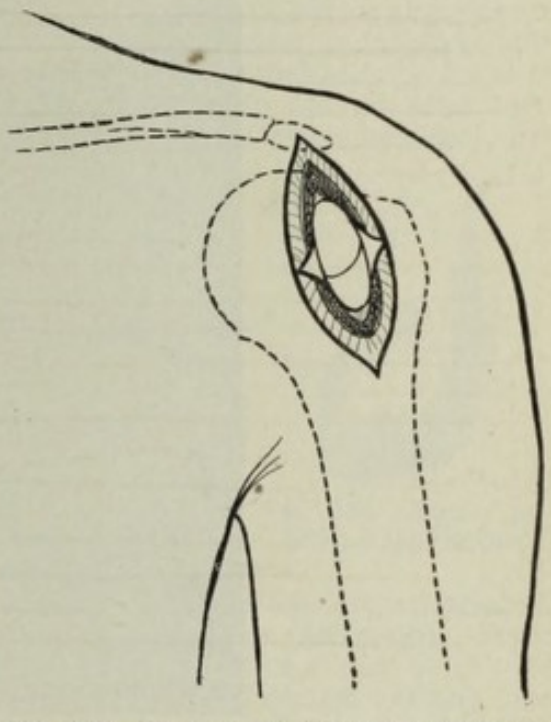


FIG. 562.—Showing incision used for demonstration of the bursa (Codman).

Codman's third form is the chronic and non-adherent. In this the full arc of motion is retained, but motion is painful. The bursa is thickened and irregular. There may or may not be local tenderness; and if this is present, one will find Dawbarn's sign. Abduction and external rotation are limited little, if at all, but at some point during abduction there is severe tenderness, which disappears as soon as the tuberosity passes beneath the acromion. The scapula does not accompany the motions of the humerus. There is often considerable pain after motion.

Codman points out that the prognosis in type one is very favorable if treatment is correct. In type two the disability, even without treatment, seldom lasts more than two years. He says that even severe or adherent cases, if there are no secondary contractures in the forearm muscles, will recover in from one to two years. In infective cases the prognosis is far worse than in traumatic cases. In chronic cases, in which the arc of mobility is not affected, the prognosis is fairly good. Twice I have removed a calcified bursa.

Treatment.—Acute cases of subacromial bursitis should be treated by keeping the arm abducted in a splint (Fig. 563). Monks suggests that the patient may sit by a table, the arm being abducted and placed upon a pillow that is on the table. This relaxes the short rotators and the deltoid, and keeps the wall of the bursa from

being in contact with the acromion. At night Codman places the arm on a pillow, with its long axis at right angles to the patient's body as he lies recumbent. If the patient has to get about, he may use a sling most cautiously. He should lift the arm outward from time to time and rest it on a table. Massage should be used about the bursa, but not directly over it. In the more severe cases with adhesions one may employ massage, passive and active movements, baking, forcible movement and manipulation under an anesthetic, followed by fixation in the position of abduction (Fig. 563),

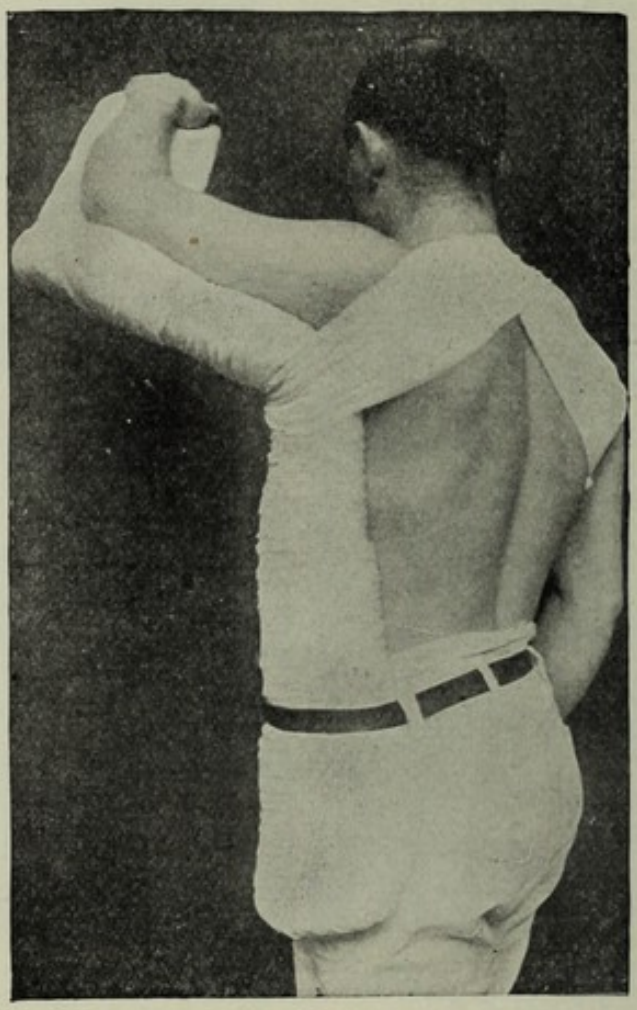


FIG. 563.—Showing the abduction splint in position, the patient standing. It is held by a figure-of-8 bandage, which crosses behind the shoulders and by a belt about the hips. The arm is at rest (Codman).

Description of Splint.—The frame of the splint which I use is made of iron wire (diameter, $\frac{1}{4}$ inch), stiff enough to maintain its form and to carry the weight of the arm securely. Sufficient wadding to pad it thoroughly is bandaged over it and the whole covered with cotton or linen cloth. The general shape is shown in the photograph. It should be just long enough to extend from the axilla to the seat of the chair on which the patient sits. It is best held in position by a belt around the pelvis and a figure-of-8 flannel bandage about the shoulders crossing back of the neck. A pad should be placed in the opposite axilla to prevent excoriation of the skin by the bandage.

During the first twenty-four hours and afterward, if worn at night, the arm should also be lightly bandaged to the projecting part of the splint. Additional security is given by the application of a swathe, which may be pinned to the bandage of the axilla.

When properly adjusted it is perfectly comfortable. Unless it is comfortable it is useless. The use of the splint is not essential and is even harmful if not skilfully cared for.

or perhaps incision of the bursa with division of the adhesions or excision of the subdeltoid portion of the bursa (Codman). In the cases in which there is irregularity of the surface of the bursa one should excise and remove the thickened folds or other irregularities.

Housemaids' knee (see Figs. 559, 560) is thickening and enlargement of the prepatellar bursa, the result of intermittent pressure. In effusion into the knee-joint the fluid is behind the patella and the bone floats up; in housemaids' knee the fluid is superficial to the bone and the osseous surface can be felt beneath it.

In **bursitis of the deep infrapatellar bursa** the swelling is under the ligament of the patella.

Miners' elbow (see Fig. 558), which is a condition similar to housemaids' knee, affects the olecranon bursa.

Weavers' bottom is enlargement of the bursa over the tuberosity of the ischium. A bursa which is simply thickened and enlarged rarely gives rise to annoyance; but when it inflames, as it is apt to do, it causes the ordinary symptoms of bursitis.

The **bursa of the semimembranosus muscle** is the largest one about the ham. It lies between the inner femoral condyle and inner head of the gastrocnemius and the semimembranosus muscle. It communicates with the knee-joint. When the joint is flexed it partly empties into the joint and becomes small and lax. When the joint is extended it becomes large and tense.

Treatment of Special Forms.—Some few cases of housemaids' knee may be cured by rest and blistering, but in most cases it is necessary to incise and pack with iodoform gauze. In enlargement of the bursa beneath the ligamentum patellæ, if rest and blistering fail to cure, aspirate or incise. In enlargement of the bursa beneath the tendon of the semimembranosus and also in "weavers' bottom" and in "miners' elbow" incise and pack. In operating for iliopsoas bursitis I follow Lund's advice and make a vertical incision below Poupart's ligament, and between the anterior crural nerve and the femoral artery. The fibers of the iliopsoas muscle are separated and the bursa is opened and drained. Some few cases of retrocalcaneal bursitis recover after rest, but most of them require incision and drainage. If osteophytic formations exist, the bony stalactites must be removed by means of the rongeur. Flat-foot, if it exists, is treated by a support (see page 698). The treatment of subacromial bursitis is considered on page 685.

A **bunion** is a bursa due to pressure, and it is most commonly situated above the metatarsophalangeal articulation of the great toe, but is occasionally seen over the joint of another toe. When the big toe is pushed toward the other toes by ill-fitting boots a bunion forms. When a bunion is not inflamed it may cause but little trouble, but when it inflames the bursa enlarges and the parts become hot, tender, and exceedingly painful. Suppuration may occur and pus may invade the joint, and the bone not unusually becomes diseased and very greatly enlarged.

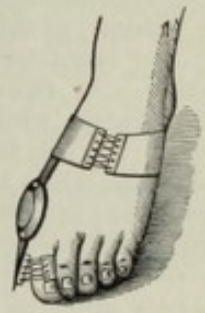


FIG. 564.—Biggs's apparatus for bunions.

Treatment.—In treating a bunion the patient must wear shoes that are not pointed, that have the inner border straight, and that have rounded toes (Jacobson). For a mild case a bunion-plaster gives comfort. Sayre advises the use of a linen glove over the toe, the toe being drawn toward the inner side by a piece of elastic webbing, one end of which is fastened to the glove and the other end to a piece of strapping from the heel. A special apparatus may be worn (Fig. 564). In many cases osteotomy of the first phalanx or of the first metatarsal bone is required; in some cases excision of the joint is necessary; in others amputation must be performed. Charles H. Mayo has operated on 65 cases successfully. He removes the head of the metatarsal bone and with it two-thirds of the hypertrophy on the medial side, and turns the bursa into the joint area in front of the bone. He sutures this bursa in place and now has a synovial membrane for a joint which becomes satisfactorily movable ("Annals of Surgery," Aug., 1908). When the bursa is not inflamed, but only thickened, blisters should be employed over it, or there should be applied tincture of iodin, ichthyol, or mercurial ointment. When the bursa inflames, ichthyol ointment is applied, and intermittent heat by foot-baths gives relief. Suppuration demands immediate incision and antiseptic dressing. If an ulcerated bunion does not heal by antiseptic dressing, stimulate it with nitrate of silver and dress it with unguent. hydrarg. nitrat. (1 part to 7 of cosmolin). Jacobson recommends skin-grafting for some cases.

OPERATIONS UPON MUSCLES AND TENDONS

Tenotomy is the cutting of a tendon. It may be *open* or *subcutaneous*, the open operation being preferred in dangerous regions.

Open Division of the Sternocleidomastoid Muscle for Wry-neck.—Subcutaneous tenotomy for wry-neck has been largely abandoned. It is not only more unsafe than the open operation, but it never completely divides all of the contracted bands.

The patient is placed recumbent, the chin being drawn more than is habitual toward the opposite side. A transverse incision is made over the muscle about ¼ inch above the clavicle. The superficial parts are divided, the muscle is exposed and sectioned, bleeding is arrested, and the skin is sutured. Avoid the anterior jugular vein, which is underneath the muscle, and also the external jugular, which is close to the outer edge of the muscle. Mikulicz advocated the removal of almost the entire muscle, leaving, however, the upper and posterior portion where the spinal accessory nerve passes. After operation for wry-neck the head is straightened and plaster of Paris is used to secure fixation for from four to eight weeks. Then inaugurate motions, active and passive.

Subcutaneous Tenotomy of the Tendo Achillis.—This operation is performed for club-foot in which the heel is raised. The tendon is cut about 1 inch above its point of insertion. The instrument used for the first puncture is a sharp tenotome. The patient lies upon his back, "with his body rolled a little toward the affected side" (Treves), the foot being placed so that its outer side rests on a sand-pillow. The surgeon stands to the outer side. The tendon is rendered moderately rigid, and a sharp tenotome, with its blade turned upward, is inserted along the anterior border of the tendon until the surgeon's finger feels the knife approaching the outer side. The sharp-pointed instrument is withdrawn and a blunt-pointed tenotome is inserted in its place. The tendon is drawn into rigidity, and the surgeon turns the blade of his knife toward the tendon, places his finger over the skin, and saws toward his finger. The tendon gives way with a snap. Treves states that a beginner is apt not to push the knife far enough toward the outside, or he may in the first puncture push the knife through the tendon; in either case the tendon is not completely cut. Another method is to insert the tenotome between the skin and the tendon and cut the tendon by a sawing motion. In this method the danger of cutting through the skin is obviated. The little wound, which is covered by a bit of gauze, will be entirely closed in forty-eight hours. In club-foot cases after tenotomy some surgeons at once correct the deformity and immobilize the limb in plaster; some partially correct the deformity and apply plaster for one week, at which time they remove the plaster, correct the deformity further, reapply the plaster, and so on; other surgeons do not attempt correction of the deformity until the cut tendon has begun to unite, when they gradually stretch the new material.

Subcutaneous Tenotomy of the Tendon of the Tibialis Anticus Muscle.—The tendon is divided about 1½ inches above its point of insertion. It can be made tense by extending and abducting the foot. The sharp-pointed tenotome is entered upon the outside of the tendon, and is passed well around it. The blunt-pointed tenotome is used to cut the tense tendon.

Subcutaneous Tenotomy of the Tendons of the Peroneus Longus and Brevis Muscles.—These two tendons are cut together back of the external malleolus, and 1½ inches above the tip of the malleolus, so as to avoid the synovial sheath (Treves). The patient lies upon the sound side, the outer aspect of the deformed foot being upward and the inner aspect of the ankle resting upon a sand-pillow. A sharp tenotome is introduced close to the fibula, and is carried around the loose tendons. A blunt-pointed tenotome is now introduced, its edge is turned toward the tendons, and these structures are cut as they are made tense.

Subcutaneous Tenotomy of the Tendon of the Tibialis Posticus Muscle.—This tendon is sectioned above the point where its synovial sheath begins; that is, above the internal annular ligament (Treves). The tendon is made tense and the pointed knife is entered above the base of the inner malleolus. The knife is entered just back of the inner edge of the tibia, and is carried around the muscle and is kept close to the bone. The tendon is sectioned with a blunt knife.

Subcutaneous Fasciotomy of the Plantar Fascia.—The contracted bands are discovered by motions which render them tense, and they are divided just in front of the attachments to the os calcis. The sharp knife passes between the skin and fascia at the inner side of the sole of the foot. The fascia is cut from without inward by the blunt-pointed tenotome. It is usually necessary to section the fascia at more than one point.

Tendon Suture and Tendon Lengthening.—Chromicized gut, kangaroo-tendon, or silk is used for an ordinary case, silver wire for a suppurating wound. In performing tendon suture make the part aseptic and bloodless. It is wise to apply a rubber bandage on the proximal side, the bandage being applied centrifugally, forcing the proximal end of the tendon into view (Haegler). If searching for the proximal end of a flexor

of the finger, flex the injured finger and hyperextend the adjoining fingers (Filiget). If this expedient fails, enlarge the incision or, what is better, make a large flap in the skin. After finding the ends, approximate them, being sure the proper ends are brought into contact; stitch them together by a continuous suture or by one of the sutures shown in Fig. 565, 1, 2, 3. In a suppurating wound suture by silver wire should be tried, though it usually fails. After suturing, remove the Esmarch apparatus, arrest bleeding, colse the wound and dress it antiseptically, relax the parts, and place the

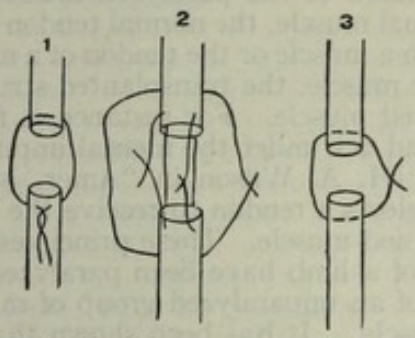


FIG. 565.—Tendon sutures: 1, Of Le Fort; 2, of Le Dentu; 3, of Lejars.

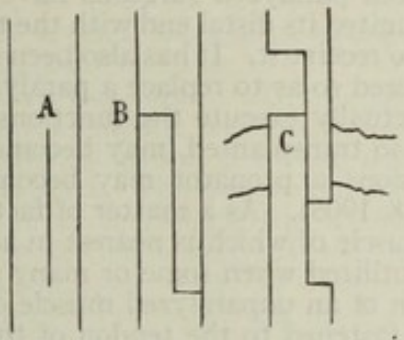


FIG. 566.—Anderson's method of tendon lengthening.

limb on a splint. If, after suturing, there is much tension, stitch the cut tendon above the sutures to an adjacent tendon, and apply a splint, the finger of the injured tendon being flexed, the others being extended. If only the distal end of the tendon can be found, graft it upon the nearest tendon with a like anatomic course and function. After a tendon has been sutured, begin gentle massage in two weeks. Positive passive motion is begun in three or four weeks. In old injuries, when the ends cannot be brought into apposition, lengthen one end or both ends. Dr. J. Neely Rhoads ("Med. News," Nov. 28, 1891) suggested that slight lengthening could be accomplished by

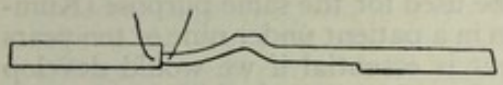


FIG. 567.—Czerny's method of tendon lengthening.

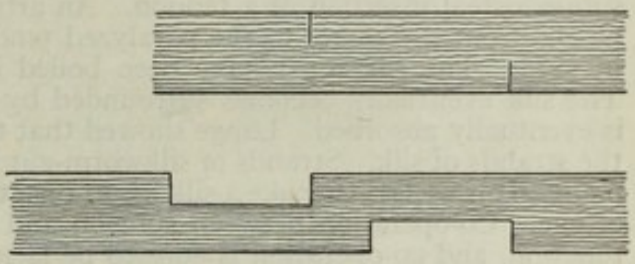


FIG. 568.—Bayer's method of tendon lengthening.

"cutting half through the tendon at different levels and from opposite sides, leaving some longitudinal fibers to slip on each other, thus gaining slight elongation" (H. Augustus Wilson in "International Clinics," vol. i, 4th series). Czerny's method is shown in Fig. 567. Poncet makes several zigzag incisions on each side of the tendon, and when the tendon is pulled upon it elongates decidedly. Bayer's method is shown in Fig. 568. Anderson's open method is the most satisfactory (Fig. 569). One of these methods of lengthening may be used if there is deformity from tendon contraction. If the tendon cannot be lengthened sufficiently, make a bridge of catgut from one cut end of it to the other, or insert a piece of tendon from one of the lower animals, or graft the distal end to a tendon of like function (*tendon grafting*).

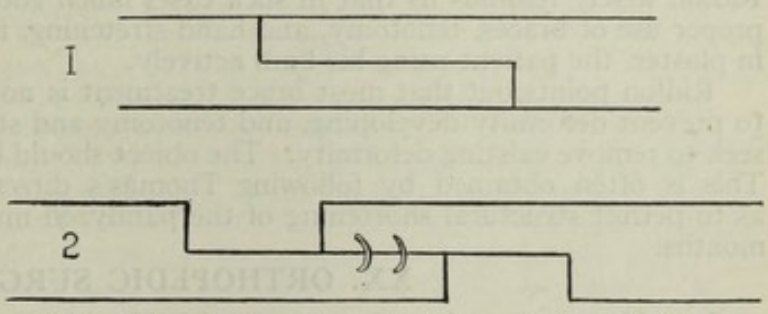


FIG. 569.—Anderson's method of tendon lengthening.

The annular ligament is sutured as shown in Fig. 548.

Tendon Transplantation and Silk Inserts.—Tendon transplantation is the transplantation of the tendon of a healthy muscle to take the place of the tendon of a paralyzed muscle. Silk inserts have been used to take the place of paralyzed muscles, "to lengthen normal tendons for the purpose of using them in transplanting, and to

reinforce joints as artificial ligaments, in place of arthrodesis" (James W. Sever, "Jour. Amer. Med. Assoc.," May 11, 1912). Tendon transplantation is usually said to have been devised by Nicoladoni in 1882; as a matter of fact, Duplay did the operation in 1876, endeavoring to secure function in an arm rendered nearly powerless by an injury (Elting in "Albany Med. Annals," April, 1902).

The first American surgeon to do the operation was Parrish, of New York, who in 1892 transplanted tendons in a case of club-foot. In some cases in which a muscle has been paralyzed surgeons have divided the tendon of the paralyzed muscle and have united its distal end with the tendon of a normal muscle, the normal tendon being split to receive it. It has also been stated that when a muscle or the tendon of a muscle is sutured so as to replace a paralyzed antagonistic muscle, the transplanted structure will actually execute the functions of the paralyzed muscle. For instance, a flexor, when so transplanted, may become an extensor and act under the mental impulse of extension; a pronator may become a supinator (H. A. Wilson in "Amer. Med.," April 8, 1905). As a matter of fact, the surgeon selects a tendon to receive the graft, the muscle of which is nearest in action to the palsied muscle. These principles have been utilized when some or many of the muscles of a limb have been paralyzed, the tendon of an unparalyzed muscle or the tendons of an unparalyzed group of muscles being fastened to the tendon of the paralyzed muscle. It has been shown that the success of the procedure depends upon the accuracy of diagnosis, the division of secondary contractures, the correction of existing deformities, and careful after-treatment. (See the article by Dr. J. Hilton Waterman in "Med. News," July 12, 1902.) The muscle of the transplanted tendon must not be put under tension. In a paralysis of the lower extremity, as Goldthwait points out, the sartorius usually retains power, and it may be advisable in such a case to divide the sartorius and suture its upper end to the quadriceps above the patella. A strip of the tendo achillis may be grafted upon the peronei in certain cases. Unfortunately the suturing of tendon to tendon seldom holds. Experience has shown that it is better, whenever possible, to make a subperiosteal insertion of a tendon. An artificial tendon may be made of silk, being passed from the sound to the paralyzed tendon. This method was devised by Auger in 1875. The silk must have been boiled in paraffin, otherwise it will slough out. The silk eventually becomes surrounded by fibrous tissue. Some maintain that silk is eventually absorbed. Lange showed that tendon regeneration may take place along the strands of silk. Strands of silkworm-gut may be used for the same purpose (Kummell). It is useless to make a silk insert on a tendon in a patient under nine or ten years of age. Co-operation between surgeon and patient is essential if we would develop function, and co-operation is sure to be lacking before that period of life. The consensus of opinion among orthopedic surgeons is that silk tendons should not be used if there is much strain or trauma. Under active use silk will be cast off by a process of non-infective sloughing and, unless sufficient scar tissue has been formed by that time, the result is bound to be a failure. Orthopedic surgeons have practically discarded silk inserts. They have found that a better operation is arthrodesis to stabilize the smaller joints of the foot, combined if necessary with tendon transplantation or tendon fixation (tenodesis). The operation of tendon transplantation is occasionally of distinct benefit, but I agree with Ridlon, and am not usually sanguine of results. Ridlon wisely reminds us that in such cases much good may perhaps result from the proper use of braces, tenotomy, and hand stretching, followed by prolonged retention in plaster, the patient using his limb actively.

Ridlon points out that most brace treatment is not curative because it only aims to prevent deformity developing, and tenotomy and stretching fail because they only seek to remove existing deformity. The object should be some restoration of function. This is often obtained by following Thomas's directions, "posturing" the limb so as to permit structural shortening of the paralyzed muscles and then fixing them for months.

XX. ORTHOPEDIC SURGERY

I was fortunate to have been assisted in the revision of this section and also in the revision of the section on Muscles, Tendons, and Bursæ by Dr. Arthur J. Davidson, Assistant Professor of Orthopedic Surgery in the Jefferson Medical College.

This branch of surgery formerly dealt only with the treatment of deformities by means of mechanical appliances, but of late years its domain has been enlarged.[1] In 1920 The American Orthopedic Association adopted the following resolution:

[1] E. S. Hatch, "Southern Medical Jour.," Dec., 1921.

"The scope of orthopedic surgery should include the framework of the human body, the bones and joints, and the abnormalities of the motor apparatus. This would include:

"1. Congenital and acquired deformities of the spine and the extremities.
"2. Infantile paralysis, after the acute stage.
"3. The deformities of adult paralysis.
"4. Stiff and ankylosed joints.
"5. Torticollis.
"6. Disabilities of joints, such as rupture of crucial ligaments, injuries to the semilunar cartilages, snapping hip, slipping patella, fractures, etc."

Note.—Most of these conditions are discussed in this edition. On account of the difficulty in reclassifying, they will not all appear in the section on Orthopedic Surgery.

Torticollis (**wry-neck**) is a condition in which contraction of certain of the neck muscles causes an alteration in the position of the head. The deformity is one sided; the sternocleidomastoid is the muscle chiefly involved, though the trapezius, the splenius, and other muscles sometimes suffer. Acute torticollis, which is rare, is a temporary condition, and results from cold or from injury (see Myalgia). Chronic torticollis may be congenital (due to injury before birth or during birth), may be due to nerve irritation, to an assumed attitude because of eye defect, to polio-encephalitis (Golding-Bird), to inflammation of the glands or to disease of the vertebræ, and it may be intermittent, but is usually persistent. The muscle stands out in bold outline, the head is turned to the opposite side, the ear of the affected side is turned toward the shoulder, the chin is thrown forward, and spinal curvature may arise (Fig. 570). The corresponding side of the face becomes distorted. Secondary facial changes result from nature's effort to balance the face and keep the eyes on a level, in accordance with Wolff's law. When the muscular deformity is overcorrected the face again becomes symmetric. There is no pain. In many cases the head may be restored to its normal position by passive movement, and in a few by voluntary effort, but it at once returns to its habitual position. Mikulicz asserts that torticollis is a chronic fibrous myositis, due often to compression during labor. He further says that the lesion known as hematoma of the sternomastoid, which occasionally follows labor, is not hematoma, but thickening due to myositis. D'Arcy Power reported the autopsy on a child one month of age. The sternomastoid muscle contained a fibrous mass the result, Power believes, of a hemorrhage into the muscle prior to birth ("Med. Chir. Trans.," vol. lxxvi). Power, Clutton, and Owens have all traced cases of hematoma of the sternomastoid from early infancy to the time when tenotomy was required for torticollis. W. W. Richardson ("Surg., Gynec., and Obstet.," 1906) believes that interstitial myositis is always present, but doubts the causal influence of the lateral position of the head *in utero*. In some cases hereditary influence is evident. One woman gave birth successively to 7 wry-necked children (Nove-Josserand and Vianny in "Revue D'Orthop.," 1906). Many writers advocate the ischemic theory as explanatory of the causation of torticollis. This theory is, that during labor lateral flexion of the head with elongation of the neck or lateral flexion with torsion produces occlusion of the sternomastoid branch of the superior thyroid artery, which vessel supplies the sternocleidomastoid muscle (see Tubby's "Orthop. Surgery"). In congenital torticollis the muscle and the cervical fascia are shortened, and the muscle does not relax under the influence of an anesthetic. In torticollis due to rheumatism and reflex causes the tonically contracted muscle relaxes when the patient is anesthetized. In spasmodic wry-neck the muscle is thrown repeatedly into clonic contractions.



FIG. 570.—Dr. Arthur J. Davidson's case of torticollis.

Symptoms.—*Congenital* wry-neck is due to central nervous disease, to spinal deformity, or to injury during birth, and in this form the sternomastoid is shortened, hardened, and atrophied. It may not be noticed for some years because of the short neck of infancy. It is associated with asymmetric development of the face, and is

usually upon the right side (see above). *Spasmodic* wry-neck may present tonic spasm only, intermittent spasm alone, or these conditions may alternate. It sometimes arises in those whose occupation demands frequent rotation of the head, but more often no such cause can be discovered. It is probably a disease of the cortical area which presides over rotation of the head. (See article by C. A. Hamann in "Buffalo Med. Jour.," Dec., 1901.) It is a disease especially of adults; in women it is often linked with hysteria. Pahl ("California State Med. Soc.," 1906) analyzed 68 reported cases. Men and women appeared equally liable, it was most frequent between the ages of twenty and thirty, and the right side was affected in twice as many cases as the left side. The exciting cause may be a cold, a blow, or a mental storm; the predisposing cause is the neurotic temperament. It may be due to enlarged glands, to carious teeth, or to eye-strain. In some rare cases bilateral spasm occurs, the head being pulled backward and the face being turned upward. Clonic spasms may come on unannounced, or they may be preceded by pain and stiffness; the head can be held still for a moment only; there is sometimes pain, always fatigue, but during sleep the contractions cease. The attack will probably pass away, but will recur almost certainly.

Treatment.—Congenital wry-neck is treated by myotenotomy through a superficial incision which is vertical or transverse (see page 687). The muscle and fascia are divided in a line parallel to and just above the clavicle near the sternal attachment. The flaps are raised, access is free to the origin of the muscle, the muscle is readily divided. Any bands should be thoroughly kneaded and stretched and the head should be twisted into a position which overcorrects the deformity. The wounds in the skin and fascia are closed. This incision leaves a trivial scar. After operation plaster of Paris is used to secure fixation and fixation is maintained from four to eight weeks. Early operation favors the establishment of muscular co-ordination before the development of permanent bony deformity of the vertebræ. Some surgeons cut the scalene muscles as well as the sternocleidomastoid. Gerdes Rowland lengthens the sternomastoid and carefully sutures it ("Practitioner," Sept., 1908). The old subcutaneous myotenotomy should be abandoned, as aseptic incision enables the surgeon to see and to feel all the contracted bands of fascia, muscle, and tendon, and to avoid vital structures (see page 687). In spasmodic wry-neck there is a fair chance of recovery. Pahl's table (*Loc. cit.*) shows that out of 68 cases, 28 recovered, 17 were improved, and 11 were not improved by treatment. Results in 12 were not stated. Treat the neurotic temperament and remove any obvious irritation (eye-strain, carious teeth, enlarged glands). Drugs usually are practically useless, although Chas. S. Potts reported a cure after the hypodermic use of atropin. The rest cure is sometimes beneficial. Tenotomy is not to be employed. In 1890 Mayo Collier suggested ligation of the spinal accessory nerve with silver wire. In persistent cases stretch or divide and exsect a part of the spinal accessory nerve (Keen). To reach this nerve make an incision along the posterior edge of the sternocleidomastoid muscle, find the nerve as it emerges from under the middle of the muscle, about 1½ inches below the tip of the mastoid process, retract the muscle at this point, and remove at least 1 inch of nerve. Neurectomy of the spinal accessory nerve paralyzes the sternocleidomastoid muscle in spite of the fact that that muscle has also a nerve supply from the cervical nerves. The paralysis is followed by atrophy, and if the spasm affected the sternomastoid muscle alone the operation will cure the case. Unfortunately, other muscles are usually involved, and cure will only be obtained by performing neurectomy on the nerves which innervate the affected muscles. (For the treatment of rheumatic wry-neck, see Myalgia, page 668.)

Dupuytren's contraction was first described by Sir Astley Cooper. In 1831 Dupuytren made the first dissection of a case (Black in "Brit. Med. Jour.," 1915, 1). It is a fibrosis and contraction of the palmar fascia, of its digital prolongations, and of the fibers joining the fascia and skin without any inflammation of the skin. The process starts in the digital prolongations. Fixed contraction of one or more fingers occurs (Figs. 571, 572). The ring-finger and the little finger most often suffer, but any finger or the thumb may be involved. The condition may be symmetric. It is far more common in men than in women. The disease arises oftenest in men beyond middle age, but is sometimes met with in youths. The **cause** of this disease is unknown; some refer it to gout, rheumatism, or osteo-arthritis; others, to traumatism, syphilis, organic nervous diseases, arteriosclerosis, reflex irritation, or neuritis. In one-fourth of the cases heredity seems to be influential. If due to traumatism, the right hand should suffer most frequently; but it occurs in the left hand nearly as often as in the right (P. Jansen in "Arch. f. klin. Chir.," Bd. lxvii, H. 4). Working men are not

more liable to it than others. Jansen examined specimens from 7 cases and found connective-tissue hypertrophy and circulatory disturbance, the contraction being a result of the above-named processes.

Symptoms.—Dupuytren's contraction is indicated by a small hard lump or crease which appears over the palmar surface of the metacarpophalangeal joint. This nodule grows and the corresponding finger is gradually pulled down. In occasional cases the tip of the finger is forced against the palm. The skin becomes dimpled or puckered. In some cases the interphalangeal joints of the contracted finger dislocate.



FIG. 571.—Dupuytren's contraction of the middle finger.

Treatment.—Fibrolysin, which is a soluble combination of thiosinamin and salicylate of sodium, has been used hypodermically in Dupuytren's contraction and, it is claimed, with success (Schwalbach). In very slight and early cases the wearing of a splint at night, associated with daily manipulation and massage retards the development of the deformity. In treating Dupuytren's contraction subcutaneous multiple incisions may be made, the tense fascia and the fasciocutaneous fibers being cut. If simple treatment fails before selecting the proper operation, always note the condition of the metacarpal phalangeal joint. In severe cases the joint is dislocated and for such a case amputation is indicated. For very mild cases the finger may be straightened and placed upon a straight splint, which is to be worn continuously for a week or ten days and at night for at least a month. The operation of Keen is better even for slight cases. He divides the skin by a V-shaped cut, the base of the V being downward, lifts up the flap, and dissects out the contracted tissue. A valuable method is that of McCurdy. He makes a long incision which crosses the contracture obliquely, stretches thoroughly, closes the wound, and keeps up mechanical fixation for a time. A cure is most certain to be obtained by Lexer's radical operation. This surgeon excises the entire aponeurosis and considerable portions of the palmar skin adherent to the aponeurosis. In order to cover this wound it may be necessary to slide a pedunculated flap into the raw surface.

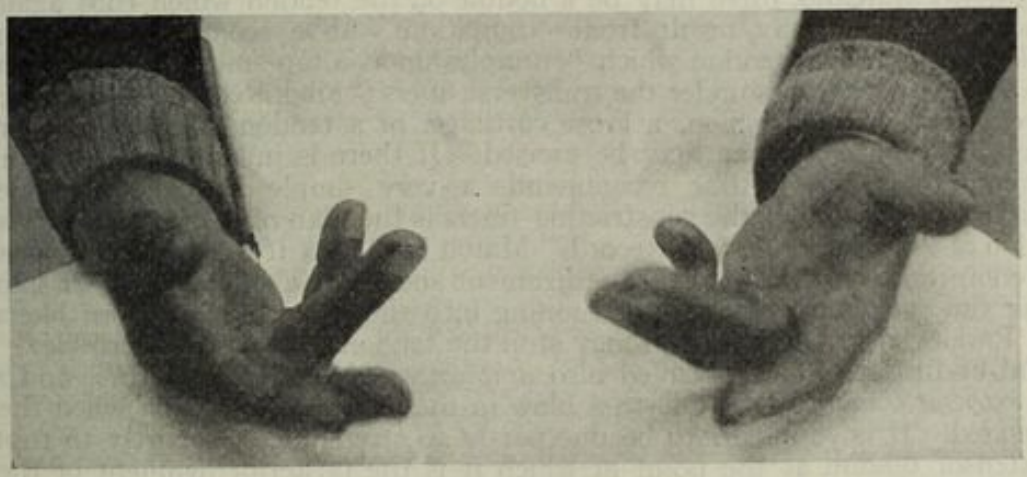


FIG. 572.—Dupuytren's contraction (Dr. William J. Taylor).

Syndactylism (webbed fingers) is always congenital, and may persist through several generations. Simple incision of the web is useless; the operation to be performed is that of Agnew or of Diday (Figs. 573, 574).

In Agnew's operation a flap of skin from the dorsum is inserted between the fingers and sutured in place.

In Diday's operation a flap is taken from the dorsal surface and another flap is raised from the palmar surface, and each flap is sutured to the finger to which it is attached.

Polydactylism (supernumerary digits) is always congenital, is often hereditary, and is usually symmetric. There may be an incomplete digit, or there may be an entire and well-developed finger or toe with a metacarpal or metatarsal bone. The connection to the metacarpus or metatarsus may be by a fibrous pedicle only. If the digit is complete, with a metacarpal bone, no operation is required; if it is incomplete or is ill-developed, the digit should be removed.

Trigger-finger or Jerk-finger (Lock-finger, Snapping-finger).—The patient can usually close the fingers, but on trying to open them one finger remains closed. It can be opened by grasping it with the other hand, but flies open with a snap, like an opening blade of a penknife (Abbe). In some cases two fingers are involved. In a reported case (Frederick Griffith, "Annals of Surgery," 1904) the ring and middle fingers of the left hand locked at the knuckle-joints on attempting flexion. The locking occurred when about one-third the amount of flexion necessary to grasp an object was achieved. By bending the fingers with the other hand unlocking was accomplished and flexion was finished voluntarily. In attempting extension blocking occurred at the same point and unlocking was accomplished in the same manner. The block may be at the proximal interphalangeal joint. In most cases, but not in all, there is pain when locking occurs. The condition is gradual in onset. Trigger-finger is often associated with rheumatism (in 52 cases out of 121, according to Necker). I have seen it in cases of polyarthritis. It is said by Tubby to be due to enlargement of the flexor tendon, or to contraction of the groove in the transverse



FIG. 573.—Agnew's operation for webbed fingers (Pye).

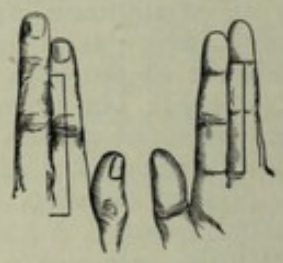


FIG. 574.—Diday's operation for webbed fingers (Pye).

ligament in the palm. It may be due to a ganglion, enchondroma, or tenosynovitis. Traumatism or irritation may produce it. The tendon sheath may be thickened or, according to Marcano, there may be a nodule on the tendon which rubs against the sesamoid bone. It may result from occupation. Abbe seems to prove that the trouble is in the flexor tendon which "crumples up as a tape might crinkle when slack above a slot." It catches under the transverse fibers ("Med. Record," March 27, 1914).

Treatment.—If a ganglion, a loose cartilage, or a tendon nodule exists, treat by excision. A sesamoid bone may be excised. If there is inflammation, use massage and counterirritation. Abbe recommends a very simple and effective operation. Subcutaneous division of the constricting fibers is the plan of Abbe. The cut is in the direction of the tendon ("Med. Record," March 7, 1914). If there is no obvious cause, put a compress over the tunnel in the ligament and apply a splint. A short splint supporting the proximal phalanx and running into the palm may be worn like a finger ring. Prolonged rest so obtained may stop the tendon's tendency to crinkle.

Mallet-finger.—This is called also *drop-finger*, *dropped phalangette*, and *rupture of the extensor tendon*. It is due to a blow in the direction of flexion when the finger is extended. It is supposed to be due partly to stretching and partly to rupture of the extensor tendon at the point at which it is the posterior ligament of the distal interphalangeal joint. Abbe has shown that baseball players are liable to a condition which is the reverse of this, in which the last phalanx is dislocated backward (*baseball-finger*). Drop-finger is treated by incision and suture of the tendon to the periosteum.

Genu valgum (knock-knee) results from an unnatural growth of the internal femoral condyle or of the internal part of the head of the tibia, or from absorption or atrophy of the external femoral condyle or of the external part of the head of the tibia. Any of these conditions causes the shaft of the femur to lean inward and the internal lateral ligament of the knee-joint to stretch, the knees coming close together and the

feet being widely separated. The condition may also be caused by curving of the tibial shaft just below the epiphysis. This deformity is usually noted when the child begins to walk, but it may not appear until puberty or even long after. Knock-knee may arise from rickets, from an occupation demanding prolonged standing, or from flat-foot. It may occur in one knee or in both knees (Fig. 575).

Treatment.—Mild rachitic cases of knock-knee may remain in slight deformity, or may get well from improvement of the general health, though they seldom do so. In an early case properly applied braces will correct deformity. In a later case operation will be necessary. In ordinary cases simply treat the rickety condition. The patient is forbidden to stand or to walk, and the limb, after being put as straight as can be, is fixed on an external splint and a pad is put over the inner condyle. Later in the case plaster of Paris is used. Some surgeons prefer to immobilize while the leg is flexed to a right angle with the thigh. In a severe case the surgeon can immobilize after forcibly straightening (causing an epiphyseal separation) or after the performance of osteotomy (see page 648). Osteotomy is preferable to fracture by a mechanical appliance (osteoclasis).

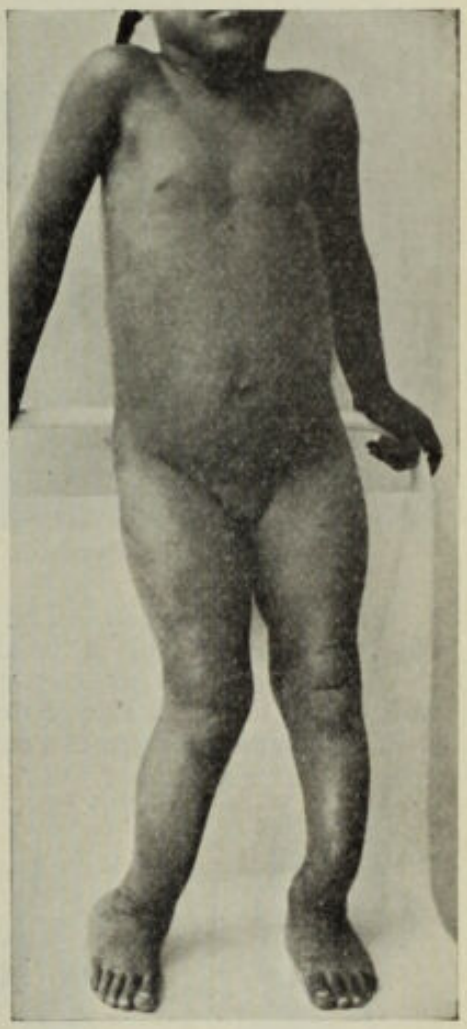


FIG. 575.—Dr. A. J. Davidson's case of bow-legs and knock-knees.

Genu varum (bow-legs) is the opposite of knock-knee. It tends much more to self-correction than knock-knee because of the arrangement of the thigh muscles, the powerful adductors acting strongly on the knee and middle of the leg (J. Torrance Rugh in "Amer. Jour. Orthop. Surg.," April, 1908). Usually both legs are bowed *out*, the knees being widely separated, the tibiæ and femora, as a rule, being curved, and the feet being turned in. This disease in early life is due to rickets, the weight of the body producing the deformity. In older people incurable bow-legs may arise from osteitis deformans.

Treatment.—Some mild cases of genu varum recover as a result of improvement in the health. Ordinary cases are treated by braces, by plaster-of-Paris bandages, and by attention to the general health. Braces usually suffice prior to three and a half years of age. Later, when the bones have hardened in marked deformity, osteotomy is necessary and should be done at the apex of the curve.

Club-hand (Fig. 576).—A congenital deformity in which the hand deviates from the normal relation to the forearm. It is usually associated with other deformities. In some cases the radius and possibly some of the carpal bones are absent.

Treatment.—By massage and passive motion, by immobilization, by tenotomy or osteotomy, or by bone-grafting.

Talipes (club-foot) is a permanent deviation of the foot into deformity. There are several forms: *talipes equinus* (Fig. 578) is a confirmed plantar flexion; *talipes calcaneus* (Fig. 579) is a confirmed dorsiflexion; *talipes varus* is a confirmed adduction, and *talipes valgus* is a confirmed abduction. Two of these forms may be combined, as in talipes equinovarus (Fig. 580), talipes equinovalgus, talipes calcaneovarus, and talipes calcaneovalgus. The **causes** of talipes are congenital or acquired. The congenital form may be due to persistence of the fetal form of the foot. There are three theories of the cause of the deformity: viz., the nervous theory, the mechanical theory (intra-uterine pressure), and arrest of development. Acquired cases may arise from infantile paralysis, from spastic contractions, from cicatrices, from traumatism, from arrest of bony growth following upon the inflammation of bone, or from hysteric contractures.

Talipes equinus is rarely congenital. In this condition the patient walks upon the toes and cannot bring the heel to the ground.

Talipes Calcaneus.—The patient walks upon the heel and cannot bring the toes to the

ground. In congenital cases the dorsal flexors of the foot are shortened and the tendo achillis is lengthened. In paralytic cases the dorsal flexors are normal and the muscles which act upon the tendo achillis are paralyzed.

Talipes varus is seldom seen without equinus. In this condition the patient walks on the outer edge of the foot.

Talipes valgus is met with in flat-foot. The patient walks on the inner edge of the foot.



FIG. 576.—Club-hand.

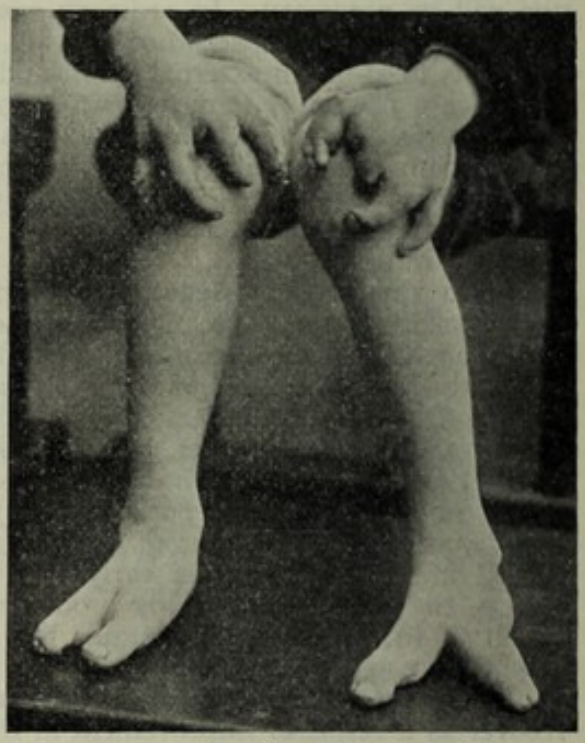


FIG. 577.—Deformities of hands and feet.

Talipes Equinovarus.—The heel is raised and the patient walks upon the outer edge of the foot. This is the usual congenital form.

Talipes equinovalgus is very rarely congenital. The heel is raised and the patient walks upon the inner side of the foot.

Talipes calcaneovarus is a combination of calcaneus and varus.

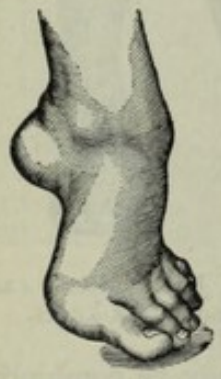


FIG. 578.—Talipes equinus (Albert).



FIG. 579.—Talipes calcaneus (Albert).

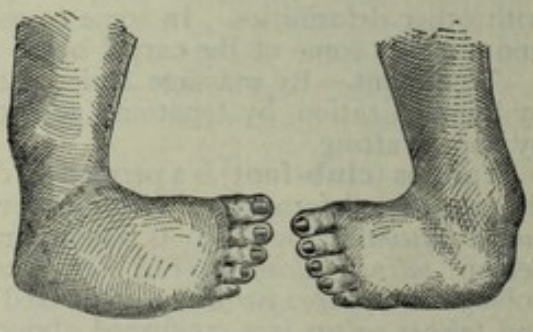


FIG. 580.—Double equinovarus ("American Text-book of Surgery").

Talipes calcaneovalgus is a combination of calcaneus and valgus and commonly follows infantile paralysis.

Treatment.—In congenital cases the condition is usually manifest on both sides, and is nearly always talipes equinovarus. It is better that both sides should be affected, as the feet will then be symmetric through life. Congenital club-foot should be treated in infancy, and when a restoration to position can be effected by the hands of the surgeon, is treated by plaster-of-Paris bandages. If a child has begun to walk, it may still be possible to correct the deformity eventually by manipulations, by plaster-of-

Paris bandages, or by club-foot shoes, but most cases require tenotomy of the tendo achillis and other contracted structures before the application of the shoe or the plaster. The club-foot shoe may do good service, but in many instances it is painful and is not so efficient as plaster of Paris. In severe equinovarus, before applying the plaster, the patient is given ether; the surgeon cuts the tendons of the anterior and posterior tibial muscles, the plantar fascia, the long flexor of the toes and the tendo achillis, in the order named, and forcibly corrects the deformity. In all cases of congenital club-foot the secret of successful treatment is the daily stretching of the foot after operative correction. In old cases, with alteration in the shape of the bones, cuneiform osteotomy, or the removal of the cuboid or other tarsal bones, may be indicated. Buchanan employs subcutaneous division of all resistant structures. Occasionally, in relapsed and inveterate cases, *astragalectomy* is performed. It is seldom practised upon young children (see page 662). In some cases of talipes calcaneus shortening of the tendo achillis is advised; but such an operation is only of temporary value, as stretching occurs after two years or more. In talipes due to infantile paralysis the operative treatment is the same, but we should not immobilize in plaster, but rather in some apparatus which can easily be removed to permit the use of massage and electricity. In paralytic cases tendon transplantation is occasionally employed. This consists in transferring the tendon of an active muscle so that it will take the place of the tendon of a paralyzed muscle. The transferred tendon should always be attached to the periosteum or pass through a hole made in a bone.

Pes planus (flat-foot—Fig. 581) is a condition in which there is loss of the arch of the foot due to muscular paralysis or ligamentous weakness, to prolonged standing, or to trauma. Flat-foot is especially apt to occur in rickets. *Spurious flat-foot*, or *inflammatory flat-foot*, occurs in Pott's fracture and in inflammation of the ankle-joint or of the tendon of the peroneus longus muscle. *Paralytic flat-foot* is seen after infantile paralysis. *Static flat-foot* is due to disproportion between the body weight and the support of that weight. All children are born with pronated feet; the arch usually begins to form soon after birth, but in some individuals it never forms. Flat-foot, according to de Vlaccos, is thus produced: If we suppose a straight line prolonged downward from the center of the leg, most of the astragalus and os calcis will be external to it; hence the body weight presses on the inner side of the foot, and tends to flatten the arch and cause outward rotation, tendencies which are antagonized by the flexors of the toes and by the tibialis posticus muscle. The os calcis is pronated and is pushed to the side, the astragalus moves after the os calcis, and the ligaments are stretched ("Rev. de Chir.," Aug., 1901). A very common cause is contraction of the tendo achillis. In childhood the condition is seldom recognized, but in an adult with contracted Achilles' tendon long hours of standing will quickly precipitate the acute symptoms of flat-foot. Pes planus is productive of much pain upon standing or walking; in fact, the individual may be completely crippled. Pain is quickly relieved upon sitting down. Walking upon the toes is not painful. A marked flat-foot can at once be recognized by wetting the sole of the patient's foot with a colored fluid and causing him to step firmly upon a piece of paper (Fig. 582, B). Beginning flat-foot cannot be thus recognized and is frequently overlooked, the patient being treated for gout or rheumatism. Even a slight case can be detected by carefully observing the inner surface of the foot. When weight



FIG. 581.—Severe case of rigid flat-feet (Dr. A. J. Davidson).



A B

FIG. 582.—Print of a normal foot sole (A) and of a flat-foot sole (B) (Albert).

is placed upon it, it is seen to descend as the arch falls. A more accurate method is measurement, to find the middle of the foot. In flat-foot the extremity is lengthened. Golding-Bird points out that the middle of the normal foot is the point of articulation of the inner cuneiform and the metatarsal bone of the great toe. In flat-foot the greatest change is in the posterior half of this line. The extent to which the posterior measurement exceeds the anterior is the degree of flat-foot. The excess may reach ¾ inch.

Treatment.—In *paralytic flat-foot*, which arises from infantile paralysis, employ exercise, electricity, and massage. To maintain a correct position of the ankle and to facilitate normal muscular action apply suitable braces. In some cases of paralytic flat-foot it is advisable to stiffen permanently the ankle-joint by operation. Operation is not indicated before the twelfth year, because during the earlier years of life union will probably fail to occur. Goldthwait removes the cartilage from the articular surfaces of the astragalus, calcaneus, tibia, and malleoli, and seeks to obtain permanent bony ankylosis. In *static flat-foot* it has long been customary to advise rest in bed for two weeks, and then exercise for several hours a day to increase the arch. The usually recommended exercise has been to rise upon the toes and lower again and again, with the ankles turned outward. The patient rests for a time after each séance of exercise by sitting tailor-fashion with the legs crossed under him or by standing on the outer edges of the feet. Massage is ordered and a special shoe is made to raise the arch of the foot. The shoe must fit the heel snugly and have a firm, broad heel. In some cases it is necessary to use a Thomas heel; in others, a steel shank. The pronation

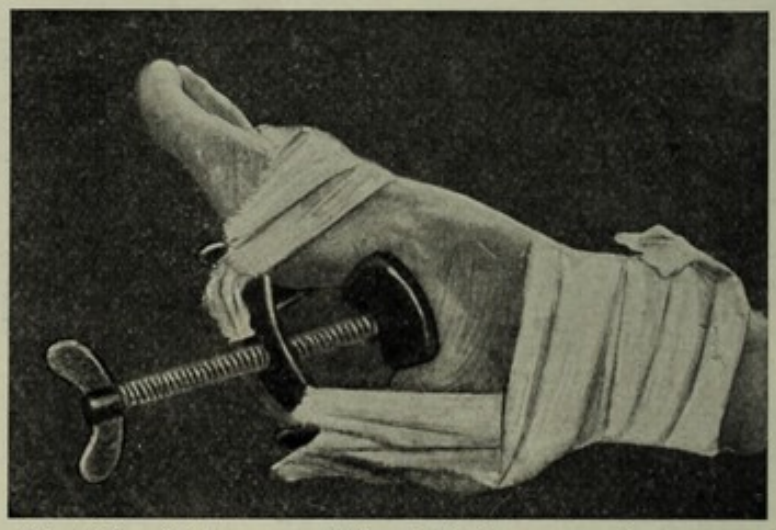


FIG. 583.—H. Augustus Wilson's flat-foot correction screw.

or inward sagging of the foot is corrected by raising the heel of the shoe 1/8 to 1/3 inch on the inner side. The patient's general health is, of course, attended to.

Many orthopedic surgeons have come to regard this usual treatment as unphilosophic and improper for many cases.

It is essential to understand that a static flat-foot may be a fully functionating foot, free from pain and disability, and therefore not a subject for treatment. For convenience flat-foot is divided into rigid and flexible. Either form may be free from pain. The pain of flat-foot is usually the result of excessive use. It must be differentiated from Albert's disease (achillodynia), metatarsalgia, osteophytes on the under surface of the os calcis, and Raynaud's disease. Rigid flat-foot can be made flexible by manipulative measures (according to Whitman's method) or by the employment of H. Augustus Wilson's flat-foot correction screw (Fig. 583). This apparatus pulls down on the posterior part of the os calcis and the distal extremities of the metatarsal bones and pushes up beneath the tarsus. The force employed is very great and much care should be exercised when it is used upon a patient under anesthesia. It is preferable to use it without ether, relying upon the patient to state when the pressure becomes unendurable. A flexible flat-foot is capable of correction by exercises.

It was formerly customary to prescribe always various forms of steel plates to correct the broken-down arch, but some orthopedic surgeons are discouraging their use, believing that they destroy the muscular control of the foot, and by weakening the foot render it susceptible to sprains and other injuries. It is my belief that steel plates should often be used, but never abused (Fig. 584). When plates are necessary because

the patient is heavy or because he must continue a trying occupation, they must be fitted to the individual case and must be worn until such time as the use of exercise has enabled the patient to maintain properly the body weight with the strenghtened arches. If the tendo achillis is shortened it must be lengthened by operation or else the heel of the shoe must be raised to permit the fullest range of dorsal flexion the tendon allows. When muscle tone is low and there is small chance of restoring it, H. A. Wilson ("Amer. Medicine," May 6, 1905, page 725) advocates the employment of the method devised by Professor Müller ("Central. f. Chir.," Jan. 10, 1903, page 40) for paralytic valgus. It consists of an arthrodesis of the astragaloscaphoid joint, and transplantation of the tendon of the extensor proprius hallucis into a hole drilled free from above downward through the scaphoid. Fixation in plaster of Paris in an overcorrected position is maintained for four weeks and then corrective exercises are employed. The anterior tibial tendon is supplemented in its action by the transplanted tendon.

Gleich shortened the foot and raised the arch by sawing through the os calcis and fastening the posterior part of this bone at a lower level. Trendelenburg advised supramalleolar osteotomy. This operation permits of adduction, and the adducted foot should be put up in an immovable dressing of plaster of Paris. Ogston resects the astragaloscaphoid joint. Golding-Bird and Davy remove the scaphoid bone. Stokes removes a wedge-shaped piece from the head and neck of the astragalus. Rugh has taken a wedge-shaped piece of bone from the inner side and inserted it in the outer side.



FIG. 584.—Whitman's plate to support the arch of the foot in flat-foot (Fowler's "Surgery").

Pes cavus (hollow foot) is an increase in the arch of the foot, due, possibly, according to Golding-Bird, to paralysis of the peronei muscles. When the peronei muscles are paralyzed the adductors act unopposed, and secondary contraction of the plantar fascia occurs. Certain it is that a contracted plantar fascia is the chief obstacle to correction. In many cases the cause is the wearing of shoes which are too short for the feet. The pressure made upon the toes causes spasm of the plantar flexors and this spasm permits the fascia to contract.

Treatment.—In a paralytic case a shoe is worn containing a plate of steel in the sole, and pressure by a strap is applied over the instep. If equinus exists, tenotomy of the Achilles tendon is indicated. If there is calcaneus, divide the plantar fascia or perhaps transplant the tendons of the peronei and posterior tibial to the os calcis (G. G. Davis, "Amer. Jour. Orthop. Surg.," 1913, xi). The operation of Forbes transplants the tendon of the extensor longus hallucis to the head of the first metatarsal bone. If there is an excessively high bony arch, A. J. Davidson lowers the arch by a cuneiform osteotomy. A combination of these methods is often advisable. In all, if the calf muscles are entirely paralyzed and there is marked calcaneus, perform astragalectomy. In paralytic cases apply electricity and massage to the paralyzed muscles. If there is no palsy, cut with a tenotome the plantar fascia and the tendon of the flexor longus hallucis.

Hallux valgus or **varus,** a displacement of the great toe outward or inward, may occur in the young, but it is most frequent in old persons, especially old women. It arises often from wearing pointed shoes, shoes that are too short, or high heels, but may be due to gout or to rheumatic gout. In many cases an exostosis forms in the inner portion of the distal end of the metatarsal bone. In hallux valgus a *bunion* (bursa) is apt to form over the metatarsophalangeal joint and it may inflame or ulcerate.

Treatment.—An arrangement may be worn to straighten the toe and to protect the bunion (see Fig. 564). The prominent and hypertrophied inner portion of the head of the metatarsal bone may be removed by means of a chisel, osteotomy may be performed upon the metatarsal bone, the joint may be excised (page 650). Amputation should not be done, as it removes the weight-bearing head of the metatarsal bone. H. A. Wilson advocates lateral excision. By means of bone forceps he cuts away that part of the distal extremity beyond the phalanx, and by a chisel removes the remaining sharp line of the edge. He places the phalanx in normal position and holds it so for two weeks ("Amer. Jour. Orthopedic Surgery," Jan., 1906). Davidson cuts away the inner part of the articular facet and the head of the metatarsal bone.

Hammer-toe (Figs. 585, 586) is a condition in which there is flexion of one or more toes at the first interphalangeal joint. Shattuck shows that this condition is due to contraction of "the plantar fibers of the lateral ligaments of the joint."[1] The disease usually begins in youth and may be congenital. A bunion is apt to form, and the joint may become dislocated.

Treatment.—Subcutaneous division of the lateral ligaments and flexor tendon usually allows straightening of the toe. After the operation the toe must be held in extension for several months by means of a short splint and adhesive plaster. Terrier's plan of treatment consists in making a dorsal flap, removing a bursa if one is found, dividing the extensor tendon, opening the articulation, removing each articular surface by cutting forceps, suturing the soft parts, and applying a plantar splint for two weeks.[2] The base of the proximal phalanx may be removed. Some surgeons simply excise the joint. Amputation should not be performed except perhaps in the case of the little toe. Amputation of a toe weakens the foot.

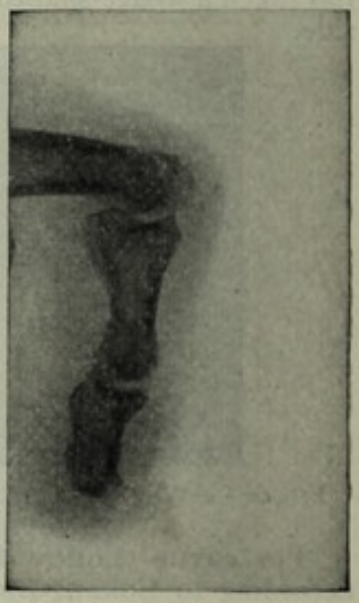


FIG. 586.—*x*-Ray of hammer-toe.

Metatarsalgia (Morton's Disease).—This disease was first described by Dr. Thomas G. Morton, of Philadelphia, in 1876. It is a painful condition of the foot, caused by ligamentous relaxation, which permits the sagging down of the heads of the second, third, or fourth metatarsal bones, two of them or all of them. The anterior (transverse arch) is lost. Morton believed the pain to be due to jamming of a nerve between the heads of the fourth and fifth metatarsal bones. The head of the fifth metatarsal bone is, by lateral pressure, forced against and below the neck of the fourth metatarsal, and as a result the superficial branch of the external plantar nerve and its two digital branches are squeezed. It is usually associated with flat-foot. Loss of the anterior metatarsal arch will jam other nerves than that between the fourth and fifth metatarsals, and will produce a condition similar to Morton's disease, the pain being differently situated. Pain, in Morton's disease, is produced by walking, and the suffering may be so severe that the patient is obliged to sit down at once. When the shoe is removed and the foot is rested the pain soon abates. The pain is felt usually between the fourth and fifth toes and about the head of the fifth and the neck of the fourth metatarsal bones. Pain can be developed by grasping the foot in the hand and squeezing it. If flat-foot exists, there is also pain due to this trouble. The condition is common in golfers and is then called *golfer's foot*.

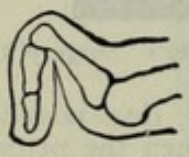


FIG. 585.—Hammer-toe.

Treatment.—Mild cases may be cured by wearing well-fitting shoes and an arch support, the use of hot air, proper exercise, and massage. The shoe should have a small elevation in the sole to restore the metatarsal arch and so relieve lateral pressure on the nerve. Some cases require a brace. Jones puts a block on the sole of the shoe so that the weight will be thrown behind the heads of the metatarsal bones. He also raises the heel 1/3 inch on its inner side, binds a band of adhesive plaster around the base of the metatarsals, directs exercise of the small muscles of the foot, and orders massage. If an early case is treated in this manner a cure will be obtained in a few weeks. In severe cases Morton advised the resection of the fourth metatarsophalangeal joint,

[1] "American Text-book of Surgery."
[2] "Rev. de Chir.," July, 1895.

or amputation of the fourth toe, and with it the head of the fourth metatarsal bone. At the present time *this method* has been discarded. Complete relief can be readily accomplished by the resection of the head of the fourth metatarsal bone. Amputation of the toe is unnecessary. Graham, of Washington, has cured cases by excising a portion of the superficial branch of the external plantar nerve.

Snapping hip, a not very uncommon condition, in which during flexion and extension the head of the bone suddenly slips around the joint. The surgeon and the patient appreciate the slip and may hear a click. In some persons the condition seems natural, can be produced voluntarily, and causes neither pain nor disability. In others it is pathologic. The cause in most cases is slipping of a fibrous band (usually the iliotibial band of fascia lata) over the great trochanter. This condition can be corrected by suturing "the anterior edge of the gluteus" to "the tendinous insertion of the vastus externus and the neighboring periosteum" (Nichols in "Keen's Surgery"). There are several other plans.

In rare cases the posterior rim of the acetabulum is deficient. To cure the tendency to subluxation raise bone and periosteum to raise that part of the rim.

Coxa Vara and Coxa Valga.—Coxa vara (*incurvation* or *infraction of the neck of the femur*—Fig. 587) is a disease characterized by bending of the neck of the femur, the femoral neck being depressed below its normal obtuse angle with the shaft, the



FIG. 587.—Congenital dislocation of the hip on one side and coxa vara on the other.

hip-joint being perfectly healthy, and the condition, as a rule, being unilateral, but sometimes bilateral. This condition was described by Müller in 1889. Coxa vara is first noticed, as a rule, between the thirteenth and twentieth years, and the commonly accepted view has been that the deformity is rachitic, but Kredel has reported 2 congenital cases.[1] Traumatic coxa vara may follow impacted fracture of the neck of the femur in a child. An individual with coxa vara develops a limp, and grows tired after slight exertion, but there is no swelling, no tenderness, and little or no pain. Shortening after a time becomes apparent, the great trochanter can be detected above Nélaton's line, and the head of the bone is in the acetabulum. If the head is in the acetabulum it can be recognized as being there by locating the femoral artery ½ inch below Poupart's ligament and making pressure directly backward at that point. The head, if in place, will be felt. The extremity is adducted and usually rotated outward. Abduction is limited. In some cases in which there is joint irritation all joint motions may be distinctly limited.

In a bilateral case there is lordosis, but shortening may not be detected. Each great trochanter is above Nélaton's line and the head of each bone is in the acetabulum.

Coxa valga is a condition in which the angle of the neck to the shaft of the femur

[1] "Centralbl. f. Chir.," Oct. 17, 1896.

is more obtuse than normal. The neck may assume a position in line with the long axis of the shaft. It occurs particularly in children who have had infantile palsy, but it may be congenital, may occur in rickets and osteomalacia, and after a prolonged period of disuse of a limb. The patient has pain and a limp, the extremity is lengthened, abducted, and in external rotation there is limitation of adduction and the trochanter is flattened. Coxa valga is usually unilateral, but may be bilateral.

Without the *x*-rays the differential diagnosis in coxa vara and coxa valga is often very difficult, and the accompanying table will materially aid in contrasting the conspicuous features of the various conditions with which these two deformities of the neck of the femur may be confounded:

TABLE MODIFIED FROM THAT OF DR. H. AUGUSTUS WILSON

	Hip disease.	Infantile paralysis.	Congenital dislocation.	Psoas abscess.	Coxa vara or valga.	Knee disease.
Age.	Three to fifteen.	Three to fifteen.	Any age.	Three to fifteen.	Any age.	Three to fifteen.
Onset.	Insidious.	Sudden.	From birth.	Insidious.	Childhood.	Insidious.
Pain.	Referred to knee.	None.	None	Referred to abdomen.	None in hip.	In knee.
History.	Tuberculous.	Inflammatory disease.	Limp from birth.	Tuberculous.	Limp.	Tuberculous.
Posture.	Flexion, abduction, external rotation.	Uncontrolled.	Shortening and external rotation.	Flexion, adduction, external rotation.	Great trochanter higher in vara and lower in valga.	Knee flexed.
Muscular rigidity.	Present in all directions.	Absent.	Absent.	In one direction.	None.	About knee.
Temperature.	1 degree high.	Normal.	Normal.	1 degree.	Normal.	1 degree.
Local tenderness.	In hip.	None.	None.	None.	None.	In knee.
Night cries.	Present.	Absent.	Absent.	Present.	Absent.	Present.
Tendency to abscess.	Yes.	No.	No.	Yes.	No.	Yes.
x-Ray.	Diseased focus in hip.	Atrophy.	Alteration in joint.	Normal hip.	Alteration in neck angle.	Normal hip, focus in knee.
Muscular atrophy.	Profound.	Profound.	Absent.	Absent.	Absent.	Profound.

The *x*-rays clearly show the deformed bone in coxa vara and coxa valga.

Treatment.—In coxa vara, as long as bending is progressing, employ rest. When the bone hardens, it may be necessary to perform osteotomy below the trochanters. In coxa valga Galeazzi performs osteotomy through the neck of the femur and allows the trochanter to ascend.

Flail-joints from Infantile Palsy.—In the subacute stage of infantile palsy there is paralysis, but no fever. Neither massage nor electricity are admissible until tenderness has disappeared. Splints are used to antagonize deformity. When the patient is convalescent massage and electricity are of great value and braces are used. After an attack of infantile paralysis involving the entire lower extremity of each side the limbs become limp and swing flail-like when the extremity is made to move, and the joints are much relaxed. In such cases the psoas and iliacus muscles are never completely paralyzed, and the aim of the surgeon is to utilize these muscles in enabling the patient to walk. In many cases the application of apparatus is sufficient. In others ankylosis may be established in the ankles and knees by operation. If ankylosis is established in these joints, the psoas and iliacus muscles become able to move the legs. Tendon transplantations may be performed, tenotomy or osteotomy may be indicated. A joint is stabilized most securely by utilizing as ligaments the tendons of totally paralyzed muscles, attaching them subperiosteally or to the bone and reinforcing by arthrodesis (ankylosis produced intentionally) of the unstable joint or joints (Putti).

XXI. DISEASES AND INJURIES OF NERVES

Diseases of Nerves

Neuritis, or **inflammation of a nerve,** may be limited or be widely distributed (*multiple neuritis*). The first-mentioned form will here be considered. The causes of neuritis are traumatism, wounds, overaction of muscles, gout, rheumatism, syphilis, infection, fevers, and alcoholism.

The **symptoms** of neuritis are as follows: excessive pain, usually intermittent, in the area of nerve distribution. The pain is worse at night, is aggravated by motion and pressure, and occasionally diffuses to adjacent nerve areas or awakens sympathetic pains in the opposite side of the body. The nerve is very tender. The area of nerve distribution feels numb and is often swollen. Early in the case the skin is hyperesthetic; later it may become anesthetic. The muscles atrophy and present the *reactions of degeneration;* that is, the muscles first cease to respond to a *rapidly* interrupted faradic current, and next to one with slower interruptions; faradic excitability diminishes, but galvanic excitability increases. When, in neuritis, faradism produces no contraction, a slowly interrupted galvanic current which is so weak that it would produce no movement in the healthy muscle causes marked response in the degenerated muscle. In health the most vigorous contraction is obtained by closing with the − pole; in degenerated muscles the most vigorous contraction is obtained by closing with the + pole. When voluntary power returns, galvanic excitability declines; but power is often nearly restored before faradic excitability becomes manifest (Buzzard).

The **treatment** of neuritis consists of rest upon splints and the use of an ice-bag early in the case and a hot-water bag later. Blisters over the course of the nerve are of value, especially in traumatic neuritis. Massage and electricity must be used to antagonize degeneration. A descending galvanic current allays pain to some extent. Deep local injections of chloroform or cocain may allay pain. Treat the patient's general health, especially any constitutional disease or causative diathesis. The salicylate of ammonium, aspirin, or phenacetin may be given internally. In some cases nerve-stretching is advisable.

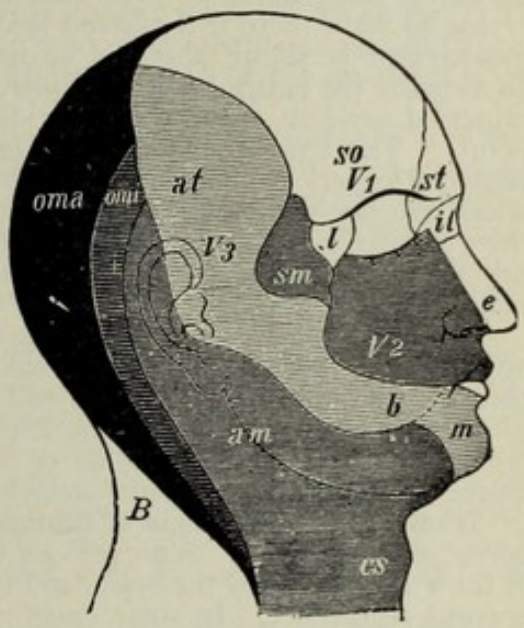


Fig. 588.—Distribution of the cutaneous sensitive nerves upon the head: *oma*, *omi*, The occipit. major and minor (from the N. cervical. II and III); *am*, N. auricular magn. (from N. cervic. III); *cs*, N. cervical. superfic. (from N. cervic. III); V_1, first branch of the fifth (*so*, N. supra-orbit.; *st*, N. supratrochl.; N. infratrochl.; *e*, N. ethmoid.; *l*, N. lachrymal.); V_2, second branch of the fifth (*sm*, N. subcutan. malæ seu zygomaticus); V_3, third branch of the fifth (*at*, N. auriculotempor.; *b*, N. buccinator; *m*, N. mental.); *B*, posterior branches of the cervical nerves (Seeligmüller).

Neuralgia is manifested by violent paroxysmal pain in the trajectory of a nerve. This disease, unless it is exceedingly severe and persistent, is treated, as a rule, by the physician. Injections of alcohol or osmic acid into the nerve may secure relief or cure. If neuralgia is due to adhesions about the nerve or to the pressure of scar or callus, these conditions should be amended surgically. There is some evidence that neuralgia arises, at least occasionally, from dilatation of the vessels of the sheath and subsequent edema and exudation. If this be the case, cure may follow opening the sheath and separating adhesions between the sheath and nerve (Robert M. Simon in "Brit. Med. Jour.," April 10, 1909). Neuralgia of stumps and scars is a surgical condition, and is due to neuromata, or entanglement of nerve-filaments in a cicatrix. *Tic douloureux* and other intractable neuralgias require careful removal of any cause of reflex irritation. Causal reflex irritation may arise from disease of the stomach, eyes, teeth, uterus, nose, throat, etc. Tic douloureux has been treated by removal of the Gasserian ganglion; intracranial neurectomy of the second and third divisions; section of the sensory root; removal of Meckel's ganglion; ligation of the common carotid artery; neurectomy of terminal branches of the fifth nerve; division of motor nerves; injections of osmic acid (see page 718); injections of alcohol (see page 718); advancing doses of strychnin (Dana) and purgatives (Esmarch). The distribution of the fifth nerve, the seat of pain in tic douloureux, is shown in Fig. 588.

Sciatica.—This may be acute or chronic, a neuralgia or a neuritis. It may be an affection of the sciatic plexus, of the lumbar plexus, or of the sciatic nerve. True sciatica is not a neuritis and is a very rare lesion. In most cases sciatica is a symptom. Violent and perhaps long-continued pain in the nerve may be a reflex phenomenon. In 3

of my cases most obstinate and crippling sciatic pain was cured by removing a diseased appendix. In each case the appendix was posterior. It may be due to pelvic disease, to disease or injury of the sacro-iliac joint, the lumbosacral joint or the lumbar articulations, to disease of the rectum, to traumatism, to exposure to cold or damp, to syphilis, or to alcohol.

Exposure to cold causes the rheumatic form. Indiscretions in diet may instigate a gouty form. In some cases of diabetes violent nerve pain is experienced; the same is true of malaria. Sitting long hours on a hard and ill-shaped bench or chair may be responsible ("Jour. Amer. Med. Assoc.," March 18, 1916). Of course focal infection has been blamed (teeth, tonsils, etc.).

Flat-foot causes some cases. Tumor of the nerve or the nerve-sheath causes violent pain. Disease of the cord, nerve-roots, and spine must be sought for. Pelvic tumor may be causal. Attacks of violent pain arise. The pain shoots down the back of the thigh and leg into the foot and is worse at night. Pain is increased by movements, coughing, and sneezing. The patient maintains the extremity in semiflexion. On trying to walk there is a marked limp. The muscles may twitch and jerk. Sensory impairment is slight, there is no paralysis or marked atrophy, herpes is common. In neuritis the entire nerve is tender, there are motor and sensory disturbances, and muscular atrophy is early and decided. In true inveterate sciatica there are tender points. The tender points of Valleix are found in the following regions: 1, Near the posterior superior iliac spine; 2, over the point in the great sacrosciatic notch from which the nerve emerges; 3, at the inferior edge of the great gluteal muscle between the great trochanter and the ischial tuberosity; 4, in the middle of the thigh posteriorly; 5, in the popliteal space; 6, back of the head of the fibula; 7, behind the external malleolus.

Treatment.—Seek for any possible cause of reflex irritation and remove it. Remove any cause of nerve pressure. Treat any existing disease or diathesis. Rigid diet, rest in bed, splinting of the extremity, warmth, application of blisters or the actual cautery over the nerve, and the high-frequency current do good. If the case does not improve, inject salt solution or cocain about the nerve. A very severe and prolonged case may call for nerve-stretching.

Treatment of Neuralgia of Stumps.—Excise the scar; find the bulbous end of the nerve, and cut it off. Senn tells us to section the nerve by V-shaped cuts, the apex of the V being toward the body, and to suture the flaps together. Senn's method will prevent recurrence. In some cases reamputation is performed. In entanglement of a nerve in a scar remove a portion of the nerve above the scar and also the neuroma in the scar.

Wounds and Injuries of Nerves

Section of Nerves (as from an Incised Wound).—After nerve-section sensation and motor power are lost at once. The entire peripheral portion of the nerve degenerates and ceases structurally to be a nerve in a few weeks, but after many months, or even years, the nerve may regenerate. The proximal end degenerates only in the portion immediately adjacent to the section; it rapidly regenerates, and if it does not adhere to the peripheral segment a bulb or enlargement composed of fibrous tissue and small nerve-fibers forms just above the line of section; this bulb adheres to the perineural tissues. The entire distal end degenerates, but new axis-cylinders form in this segment by proliferation of the nuclei on the sheath of Schwann. Union of a divided nerve is brought about by the projection of axis-cylinders from the proximal end and the entrance of these cylinders into the distal end. The nearer the two ends are to each other, the better the chance of union. When a nerve has been divided and has not been sutured, abolition of function may be permanent or restoration may occur. Sensation may return in from six weeks to several months after division. Motor power may never return. If it does return it will be long after sensory restoration. Restoration of motor power requires from twelve weeks to three and one-half years. It is seldom noted before six months. The return is always slow (John B. Murphy in "Surg., Gynec., and Obstet.," April, 1907). Failure of return means that the ends are separated by a wide interval or that fascia is interfused between them. In some recorded cases motion and sensation have returned with great rapidity, due, some have said, to anastomoses with adjacent nerves. Murphy shows that when restoration begins, trophic energy returns even before sensation, and when trophic energy returns the blueness and coldness of the limb lessen.

The nerve-fibers which convey impressions of cutaneous pain and of extreme

heat and cold regenerate far more rapidly than those which subserve sensations of light touch and slight degrees of heat and cold.

The investigations of Head and others show that restoration of sensation does not begin at the normal area and spread from there over the anesthetic area, but that the reverse is the case. It begins from the confines of the anesthetic area and spreads toward the normal part.

General Symptoms.—Immediately after nerve-section vasomotor paralysis comes on, and for a few days the paralyzed part presents a temperature higher than normal. It then becomes blue and cold. Pronounced changes occur in the trajectory of a divided nerve. The muscles degenerate, atrophy and shorten, and develop the reactions of degeneration (page 703). When union of the nerve occurs the muscles are restored to a normal condition. If the nerve contains sensory fibers, complete anesthesia (to touch, pain, and temperature) usually follows its division; but if a part is supplied by another nerve as well as by the divided one, anesthesia will not be complete. Trophic changes arise in the paralyzed parts. Among these changes are muscular atrophy; glossy skin; cutaneous eruptions; ulcers; dry gangrene; painless felons; falling of the hair; brittleness, furrowing, or casting off of the nails; joint inflammations and ankylosis. The diagnosis as to which nerve is cut depends upon a study of the distribution of the motor and sensory paralysis.

A curious fact that was pointed out by Letiévant is that after division of a nerve blunt pressure may be appreciated over the entire analgesic area. This phenomenon was long thought to be due to nerve anastomoses, the sensory areas from different nerves overlapping. The explanation now given is founded on Sherrington's demonstration that the motor branches of a mixed nerve carry sensory fibers through muscles and tendons, and Head's proof that certain afferent fibers convey impressions of deep sensibility as produced by pressure.

The Symptoms of Division of Nerves.—*Brachial Plexus.*—If one or more cords of the brachial plexus are divided, motor paralysis and anesthesia appear in the limb, the extent of the paralysis and the area of the anesthesia depending upon the cord or cords involved. It should be remembered that the inner cord of the brachial plexus gives origin to the ulnar nerve. The inner and outer cords give branches which fuse to form the median nerve. The posterior cord gives origin to the subscapular, the circumflex, and the musculospiral nerves. The outer cord gives origin to the external anterior thoracic and the musculocutaneous, as well as to the outer trunk of origin of the median.

Avulsion or *rupture of the brachial plexus* is sometimes effected by an injury, when the arm is not lost. Most cases are due to indirect violence and are associated with skeletal injury, for instance, dislocation of the shoulder, fracture of the humerus, or fracture of the clavicle (Frazier and Skillern, paper before Section on Surgery, "Amer. Med. Assoc.," 1911). Bristow ("Annals of Surgery," Sept., 1902) reported 3 cases of avulsion of the plexus and collected 24 more. Frazier and Skillern (Loc. cit.) collected 23 cases of avulsion without skeletal injuries and confirmed by operation. In each of these cases the rupture was between the clavicle and the transverse processes of the vertebra. In the case of Frazier and Skillern the rupture was within the dura. The patient was seen by them three months after the accident. He suffered from horrible pain in the arm and hand. Sensations to touch and pain were entirely lost in the hand and forearm and in the arm to 2 or 3 inches above the elbow. From this point to about 4 inches below the shoulder they were much impaired. Sensation was impaired in the entire distribution of the intercostohumeral nerve, and of the fifth and sixth cervical roots, as well as in the distribution of the brachial plexus. There was flaccid palsy of the entire extremity, including the deltoid. On the injured side the pupil was contracted and the palpebral fissure narrowed. One of Bristow's cases was operated upon the third day after the accident (Loc. cit.). In this case there was complete paralysis of the upper extremity, with the exception of the sensory area of the intercostohumeral and the circumflex nerves. The accident had been inflicted by the patient's forearm becoming entangled in a rope, which was pulled upon by a steam winch. On reaching the hospital he felt severe pain referred to the arm. There was mucn swelling in the inner portion of the subclavian triangle, the left pupil was contracted, and it seemed likely that the nerves had been avulsed close to the intervertebral foramina. From the fact that sensation was preserved in the skin of the convexity of the shoulder down to the insertion of the deltoid, Bristow concluded that some fibers of the posterior cord of the plexus had escaped division; but when the operation was performed this conclusion was found to be erroneous. An incision was made,

and it was found that the plexus had given way at the point where the four cervical nerves and the last dorsal unite to form the three trunks. In order to reach the lower ends it was necessary to saw the clavicle and divide the two pectoral muscles; and the torn ends of the nerve-trunks were found underneath the clavicle. Suturing was performed. The ends of the sawn clavicle were sutured together, the wound was closed and dressed, and the arm was put up in Sayre's dressing (Fig. 346).

After the performance of this operation sensation over the entire upper arm returned. The author once operated upon a patient who had developed paralysis, motor and sensory, after violent stretching of the arm. In the light of Bristow's case I assumed that avulsion of the plexus had probably taken place. Incision disclosed the fact that the plexus was intact, but was surrounded with dense scar tissue. The tissue was removed, so as to loosen the nerves, which felt like hard cords; but I have lost track of the patient, and do not know the result. My patient was operated upon many months after the injury. I operated upon another case and found intravertebral rupture. I anastomosed two divided nerves to a sound one. The operation was done months after the injury and the patient is apparently slightly improved three months after operation. The location of the seat of injury is of great importance. Lesion within the vertebræ is positively indicated by contraction of the pupil, narrowing of the palpebral fissure, and enophthalmos on the affected side (Frazier and Skillern, "Amer. Med. Assoc.," 1911), but there can be intravertebral injury without these phenomena. The ciliospinal fibers on which these phenomena depend usually accompany the eighth cervical and first thoracic nerves.

Injury above the clavicle will involve the circumflex and musculospiral. As the great pectoral is supplied from both the external and internal cords of the plexus, complete paralysis of the great pectoral proves that both cords are involved, and unimpaired movements of the diaphragm on the side of the lesion (observed with the fluoroscope) show that the cords of the plexus are not divided within the foramina, but well outside of them (John B. Murphy in "Surg., Gynec., and Obstet.," April, 1907). In all cases of rupture prompt operation is indicated. Long delay means a hopeless prognosis.

In injury without complete rupture the nerves become fibrous and embedded in scar tissue. If operation is done before scar tissue forms follow the advice of Frazier and incise the sheaths of the trunks or cords to liberate inflammatory exudate. If scar tissue has formed, excise it. It may be necessary to excise portions of nerves or trunks with it. If this is done, suture the divided ends together. It may be necessary to do nerve lengthening, *suture à distance*, or grafting in of a nerve from a recently amputated limb (if one can be obtained), or of the sciatic of a rabbit. In accessible rupture suture the divided nerves. In some cases a divided cord or trunk may be anastomosed into a sound one. Ruptures near to, in, or within the intervertebral foramina do not admit of suturing. If a sound nerve is left the distal portion of the divided nerve or nerves should be anastomosed to it. If the entire plexus is ruptured we should consider the plan of Alexinsky (quoted by Frazier and Skillern, Loc. cit.): effect anastomosis between nerves of the injured side and nerves of the sound side. When intractable neuralgia follows rupture the posterior roots may be divided.

Brachial Plexus Palsy.—This can occur in the adult or at birth. In the adult it is due to a fall upon the side of the head or blows over the side and base of the neck (Wm. Sharpe in "Jour. Amer. Med. Assoc.," March 18, 1916). It is rare in the adult. It is far more common as a *birth palsy*. Brachial birth palsy was first fully described by Duchenne in 1872. Erb in 1874 maintained that the lesion was at the junction of the fifth and sixth cervical roots (Erb's point). Brachial palsy may arise after a difficult delivery. In most cases forceps have been used. Seventy per cent. of Sharpe's 56 cases involved the right arm and 28 per cent. the left arm, 78 per cent. followed head presentation, and 22 per cent. breech presentation. In 1905 Whitman pointed out that posterior dislocation of the humerus is frequently associated with the palsy. It is not a congenital dislocation, but results from the relaxation caused by the palsy. It has been pointed out by Clark, Taylor, and Prout ("Amer. Jour. Med. Sciences," Oct., 1905) that brachial birth palsy results from tension on the nerve-trunks by overstretching during delivery, the nerve-sheath first rupturing and then the nerve-fibers. When the sheath ruptures hemorrhage occurs, fibrous tissue forms, and the scar presses on the intact, slightly stretched, or actually lacerated nerve, and prevents repair. The authors tell us that the fifth cervical root first gives way, then the sixth, and so on down the plexus if there be sufficient force. In the milder cases the fifth root alone suffers. They call it *brachial birth palsy*, or *laceration palsy*, and sum up the symptoms

in a severe case as follows: The arm hangs powerless; abduction at the shoulder is impossible because of deltoid and supraspinatus palsy; the forearm is extended and flexion is impossible because of biceps, brachialis anticus, and supinator longus palsy; palsy of the supinator brevis and biceps is responsible for pronation of hand; there is inward rotation of the humerus because of palsy of the supraspinatus, infraspinatus, and teres minor.

In a less severe case in which only the fifth and sixth cervical roots and the suprascapular nerve are involved the upper arm is paralyzed, but in the forearm only the supinators. (On this subject read the admirable study by A. P. C. Ashhurst in "Annals of Surg.," Jan., 1918.)

Klumpke's paralysis is a birth palsy in which the forearm alone is involved.

Brachial birth palsy is manifest soon after its infliction by evidences of pain on handling the extremity, the pain being due to neuritis (authors above quoted). The pupils may be unequal. This means injury to the sympathetic and to the eighth cervical or first dorsal which receive communications from the sympathetic (Sever in "Amer. Jour. Orthop. Surg.," 1916, xiv). The same force which caused the nerve injury may also have caused dislocation of the humerus.

The usual plan of treatment is to reduce a dislocation if it exists and fix the arm in a bandage which elevates the shoulder. This relaxes the injured nerve-roots and so favors union. Sharpe (Ibid.) points out that this plan may be efficient in mild cases in which the roots have been merely overstretched or in which the impairment is due to dislocation. This treatment should be restricted to the mild cases. It is not the proper treatment for a case of "total paralysis of the arm, hand, and fingers." It is true that improvement may occur even in severe cases, but "improvement rarely continues beyond one year of age, and the end-result is an impaired arm of greater or less severity; a useful arm is seldom obtained" (Sharpe, Ibid.). In a case of total paralysis I am convinced we should follow Sharpe's plan and expose the plexus when the child is one month of age. At this early age very little ether need be given, very little fibrous tissue will be met with, the nerve-ends will not have retracted, and the results are always better from early than from late neurorrhaphy.

Posterior (Long) Thoracic Nerve.—Division of this nerve causes paralysis of the serratus magnus muscle, which is made evident by eversion from the thorax and rotation of the scapula when the arm is taken forward (*wing-like scapula*). In paralysis of this muscle the arm cannot be raised above the horizontal.

Suprascapular Nerve.—Division of this nerve produces some anesthesia over the scapula and paralysis of the supraspinatus and the infraspinatus muscles. The supraspinatus is but an adjuvant to the deltoid and palsy of it is not manifestly disabling. Palsy of the infraspinatus renders external rotation of the humerus impossible, and writing becomes most difficult because the pen cannot be moved along the paper. Sewing, too, is greatly interfered with.

Circumflex Nerve.—Division of the circumflex nerve produces paralysis of the deltoid muscle, so that it becomes impossible to lift the arm to a right angle with the body. There is some slight retention of power in the anterior fibers, which are supplied by the anterior thoracic nerve. The skin over the lower part of the muscle is usually anesthetic.

Musculocutaneous Nerve.—Division of this nerve produces paralysis of the biceps and of the brachialis anticus muscles (paralysis of the forearm flexors). This palsy becomes especially evident when the forearm is supinated, because in this position the supinator longus can no longer act as a flexor of the elbow. There is anesthesia of the radial side of the forearm anteriorly and posteriorly.

The Musculospiral or Radial Nerve.—Division of this nerve high up near the plexus causes paralysis of the extensor muscles of the elbow and the wrist, of the supinators, and of the long extensors of the thumb and fingers. When divided near the middle of the humerus, the triceps usually, but not invariably, escapes. If the injury is below the branch going to the supinator longus, that muscle will escape; otherwise it will become paralyzed. The extensor palsy causes wrist-drop and loss of the power of extending the first phalanges of the fingers and thumb; and, as Gowers has pointed out, flexion is reduced to one-third of the normal, the flexors having lost power "from the loss of antergic support." As a rule, in musculospiral palsy there is loss of supination. Sensibility is sometimes greatly affected, and sometimes very slightly. If the injury is above the level of the musculospiral groove there will be anesthesia in the area supplied by the sensory fibers of the nerve (Fig. 589). If the nerve is injured in the musculospiral groove there are seldom sensory disturbances. Anesthesia rarely

occurs in the upper arm in any case, and even after an injury in the groove sensation in the hand may be normal or nearly so. Figure 590 shows the position of the hand and fingers in musculospiral palsy and Figs. 589 and 591 the sensory distribution of the nerve. Fracture of the humerus may cause division of the musculospiral nerve.

The Median Nerve.—After division of this nerve there is paralysis of the pronators; the flexor carpi radialis; the finger flexors, except the ulnar portion of the deep flexor; the abductors, and the flexors of the thumb; and the two radial lumbricales. The forearm can be placed in a position midway between pronation and supination, but further pronation cannot be voluntarily affected. In executing flexion of the wrist a strong deviation toward the ulnar side takes place. The thumb is in a position of extension and abduction, and cannot be brought into apposition with the finger-tips.

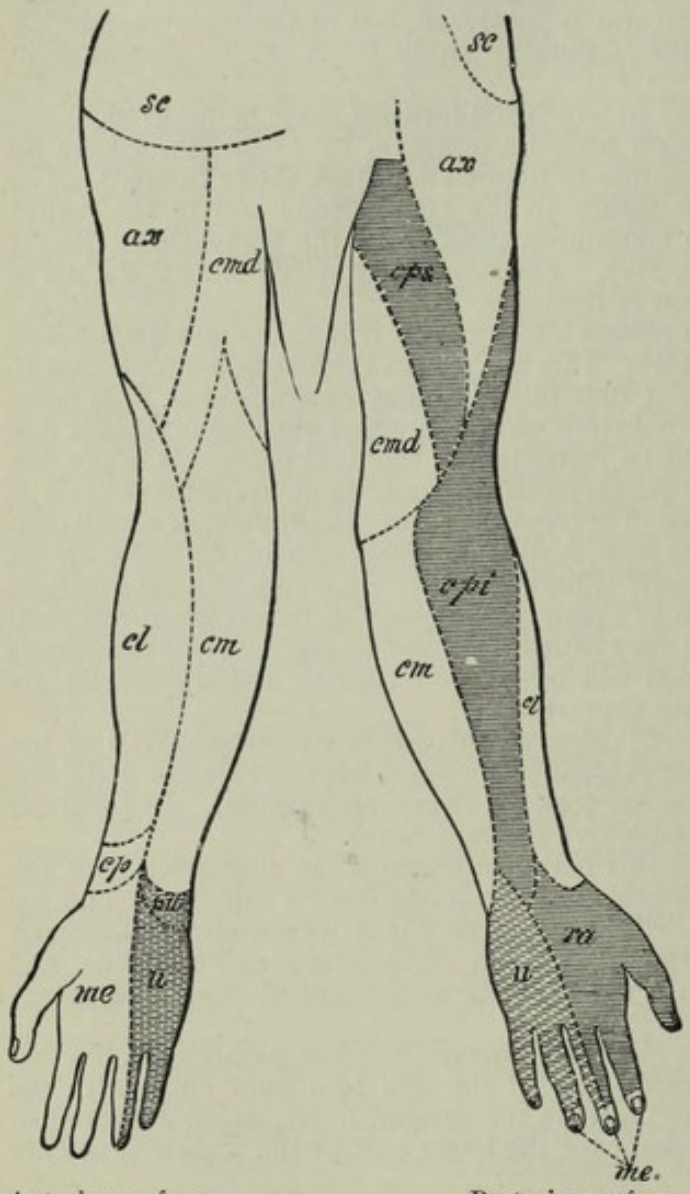


FIG. 589.—Distribution of the cutaneous nerves to the shoulder, arm, and hand. The region of the N. radialis is represented by the unbroken hatched line, that of the N. ulnaris by the broken hatched lines. *a*, Anterior, *b*, posterior surface; *sc*, Nn. suprascapular (plexus cervicalis); *ax*, chief branch of N. axillar.; *cps*, *cpi*, Nn. cutanei post. sup. and inf. (from N. radialis); *ra*, terminal branches of N. radialis; *cm*, *cl*, Nn. cutanei medius (also to the plexus) and lateralis (chiefly to the N. medianus); *cp*, N. cutan. palmar., N. rad.; *cmd*, N. cutan. medialis; *me*, N. medianus; *u*, N. ulnaris; *epu*, N. cutan. palm. ulnaris (Henle).

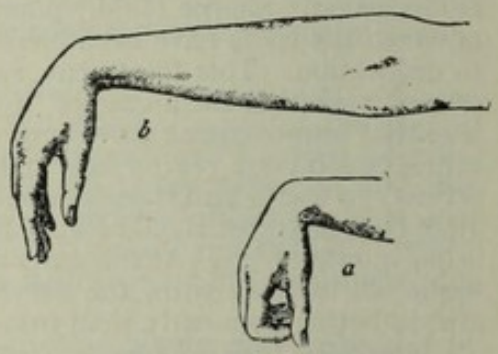


FIG. 590.—Paralysis of musculospiral nerve after fracture of the humerus ("wrist-drop"); but when fingers have been flexed into palm, *a*, they can be extended, *b*, at first interphalangeal joints by lumbricalis and interossei, which are supplied by the ulnar and median nerves (Erichsen).

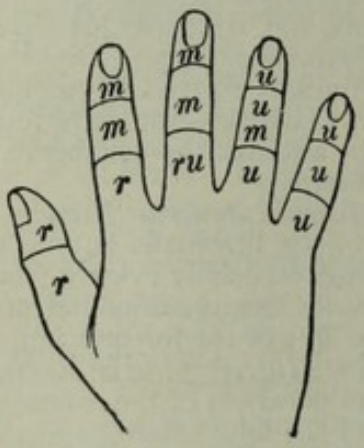


FIG. 591.—Distribution of sensory nerves on the backs of the fingers: *r*, Musculospiral or radial nerve; *u*, ulnar nerve; *m*, median nerve (Krause).

The second phalanges of the fingers cannot be flexed on the first, and the distal phalanges of the first and second fingers cannot be voluntarily flexed. The corresponding phalanges of the third and fourth fingers can be flexed, this being accomplished by the unparalyzed ulnar half of the deep flexor. Flexion of the first phalanges is still possible, as it is accomplished by means of the interossei. The extensor action

of the interossei muscles upon the middle and distal phalanges, being unopposed, may eventually cause subluxation. The sensory distribution of the median nerve is shown in Figs. 589, 591–593. It is the sensory nerve of the radial side of the palm, the front of the thumb, the first and second fingers and half of the third finger, and the back of the last phalanx of the index- and the middle finger (Gowers). The sensory changes after median paralysis are quite variable—sometimes wide-spread and complete, at other times trivial, and occasionally absent. Gowers says that if there is

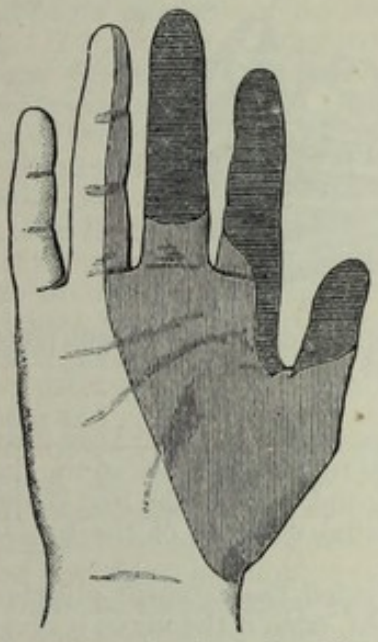


FIG. 592.—Section of median nerve; areas of anesthesia (heavy shading) and of dysesthesia (light shading) on palmar surface of hand (Bowlby).

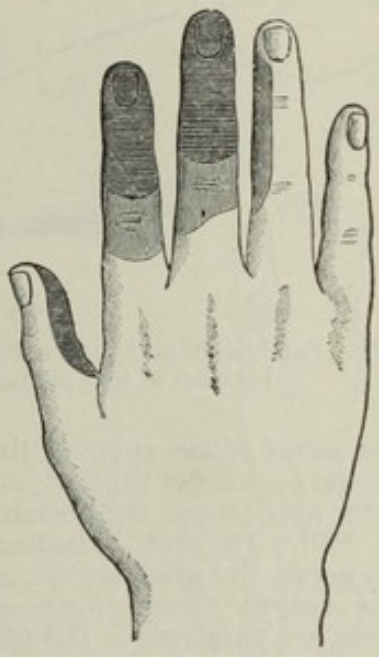


FIG. 593.—Section of median nerve; regions of anesthesia and dysesthesia on dorsal surface of hand (Bowlby).

anesthesia it is usually of the palmar surface, but it may also occur on the dorsal aspect of the ends of the first two fingers.

The Ulnar Nerve.—When this nerve is divided there is paralysis of the flexor carpi ulnaris, of the ulnar portion of the deep flexor, of the muscles of the little finger, of the adductor pollicis, and of the inner end of the flexor brevis pollicis. It becomes impossible to adduct the thumb, and the majority of the movements of the little finger are abolished. Flexion of the fingers is impossible at the first joints, and extension is impossible at the other joints; but, as Gowers points out, the loss is slighter in

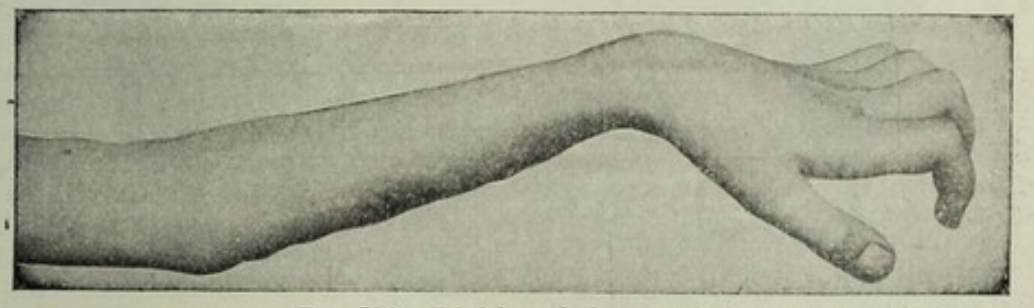


FIG. 594.—Division of ulnar nerve.

the first two fingers than in the others because the lumbricales of the first two fingers are supplied by the median nerve. Interosseal flexion is impossible, and the opponents of the interossei, acting without normal antagonism, contract and produce what is known as *claw-hand* (Figs. 594, 595), a condition in which the first phalanges are over-extended and the others are flexed. Adduction and abduction of the fingers cannot be performed. There is wasting of the thenar and hypothenar eminences and in the interosseous spaces. The sensory loss in ulnar paralysis is extremely variable. The sensory distribution is to the ulnar side of the hand, both back and front, involving the little finger, the ring-finger, and the ulnar half of the middle finger on the dorsal

surface; the little finger and the ulnar half of the ring-finger on the palmar surface (Figs. 589, 591, 596, 597).

The *lumbar plexus* supplies the cutaneous surface of the lower portion of the abdomen, of the front and the sides of the thigh, and of the inner portion of the leg and foot (Fig. 598). It innervates the flexors and adductors of the hip-joint, the extensors of the knee, and the cremaster muscle. The branches sent to the leg are the obturator and the anterior crural nerves.

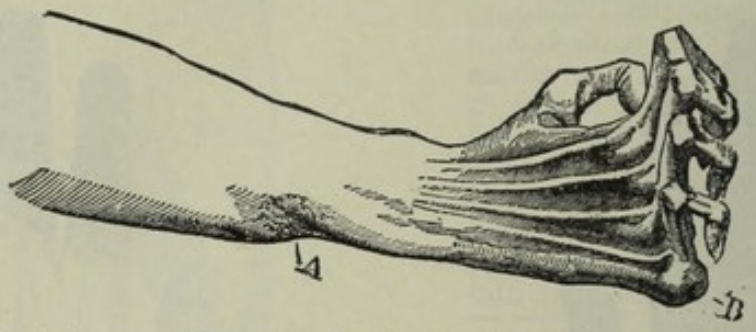


FIG. 595.—Paralysis of ulnar nerve from wound at *A*; contracture of common extensor with posterior luxation of first phalanges; *B*, head of metacarpal bone (Duchenne).

The *sacral plexus* supplies the extensors and rotators of the hip, the knee-flexors, and all the muscles of the foot; also the skin of the gluteal region, the back of the thigh, the outer portion and the posterior part of the lower leg, and most of the foot (Gowers—Fig. 599). Its chief branches are those to the external rotators of the hip—the gluteal nerve, the small sciatic, and the great sciatic.

The Anterior Crural Nerve.—When this nerve is divided the extensor muscles of the knees are paralyzed. The psoas muscle is not affected, even if the nerve is divided within the abdomen; but high division may produce paralysis of the iliacus muscle.

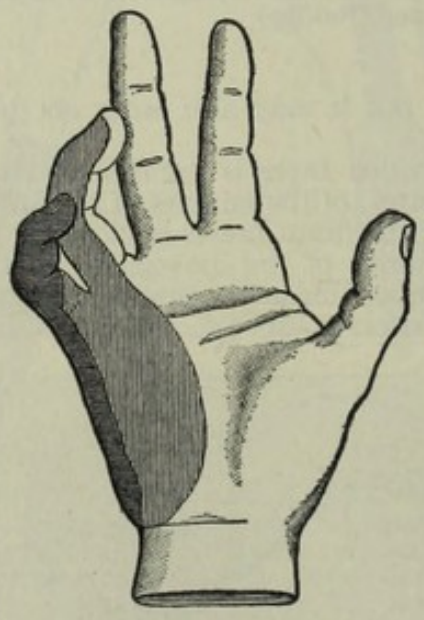


FIG. 596.

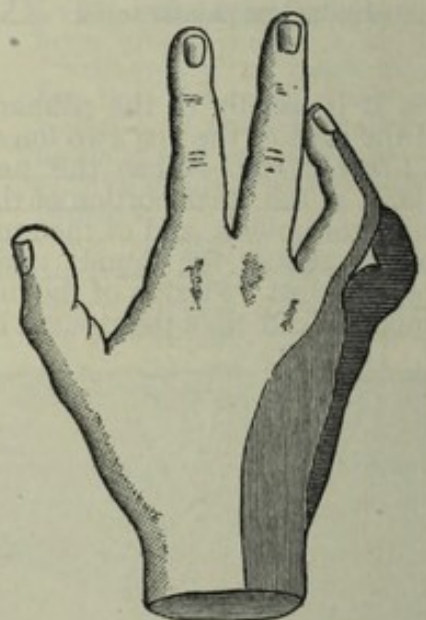


FIG. 597.

FIGS. 596, 597.—Showing sensory loss and ordinary position in injuries of the ulnar nerve (Bowlby).

In anterior crural palsy the skin is anesthetic over almost the entire thigh, the inner surface of the leg and foot, and the inner sides of the first and second toes (Fig. 598).

The Obturator Nerve.—In obturator palsy the adductor muscles of the thigh are paralyzed, and, in consequence, the patient is unable to cross one leg over the other. Gowers points out that external rotation of the thigh is also interfered with (Fig. 599).

The Superior Gluteal Nerve.—The division of this nerve paralyzes the gluteus medius and the gluteus minimus muscles, and there is "loss of abduction and circumduction of the thigh" (Gowers).

The Small Sciatic Nerve.—Division of this nerve paralyzes the gluteus maximus

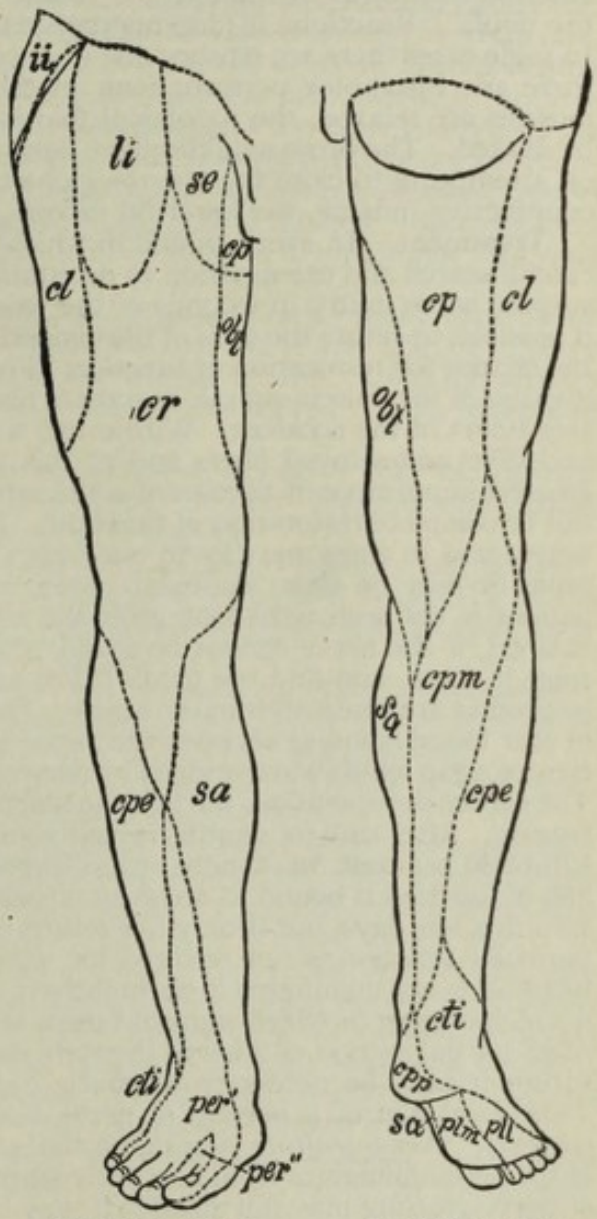
muscle and produces anesthesia of the upper half of the calf of the leg and of the middle third of the back of the thigh (Gowers—Fig. 599).

The Great Sciatic Nerve.—If this nerve is divided near the sciatic notch there will be paralysis of the flexor muscles of the leg. These muscles, as Gowers points out, are also extensors of the hip. There is likewise paralysis of all the muscles below the knee. If, however, the injury is below the upper third of the thigh, there will be no paralysis of the flexors of the leg. If the nerve is damaged on a level below the small sciatic, there will be anesthesia of the outer portion of the leg, of the sole of the foot, and of most of the dorsum of the foot (Figs. 598 and 599).

The External Popliteal Nerve.—When this nerve is divided, there will be paralysis of the tibialis anticus muscle, the extensor longus digitorum, the extensor brevis digitorum, and the peronei; and the patient will be unable to flex the ankle and extend the first phalanges of the toes. When he tries to walk he cannot lift the foot from the ground; and eventually there will be the development of talipes equinus (Gowers). The anesthesia is manifest on the outer portion of the anterior surface of the leg, and also on the dorsum of the foot (Fig. 598).

The Internal Popliteal Nerve.—Damage to this nerve paralyzes the posterior tibial muscle, the flexor longus digitorum, the muscles of the calf, the popliteus muscle, and the muscles of the plantar surface of the foot. The toes become flexed at the two distal joints, and extended at the proximal joints. Walking is greatly interfered with. There is loss of the power of rotating the flexed leg inward, if the damage is above the branch to the popliteus muscle; and extension of the ankle-joint is lost. As the consequence, talipes calcaneus develops (Gowers). The anesthesia is variable, but usually involves the sole of the foot and the outer surface and lower portion of the back of the leg (Fig. 599).

The Plantar Nerves.—Division of the internal plantar nerve paralyzes the short toe flexor, the two inner lumbricales, and the plantar muscles of the great toe, except the adductor (Gowers). There will be anesthesia of the inner portion of the sole of the foot and of the plantar surface of the three inner toes and of half of the fourth toe (Fig. 599).



Anterior surface. Posterior surface.

FIGS. 598, 599.—Distribution of the cutaneous nerves of the lower extremity: *ii*, N. ilio-inguinal. (plex. lumb.); *li*, N. lumbo-inguinal. (to the genitocrural, plex. lumbal.); *se*, N. spermat. ext. (to the genitocrural); *cp*, N. cutan. post. (plex. ischiad.); *cl*, N. cutan. lateral. (plex. lumb.); *cr*, N. cruralis (plex. lumbal.); *obt*, N. obturator. (plex. lumb.); *sa*, N. saphen. (plex. lumbal.); *cpe*, N. commun. peron. (N. peron. tibial.); *cti*, N. commun. tibial; *per'*, *per''*, N. peronæi ram superfic. et prof.; *cpm*, N. cutan. post. med. (plex. ischiad.); *cpp*, N. cut. plant. propr. (N. tib.); *plm*, *pll*, N. plantar. medial. et lateral. (N. tib.) (Henle).

Division of the external plantar nerve causes paralysis of the muscles of the little toe, of the adductor of the great toe, of all the interossei, of the two outer lumbricales, and of the flexor accessorius (Gowers). There will be anesthesia of the skin of the outer half of the sole of the foot, of the little toe, and of half of the fourth toe (Fig. 599).

The Facial Nerve.—This nerve may be divided during the mastoid operation or

may be lacerated by a fracture of the petrous portion of the temporal bone, and a peripheral palsy results. The face is asymmetric and is drawn to the sound side. Asymmetry becomes more marked on attempting to smile or to show the teeth. Whistling and frowning are impossible. The sense of taste may be less acute or lost on the anterior two-thirds of the tongue. There is relaxation of the palate and deviation of the uvula. Reactions of degeneration can be demonstrated in the palsied muscles. In some cases there are sensory disturbances (hyperesthesia or anesthesia) and in some there are vasomotor perturbations on the palsied side. On the paralyzed side the muscles are relaxed, the nasolabial fold is to a great extent gone, the nostril cannot be dilated. The brow wrinkles have been smoothed out, the eyelids cannot be closed; on attempting to close the eye the globe tilts upward and outward. The cornea and conjunctiva inflame, the lower lid droops, and tears run down the cheek.

Treatment.—In every wound in which a nerve or nerves might be damaged make careful search and examination to determine whether such damage is present. Always suspect nerve injury in wounds of the wrist. In all recent cases of nerve-section try, if possible, to suture the ends of the divided nerve. The earlier suture is done, the better the chance for restoration of function. For instance, in fracture of the humerus, with division of the musculospiral, operate at once. Primary suture is suture within twenty-four hours of the accident. Within two weeks of the injury it is possible to recognize and save undestroyed fibers and at this period suture is easy. After-care is of the greatest importance in all cases of nerve suture. Suturing may fail. There may be partial or complete restoration of function. In 123 reported cases of *primary suture*, 119 were cured in from one day to one year (Willard). The return of sensation may be rapid or may be slow; muscular power returns more slowly than sensation. If the patient is not seen until long after the accident, incise and apply sutures (*secondary sutures*); if the nerve cannot be found, extend the incision, find the trunk above and trace it down, and find the trunk below and follow it up. The results are not nearly so good as are those of primary suture. Long after the accident a considerable amount of scar tissue is found between the nerve ends; this must be removed and the removal creates a gap which when bridged by nerve suture is responsible for tension on the nerve. The earlier the operation, the less the scar tissue, the narrower the gap, and the less the tension. After-care for months is highly important. In 130 reported cases of secondary suture 80 per cent. were more or less improved (Willard). Even after primary suture loss of function is bound to occur for a time. After secondary suture sensation may return in a few days, but it may not return until after a much longer period; in any case muscular function is not restored for months. It is usually stated that if return of function is not manifested in six months it will not occur, but Müller performed a radial nerve operation in which signs of return of function were not noted for eleven months. After partial section of a nerve the ends should be sutured. In performing secondary suture it may be necessary to effect *lengthening* in order to approximate the ends. *Transplantation* of a portion of nerve is sometimes practised (*implantation* or *anastomosis*). *Nerve-grafting* is bridging the gap by means of a portion of nerve from one of the lower animals or from a recently amputated human limb. Nerve transplantation or nerve grafting may fail utterly; it may be followed by great improvement, but absolute and perfect restoration of function cannot be obtained. R. Peterson[1] has made a study of the 20 recorded cases of nerve-grafting; 8 of the operations were primary and 12 were secondary. The periods after the injury at which operation was performed varied from forty-eight hours to a year and a quarter; 4 of the 8 primary cases improved; 8 of the 12 cases of secondary operation showed improvement in motion or sensation. The distance between the nerves did not seem to affect the results. No cases recovered completely, but in 1 case sensation returned completely and only the abductors of the thumb remained weak. In most of the cases that were benefited sensation returned by the tenth day and motion within two and a half months. In one of the successful cases, that of A. W. Mayo Robson,[2] the spinal cord of a rabbit was used. A facial nerve divided in the aqueduct of Fallopius may perhaps be sutured at the site of the injury. This should be attempted as soon as the palsy is observed, as was suggested, I believe, by Frederick Sydenham ("Brit. Med. Jour.," May 8, 1909). If the ends of the divided nerve cannot be approximated, *suture à distance* may be practised, as was done successfully by Sydenham (Ibid.). If suture at the site of injury is impossible the end of the peripheral segment of the divided nerve may be anastomosed to the hypoglossal, glossopharyngeal, or spinal accessory nerve (see page 715).

[1] "Amer. Jour. Med. Sciences," April, 1899.

[2] Ibid.

Pressure upon nerves may arise from callus, scars, a dislocated bone, a tumor, or an external body (a crutch).

The **symptoms** may be anesthetic, paralytic, or trophic.

The **treatment** is as follows: Remove the cause (reduce a dislocated bone, chisel away callus, excise a scar, etc.); then employ massage, douches, exercise, and electricity.

Dislocation of the Ulnar Nerve at the Elbow.—This condition is very rare. It may occur as a complication of a fracture or a dislocation, or as an uncomplicated condition. It may be produced by violence or by muscular effort, which ruptures the fascia, the function of which is to retain the nerve back of the inner condyle of the humerus. In some cases the symptoms are slight and transitory, the nerve functionating well in its new situation. As a rule, there are pain, numbness, or anesthesia of the ulnar trajectory, some stiffness of the elbow, and stiffness of the little finger and ring-finger. The nerve can be felt in front of the inner condyle of the humerus. In some cases neuritis follows, with trophic changes.

Treatment.—Expose the nerve by an incision, incise the fibrous tissue back of the inner condyle, and press the nerve into the bed prepared for it and hold it in place by sutures of chromic catgut passing through the triceps tendon. Wharton advises suturing also "the margin of the fascial expansion of the triceps tendon superficial to the nerve."[1]

Contusion of Nerves.—The symptoms of contusion of nerves may be identical with those of section. Sensation or motion, or both, may be lost. The case may recover in a short time, or the nerve may degenerate as after section.

The **treatment** at first is rest, and later electricity, massage, friction, and douches.

Punctured Wounds of Nerves.—The symptoms of punctured wounds of nerves may be partly irritative (hyperesthesia, acute pain, and muscular spasm) and partly paralytic (anesthesia, muscular wasting, and paralysis).

The **treatment** after the puncture has healed is the same as that for contusion.

Gunshot Wounds of Peripheral Nerves.—There were many nerve injuries in the World War. On the whole, the results of treatment were disappointing.

The nerves most commonly injured are the musculospiral and ulnar, next to them comes the median, and next the sciatic and the external popliteal.

A bullet may split a nerve longitudinally, dividing few or no fibers—may partially divide or completely sever a nerve. It may simply open a sheath. The resultant scar is a *lateral neuroma*. A bruise by a bullet, or the passage of a bullet near a nerve may cause a complete physiologic interruption which for days or even weeks cannot be distinguished from anatomic interruption (page 713). If the interruption has been physiologic and not anatomic, function will show positive evidences of restoration in a few weeks. Moynihan says we cannot tell before operation if the nerve was or was not divided ("American Addresses"). When a bullet actually strikes a nerve it produces wide damage to the nerve trunk and much fibrous tissue forms. The fibrous tissue which forms between the ends of a divided nerve is a *terminal neuroma*.

If a nerve is injured and pus forms the scar is sure to be enormous and densely hard. A dense scar may cause frightful pain. It is sure to do so in the median nerve.

If a bone has been broken by a bullet, splinters of bone may be driven about and into the nerve. The nerve may grow first to the broken bone or callus may press upon the nerve. Either condition produces violent pain. An intraneural scar may be responsible for pain or palsy. It is called a *central neuroma*.

If early suturing were always possible the results would doubtless be much better. But it is seldom that a surgeon knows a nerve has been completely divided. There is often a very grave associated injury of bone, soft parts, or both. The wound must be regarded as infected and suture in a purulent area would be bound to fail. Most of the operations have been done after cicatrization of the wound.

The operation may show no lesion, may show an uncut nerve in a scar, may show a partly divided or a completely divided nerve in a scar.

In some cases even on exposing the nerve we cannot be sure it is divided (Quénu). The hard mass of scar between the ends may be the shape and size of the nerve trunk. Tuffier has been so disappointed with resection of the scar and suturing that he now simply liberates the nerve from the surrounding scar and surrounds it with a sheath. He leaves a bridge of scar the shape and diameter of the nerve and hopes it may be canalized by nerve-fibers. Stoffel not only removes the perineural scar but also the

[1] A report of 14 cases of dislocation of the ulnar nerve at the elbow, by H. R. Wharton, "Amer. Jour. Med. Sciences," Oct., 1895.

endoneural scar by gently separating the nerve tracts longitudinally. English surgeons believe in suturing (see Neurorrhaphy).

Moynihan's rules are as follows ("American Addresses"): Operation is decided upon:

1. In cases of complete division.
2. In cases of incomplete division where progress ceases.
3. Where there is severe neuralgic pain (*causalgia*).

Operation is deferred:

1. For one month after closure of the wound if the soft parts only were injured.
2. For two or three months after complete closure if bone was involved.
3. Definitely so long as evidences of progressive restoration are found.

Operations Upon Nerves

Neurorrhaphy, or Nerve Suture.—When a nerve has been completely or partially divided by accident it should be sutured at the first possible moment. Round needles are used. If there is no tension the best suture material is fine plain catgut; if there is any tension, lightly chromicized catgut (Sherren, in "Brit. Med. Jour.," Jan. 15, 1910). Sherren points out that if silk or linen is used it interferes with complete recovery and may cause symptoms months after the operation. In primary suture render the part aseptic. Formerly I used the elastic band to secure a bloodless field. Lately I have given it up. It may damage the divided nerve or other nerves and may be followed by oozing of the blood between and about the nerve ends. Enlarge the incision if necessary. Handle the nerve as little as possible and do not raise it from its bed for any considerable distance. If the ends can be approximated readily, pass two or three sutures through the sheath and connective tissue outside, and tie them (Figs. 600, 601). If the ends cannot be approximated, stretch each end and then suture. The sutures do not traverse the nerve, but go through the perineurium and adjacent connective tissue. If the nerve is found partially divided the cut fibers are sutured in the same way and the undivided portion is folded upon itself so as to permit approximation. Suture the deep fascia. Arrest bleeding, suture the skin, dress antiseptically, and put the muscles supplied by the injured nerve in a relaxed position and fix the limb on a splint. After union of the wound continue the use of the splint to

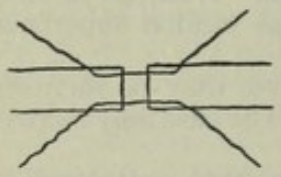


Fig. 600.—Nerve suture.

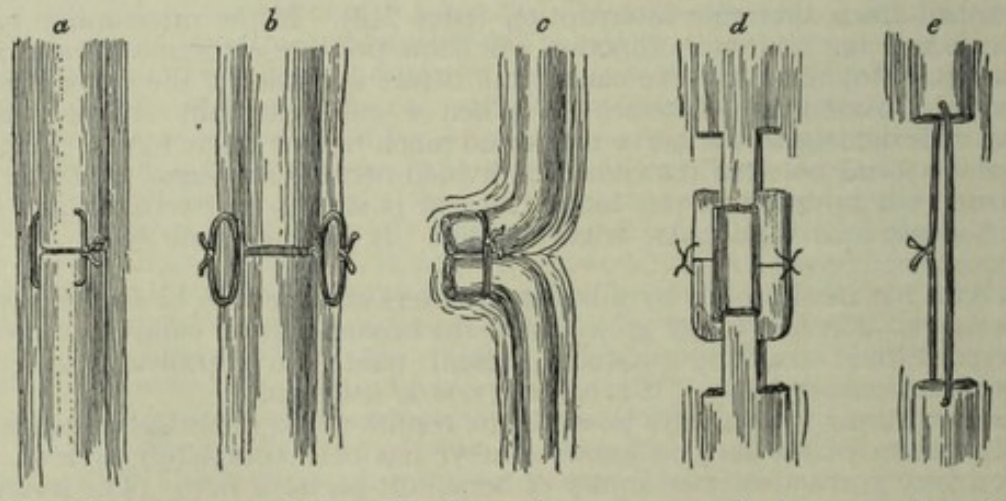


Fig. 601.—Nerve suture: *a*, Direct; *b*, perineurotic; *c*, paraneurotic; *d*, *e*, neuroplasty (Senn).

maintain muscular relaxation as long as the muscles are paralyzed (Ibid.), and use massage, friction, electricity, and the douche. When voluntary power returns remove the splint and insist on active exercise. The operation in some instances fails, but in many cases succeeds. In some few cases sensation returns in a few days, but in most cases does not return for many weeks or months. Sensation is restored before motor power. After successful suturing of a divided median nerve sensations of skin pain and of extreme heat and cold appeared in fifty-six days and were restored in two hundred and seven days. Sensations of light touch and slight degrees of heat and cold appeared in two hundred and sixty days and were not completely restored for one year (Kenneth A. J. Mackenzie in "Annals of Surg.," July, 1909). *Secondary suture* is

performed upon cases long after division of a nerve. If operation is not done for three years or more after division it is very improbable that complete regeneration will ever occur, and yet it is always worth trying, for muscular control has been regained after suturing in 1 case twenty-nine years subsequent to nerve division (Alfred S. Taylor in "Jour. of Orthopedic Surg.," Nov., 1908). An elastic band is not used. An incision is made. The nerve trunk is looked for and identified above and below the point of division. The bulbous upper end is easily found, the wasted lower end is much more difficult to locate. The perineural scar is dissected from the nerve by a very sharp knife, scrupulous care being taken to save the nerve from injury, and to avoid squeezing, pulling, twisting, and lifting the nerve extensively from its bed.

The bridge of fibrous tissue between the ends is examined. If the distance between the ends is considerable, gently stretch each end by making traction up and down on the fibrous bridge. Moynihan ("American Addresses") says: "The fibrous band is now split longitudinally, and then its ends are divided above in one direction, below in the other, so that to each cut end of nerve a fibrous tag is attached by means of which the nerve ends can be drawn together." "Progressive transverse cuts are now made into the nerve-cells until on the cross-section nothing but nerve-fibers are seen. Even the tiniest particle of fibrous tissue must be removed or the operation will fail."

If in spite of the preliminary stretching approximation is not possible some surgeons adopt the expedient shown in Fig. 601, *d*, or that portrayed in Fig. 602. This operation is *neuroplasty* by the *flap method*. Another method is to make a bridge of strands of catgut running from one divided end to the other. We speak of this plan as *suture à distance* (Fig. 600, *e*). The catgut bridge is thought to support the growing reparative material. It does not seem possible to me that either neuroplasty or *suture à distance* can be of any service. In fact, Sir Berkeley Moynihan says of them that they "are methods with nothing whatever to recommend and with everything to discredit them" ("American Addresses"). Allis suggested shortening the limb by resecting a piece of bone and then getting the ends of the nerves together. This has been done successfully by Keen, Rose, and others.

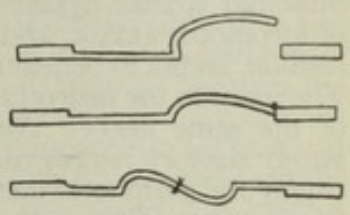


FIG. 602.—Suture of a nerve by splitting the ends (Beach).

Guelliot suggested *tubulization* after all operations of nerve suture, that is, erecting barriers along the path of reparative material to save the ends of the nerve from cellular invasion from the perineural structures, which would deviate the new nerve-fibers and would block repair. Even a blood-clot might prevent repair. Tubulization is supposed to guide and protect the new fibers. Vanlair uses a piece of recently removed blood-vessel or surrounds the ends with decalcified bone. Payr uses a tube of absorbable magnesium. Hashimoto and Toknoka use a vein or artery from a recently slaughtered calf, hardened in formalin. Edinger uses a bit of artery filled with agar jelly.

Gelatin tubes have been used, silver-foil has been tried, and Cargile membrane has been employed. None of these plans is entirely satisfactory. Murphy covers the line of nerve suture with fascia, muscle, or fat. In regions where he cannot obtain suitable covering tissue he wraps about the suture line a material composed of equal parts of paraffin and oil of sesame. This mixture can be flattened out very thin ("Surg., Gynec., and Obstet.," April, 1907).

I used to surround the nerve with Cargile membrane, but abandoned the practice, and do not surround the ends of the nerve with any protective.

Sir Berkeley Moynihan ("American Addresses") questions the value of surrounding the nerve with any protective material, says that such procedures are sometimes harmful, that they prevent free access of blood, and cause adhesions and compression of the nerve. He advises us to avoid all such membranes and simply to be certain that "the nerve is laid along the path of uninjured tissues."

Implantation or *anastomosis* is employed in some cases. In this operation the distal end of a palsied nerve is inserted into an adjacent nerve of like or similar function. Letiévant attaches the peripheral portion of a divided nerve into a longitudinal slit in a sound nerve (*end-to-side anastomosis*). Some surgeons have implanted both ends into a sound nerve, either splitting the sound nerve or leaving it unsplit.

Moynihan (Ibid.), in speaking of nerve anastomosis, says: "All such procedures are worthless and cannot be too strongly condemned. I have never seen any good come of them; indeed, nothing but harm could conceivably result from section of a healthy nerve." This view seems too radical. The operation of anastomosis is

employed after an exsection which leaves a very large gap, for facial palsy, for infantile palsy, for avulsion of the brachial plexus, and for brachial birth palsy.

Nerve-grafting is practised by some. A. W. Mayo Robson used the spinal cord of a rabbit to fill a gap between the ends of the divided median nerve of a man. The restoration of function was almost complete. Some surgeons have grafted in a bit of nerve obtained from a recently amputated limb. It makes no difference whether the grafted nerve is motor, sensory, or mixed. The results of grafting are seldom good. Some use as a graft a bit of cutaneous nerve, for instance, the radial, the internal cutaneous of the thigh, or an intercostal nerve. Chas. A. Powers ("Transactions of the American Surgical Assoc.," 1904) collected 22 cases from literature, 20 from Peterson's paper, 1 case of Durante's, and 1 of his own. In this series there were 3 good results and 3 "fair" results. Robson ("Brit. Med. Jour.," Jan. 27, 1917) reports another striking case of nerve-grafting. All the nerves supplying the forearm except the musculospiral had been cut seven months before. The gap between the ends of the ulnar was bridged by a part of the sciatic nerve of a rabbit. The gap between the ends of the median was bridged by a part of the rabbit's spinal cord. In eleven days sensation began to return. Complete restoration, motor and sensory, was obtained in six months. The bit of nerve grafted does not participate in repair—it is a mere bridge, and acts as would the *suture à distance* if it worked.

If a divided nerve cannot unite, tendon transplantation may be practised. "Tendon transplantation, especially in the case of the musculospiral nerve and the posterior interosseous, gives results which, in point of function, are almost as good as those which come from nerve suture and in point of time are much quicker."

Neurectasy, Neurotomy, and Neurectomy.—*Neurectasy*, or nerve-stretching, may be applied to motor, sensory, or mixed nerves. A nerve can be stretched about one-twentieth of its length. Neurectasy has been employed for neuralgia, neuritis, muscular spasm, hyperesthesia, anesthesia, painful ulcer, perforating ulcer, the pains of locomotor ataxia, and many other conditions. The operation, which was once the fashion, seems to benefit some cases, but it is not now thought so highly of as formerly. The incision for neurectasy is identical with the incision for neurectomy or neurotomy of the same nerve. *Neurotomy*, or section of nerve, is performed upon small and purely sensory nerves (in spasmodic wry-neck a motor nerve is cut). It is performed chiefly for peripheral neuralgia or for some other painful malady. It is almost useless in painful conditions, because sensation, as a rule, soon returns. Paget saw complete return of sensation in four weeks after division of the median nerve. Corning endeavors to prevent this regeneration by inserting oil between the ends. He uses oil of theobroma containing enough paraffin to make the melting-point 105° F. The oil is melted, is injected around the nerve, and cold is applied. The nerve is now sectioned with a canaliculated knife, the ends are separated widely, more oil is injected, and cold is again applied. The theory is that this oil, which is solid at the temperature of the body, devitalizes the nerve at the point of section and acts as a barrier to the passage of regenerating fibers. This method has been applied especially in cervicobrachial neuralgia.[1] *Neurectomy*, or excision of a portion of a nerve trunk, is applicable to sensory nerves and to painful affections.

Cervical Sympathectomy.—*Jonnesco's Operation.*—It has long been known that division of the sympathetic nerve in the neck may produce changes in the eye and in the cerebral circulation. In 1893 Jaboulay, of Lyons, divided the sympathetic on each side for the purpose of treating epilepsy. The removal of the ganglia of the sympathetic was proposed by Baracz; and the operation was first performed by Jonnesco, then of Bucharest, now of Vienna, in 1896, for epilepsy. The operation is performed by some surgeons for epilepsy, for exophthalmic goiter, for glaucoma, for migraine, for angina pectoris, and for trifacial neuralgia. In operating for glaucoma the superior cervical ganglion on each side is removed, as it is from this that the sympathetic fibers that pass to the eye are derived. One ganglion, two or all on one side may be removed, but if the operation is done at all, it should be a bilateral one.

This operation is used in epilepsy on the theory that there is an anemic condition of the brain in this disease which is corrected by producing a hyperemia, and that the hyperemia improves cerebral nutrition. The operation in epilepsy is largely theoretic, although Jonnesco claims 12 per cent. of cures in a large number of operations. In exophthalmic goiter there seems to be some distinct evidence that the operation may be beneficial. Jonnesco has operated for Graves's disease 50 times, with 4 deaths (see his monograph, "Le sympathique cervico-thoracique"). Such a mortality is higher than

[1] "Medical Record," Dec. 5, 1896.

that given for ligation of thyroid arteries or for lobectomy of the thyroid gland. Jonnesco did 4 operations for angina pectoris and the results were very satisfactory. Coffey and Bain (see editorial in "Lancet," Dec. 15, 1923) report 4 operations for angina. Two of the patients were freed from the attacks and the other 2 were relieved decidedly. Personally I have not employed it in epilepsy, and at the present time I should not be inclined to do so. In exophthalmic goiter, if any operation is necessary, I perform partial thyroidectomy or ligation of the thyroid arteries, but in Graves's disease with extreme exophthalmus and a small thyroid gland I believe it is a justifiable procedure. I have done it twice in acute glaucoma, but without benefit. We used to think that the operation should be considered for simple glaucoma if myotics prove inefficient, and for acute glaucoma if iridectomy fails, but the "Lancet" says editorially (Dec. 15, 1923) "in glaucoma it would seem to be definitely contraindicated." The operation causes immediate contraction of the pupil (won't dilate to light or mydriatics); drooping of the upper lid (which is permanent); retraction and lowered tension of the eyeball; dilatation of the vessels of the head and neck; increase of tears, saliva, and nasal mucus; increased sweating of head and neck; and lowered pulse-rate. In angina the operation may prevent painful attacks; but the pain is not the disease, it is only expressive of the disease.

The incision should be made along the posterior margin of the sternocleidomastoid muscle. I have become convinced, in performing two operations of this kind and through studies made upon the dead body, that the ganglion may be more easily reached from behind the sternocleidomastoid than from in front of it. The sheath is opened, the muscle is retracted forward, great pains being taken to avoid the spinal accessory nerve and the branch to the trapezius. The posterior portion of the muscle sheath is opened, and the sheath of the great vessels of the neck with the vessels and pneumogastric nerve is retracted forward and inward. The superior ganglion, in its envelope of fascia, lies directly beneath the carotid sheath and will usually adhere to the under portion of the sheath and be lifted up with it. Theoretically, it is not necessary to open the carotid sheath in this operation, but, practically, this had better be done, so that one may, without any possibility of doubt, distinguish between the pneumogastric and the sympathetic nerve. The branches of the ganglion are divided and the nerve above the ganglion is cut. The moment the sympathetic nerve is cut the pupil on that side will contract. The surgeon then dissects down to the middle ganglion by the inferior thyroid artery and separates it. To expose the inferior ganglion requires retraction of the great vessels and sternocleidomastoid muscle forward and inward, and retraction of the anterior scalene muscle, the vertebral vessels and the thyroid axis downward and outward. Care is taken to avoid the pleura. The ganglion is separated and removed. [1]

Stretching of the Sciatic Nerve.—Some surgeons stretch the sciatic nerve by anesthetizing the patient and holding the leg and thigh in line, strong flexion being made upon the hip, the entire lower extremity being used as a lever. This method, which has caused death, inflicts needless damage, and stretching after an incision has been made is safer and better. The patient lies prone, the thighs and legs being extended. An incision 4 inches in length is made a little external to the middle of the thigh, and going at once through the deep fascia; the biceps muscle is found and is drawn outward; the nerve is discovered between the retracted biceps on the outside and the semitendinosus on the inside, resting upon the adductor magnus muscle. The nerve, which is caught up by the finger, is first pulled down from the spine and then up from the periphery, and finally the hook of a scale is inserted beneath the trunk and the nerve is stretched to the extent of 40 pounds. Very rarely is even a single ligature needed. The wound is sutured and dressed. If the incision is made at a higher level, just below the gluteofemoral crease, the sciatic nerve will be found just at the outer border of the biceps.

Neurectomy of the Infra-orbital Nerve.—This operation was first performed by Abernethy in 1793. The patient lies upon his back, the head being raised a little by pillows. The surgeon stands to the outside of and faces the patient. A curved incision $1\frac{1}{2}$ inches long is made below the lower border of the orbit. The nerve lies in a line dropped from the supra-orbital notch to between the two lower bicuspid teeth and is found upon the levator labii superioris muscle. A piece of silk is passed under the nerve by an aneurysm needle and firmly fastened. The upper border of the in-

[1] For selected cases of spasticity Royle, of Sydney, devised and performed successfully removal of the sympathetic rami which join certain cervical and connect certain lumbar nerves. The operation is called *ramisectomy*. (See Royle in "Brain," August, 1924.)

cision is drawn upward; the periosteum of the floor of the orbit is elevated and held by a retractor; the roof of the infra-orbital canal is broken through; the nerve is picked up far back by the blunt hook and is divided by scissors, and the entire nerve in front of the section is drawn out by making traction upon the silk. The bleeding in the orbit is checked by pressure. The wound is stitched without drainage.

Neurectomy of the Supra-orbital Nerve.—Before sterilizing the parts shave off the eyebrow. A curved incision 1 inch long discloses the nerve as it emerges from the supra-orbital notch or foramen at the junction of the inner and middle thirds of the eyebrow. The nerve is pulled forward and cut off above and below.

Neurectomy of the Inferior Dental Nerve.—Make a curved incision around the angle of the jaw. Lift the supramaxillary branch of the facial nerve downward (Kocher). Separate the masseter muscle by means of a periosteal elevator and slight touches of the knife. Chisel an opening in the center of the ascending ramus (Velpeau's rule). This opening exposes the beginning of the dental canal. If necessary, the opening may be enlarged by use of a rongeur. Pull the nerve out by a hook and remove a piece from it.

Extracranial Operation for Neuralgia of the Fifth Nerve (Tic Douloureux).—Removal of portions of the pain-haunted nerve-trunks sometimes cures the condition and often ameliorates it for a considerable time. Avulsion of a nerve by the method of Thiersch removes a large piece and gives better results especially if the nerve canal be plugged to prevent regeneration. The nerve is twisted slowly around a blunt forceps. Mayo plugs a canal with a silver screw. Albee and others use a bone-graft. The injection of osmic acid into the peripheral nerves, or of alcohol into the nerves as they emerge from the cranium, may actually cure or secure prolonged relief. The serious operation of removing the Gasserian ganglion may be performed if peripheral operations and injections fail, or in violent and intractable cases of long standing in which pain is felt in more than one branch. Removal of nerves by ordinary neurectomy often gives comfort for a few months, but rarely gives prolonged relief. In the worst forms of tic douloureux, particularly in those cases in which there are facial spasm and vasomotor phenomena, relief following peripheral operations is usually transitory. If we seek striking benefit by an extracranial operation, it must be thoroughly done.

Injection of Osmic Acid.—As long ago as 1874 Bartholow injected chloroform about and into nerves. Osmic acid was suggested by Billroth and Neuber in 1884. It was strongly advocated by Bennett, of London, in 1897. Osmic acid had been used for many years in a sort of haphazard way, having been injected into tissues about the nerves by means of a hypodermic syringe. Bennett suggested exposure of the nerve and the injection of 5 to 10 min. of a 1 per cent. solution. Acid when so used actually destroys nerve-fibers, and a considerable amount of fibrous tissue forms which intercepts regenerating fibers. It is probable that secondary degenerative changes occur in the nerve-trunks, but they do not ascend and reach the ganglion. Murphy warmly advocated the method. It certainly produces immediate relief by causing anesthesia, but such relief is very seldom, if ever, permanent. I have used it in several cases with satisfaction. In 1 case in which I exposed the ganglion I injected that structure, and the result seemed to be the same as if I had removed the ganglion. In neuralgia of the fifth nerve the painful nerve or nerves should be exposed, and from 5 to 10 min. of a 2 per cent. solution of osmic acid injected into several different parts of the nerve and also between the nerve-sheath and the bony canal (Murphy). The osmic acid method does not seem to grow in favor.

Injections of Alcohol into the Second and Third Division of the Fifth Nerve.—Dr. Matas as long ago as 1889 planned routes to reach the branches of the fifth nerve in order to produce regional anesthesia (Urban Maes, "Review of Surgical Treatment of Tic Douloureux" in "Internat. Abst. of Surgery," Oct., 1915). Alcohol injections were introduced by Schlösser in 1903. The injections are made into peripheral branches or divisions of the ganglion, and have even been made into the ganglion. Hartel enters the needle through the foramen ovale and injects the ganglion, a difficult and uncertain procedure. Dorrance performs a similar operation. Pollock and Potter suggest injecting the ganglion under fluoroscopy ("Jour. Amer. Med. Assoc.," Nov. 14, 1916). Siccard and others have warmly praised the alcohol injection method. It acts similarly to osmic acid. It produces local necrosis of the nerve and fibrosis about it. The necrosis does not tend to ascend (May, "Brit. Med. Jour.," Aug. 31, 1912). It gives relief sometimes after one injection, sometimes after two or more. The permanence of the relief is uncertain. Usually it is complete for six months and then recurrent pain may require renewed injection. Recurrences are milder than the previous condition. Apparent cure may last for three or four years.

I have used the method many times and am satisfied as to its value in proper cases. It is superior to peripheral operations. It is used in very old subjects, feeble subjects, the victims of grave organic disease, and in those who refuse radical operation. In strong young persons removal of the ganglion may still be preferred. In some cases alcohol is used before a ganglion extirpation in order to remove pain and permit of such improvement in health and strength as to make the radical operation safer. Never attempt to make a deep injection about the ophthalmic branch. To do so may damage a great vessel, the optic nerve, the third, fourth, or sixth nerve, or the alcohol may enter the orbit and destroy the eye. If there is pain in the supra-orbital and supratrochlear branches, inject them where they are superficial.

Injection of the Supra-orbital Branch.—Use an ordinary hypodermic needle and inject 10 to 20 min. of the fluid recommended below. Throw the fluid about the nerve at the foramen. After withdrawing the needle make pressure at the puncture. Such pressure is advised by Patrick to stop bleeding, prevent a black eye, keep the tissues exsanguine, and add to the effect ("Jour. Amer. Med. Assoc.," Jan. 20, 1912). The lids always swell.

I used for a time 80 per cent. alcohol, each dram of which contained 1/6 gr. of stovain, but this hardens the tissues so much that they become resistant to reinjection. I now use Patrick's formula, viz., 2 gr. of muriate of cocain, 2½ drams of alcohol, and distilled water sufficient to make ½ oz. The usual dose is 2 c.c. A special needle is used. It is straight, is graduated in centimeters, and carries a stylet which is flush with the point. The stylet is pulled back slightly while the needle is being driven through the skin and fascia; it is then pushed all the way in. Various plans have been suggested for reaching the nerves (see Dorran Plan in "Penna. Med. Jour.," Aug., 1916). I follow the method of Lévy and Baudoin ("Presse Méd.," April 17, 1906), which is as follows:

Superior Maxillary Division.—Drop a perpendicular from the posterior border of the orbital process of the malar bone (the beginning of the zygoma) to the inferior edge of the zygoma; 5/10 c.c. back of this point is where the needle should be introduced. It is carried in and very slightly upward. At a depth of 2 cm. the coronoid process may obstruct; at a greater depth, the external pterygoid plate. Either obstruction may be avoided by inclining the needle very slightly forward (never much, or alcohol may enter the orbit). At a depth of 5 cm. the needle encounters the nerve as it emerges from the foramen rotundum. The injection usually causes decided but brief pain. If the injection reaches the nerve there will be immediate analgesia throughout its trajectory. This should last two or three days.

Inferior Maxillary Division.—The point for entrance of the needle is at the lower border of the zygoma, 2.5 cm. in front of the anterior root of the zygoma. The needle is carried inward, somewhat backward, and slightly upward. At a depth of 4 cm. the nerve is reached. Be sure the nerve has been reached by finding analgesia throughout its trajectory after injection.

Removal of the Gasserian Ganglion.—This formidable procedure was first suggested by J. Ewing Mears in 1884. Wm. Rose in 1890 was the first surgeon to perform it successfully. It is only undertaken in very severe cases of tic douloureux, in which the first division is involved, or in cases upon which less grave procedures have failed. Jaboulay and Cavaillin ("Lyon. Med.," May 17, 1908) speak of it as a grave operation of difficult technic which should be left as a final resort. The greater the experience of the surgeon in this operation, the smaller will be the mortality. Knowledge of the region and parts, dexterity from frequent repetition, and special training count for much. The operation usually cures the pain if the patient recovers from the actual procedure. It is claimed that the pain may recur even after complete removal of the ganglion. I am disposed to think that recurring pain is apt to mean that there was a partial removal. In one case of undoubted complete removal the patient still claims to suffer. This condition may mean a lesion of the sensory root back of the ganglion. The victims of tic are usually elderly, weakened by prolonged suffering and shattered by opiates. They would be poor risks for any operation.

Prof. Frazier ("Keen's Surgery," vol. v) collected 230 cases and finds a mortality of only 3.7 per cent. These figures come from the clinics of men particularly skilled in this operation (clinics of Cushing, Horsley, Frazier, Lexer, and so on). The figures of some other writers are far less favorable. In a series of 121 intracranial operations Frazier had but 4 deaths. One hundred and thirteen of the operations were upon the sensory root (personal communication). Carson collected 100 cases; Murphy and Neff, 42 cases. The mortality in this group of 142 cases was 15 per cent. Most

of the cases reported by Murphy and Neff were operated upon during or after 1899, and in this group the mortality was 10 per cent. ("Progressive Medicine," March, 1903). In Lexer's series of 201 cases, referred to below, the mortality was 17 per cent. In many cases a perfect cure is obtained. In some few the pain returns upon the side operated upon. Occasionally it arises on the side not operated upon. In some cases ulceration of the cornea follows operation. Such ulceration may be trivial, may result in opacity, or may destroy the eye. Paralysis of the abducens occurs in some cases. In rare cases the hemorrhage is so profuse as to require packing of the wound and suspension of the operation for a few days. The bleeding may come from the meningeal artery, from the sinus, or from the veins of Santorini. Lexer ("Arch. f. klin. Chir.," Bd. lxv, H. 4) gives a table of 201 cases. Of the survivors, 93.4 per cent. were apparently cured. In two-thirds of the cases the trouble was right sided. In 10 the operation was temporarily abandoned because of hemorrhage. The experience of surgeons in general is that after the removal of the ganglion there is apt to be some atrophy of the tongue and the eye usually remains insensitive and watery. The masseter muscle will be paralyzed.

The Hartley Operation for Removal of the Gasserian Ganglion.—This operation was first performed by Hartley in 1891, five months before Krause performed it. An electric forehead light is required. Long strips of gauze must be ready for packing in case of hemorrhage. Some operators place the patient recumbent, with head turned to the opposite side. If the patient is placed semi-erect venous bleeding will be much lessened, as

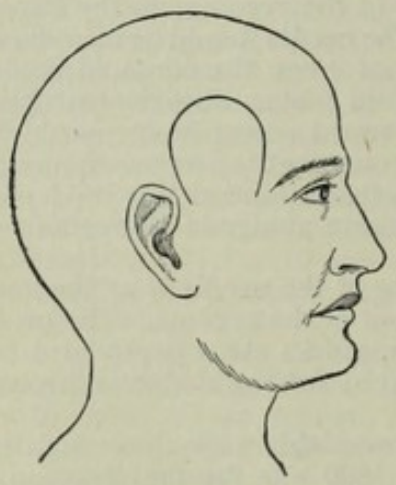


FIG. 603.—Hartley's osteoplastic flap in removal of Gasserian ganglion (Tiffany).

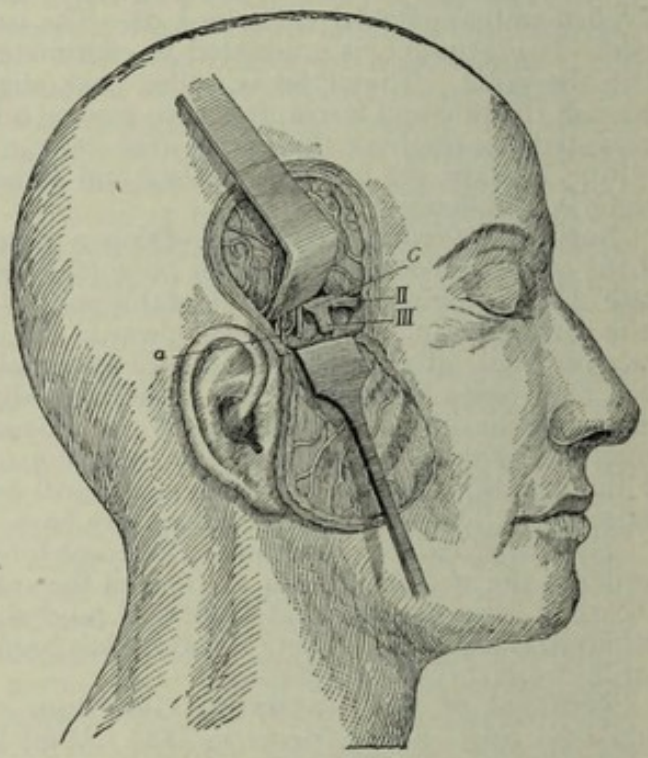


FIG. 604.—Removal of Gasserian ganglion: *a*, Middle meningeal artery; *II*, ophthalmic division; *III*, submaxillary division; *G*, ganglion (Krause).

was pointed out by Lexer. The application of a provisional ligature or clamp to the external carotid artery is advocated by Crile, but this step will not control the venous bleeding, which is the most harassing hemorrhage encountered. Some operators form a large osteoplastic flap in front of the ear (Figs. 603, 604). I do not believe that an osetoplastic flap is necessary. The temporal fascia is so thick and tense that when the wound in it is carefully sutured protection is perfect and safety is secured. Hemorrhage is to be carefully arrested. Most of the bleeding is venous and from the diploë. It can be arrested by pressure with compresses soaked in hot water, Horsley's wax, or plugging the bone spaces with bits of frayed out temporal muscle. It may be found that the meningeal artery has been ruptured. If this accident has happened and the vessel lies in a bony canal, plug with Horsley's wax. If the vessel is bleeding upon the dura, ligate by passing suture ligatures or compress with silver clips. If it is torn off at the foramen spinosum ligate, if possible. If not possible, pack the foramen with a bit of temporal muscle or a sterile piece of wool. In some cases pack with iodoform gauze, and postpone the conclusion of the operation for forty-eight hours. It may be necessary at any stage of this operation to pack the wound and

postpone completion for two days. Some surgeons (Krause, Bergmann) ligate the meningeal artery as a routine procedure, but this operation may be difficult and require considerable time. If the unligated vessel is divided, the hemorrhage can be arrested easily. If the head and body of the patient were not elevated before, they should be now. This position allows the brain to drop posteriorly and renders forcible retraction unnecessary, and, further, it lessens venous bleeding (Lexer). The next step is to lift up the dura and with it the brain (Fig. 604). Find the inferior maxillary nerve and clamp it with hemostatic forceps. Find the superior maxillary nerve and clamp it. Uncover the ganglion. Loosen the nerves from their beds by a dry dissector and divide each one at its foramen of exit. Twist the clamp forceps so as to reel up the nerves. This pulls out the ganglion intact with the motor root and the root of origin, as far back as the pons (Krause's method). Arrest bleeding; close the flap; sew together with a couple of stitches the lids of the affected side in order to keep them temporarily closed. An opening is left at each end to permit of irrigation. Cover the eye with a watch-crystal. The eye is to be washed out frequently. Thus irritants are excluded.

Cushing's Operation.—Cushing has modified the Hartley operation so as to permit of extradural manipulation below the arch made by the middle meningeal artery and thus lessen the danger of laceration of the artery ("Jour. Amer. Med. Assoc.," April 28, 1900). The anterior arm of the incision of the soft parts is so placed that it does not cut the nerve to the occipitofrontalis muscle. Thus drooping of the lid and oblation of brow wrinkles on that side are avoided. The incision in the soft parts starts ½ inch behind and a little above the external angular process and is curved downward and backward. It reaches the zygoma just in front of the ear. The skin is reflected downward, the zygoma is resected by the subperiosteal plan, the temporal fascia and muscle are incised and reflected downward. The lower part of the temporal fossa is thus laid bare. The bone is opened with a gouge at the prominence of the greater wing of the sphenoid. Opening the wall of the temporal fossa very low down allows the surgeon to work below the arch of the meningeal vessels, and he thus avoids the middle meningeal at the foramen spinosum of the sphenoid bone and the sulcus arteriosus of the parietal bone. The opening in the bone is enlarged by means of rongeur forceps until it is 1½ inches in diameter and reaches down to and includes the ridge which lies at the junction of the temporal and zygomatic fossæ. The dura is raised from the base of the skull until the foramen ovale is reached. The inferior maxillary nerve which passes through the foramen ovale guides the surgeon to the ganglion. Split the dural sheath of the ganglion and expose the superior surface of the ganglion. Expose by blunt separation the ganglion, its three branches, and its sensory root. Catch the ganglion with forceps just in front of the sensory root, raise each branch on a hook, and divide it. Twist the ganglion in order to pull out the sensory root. The wound is drained by means of rubber tissue for forty-eight hours.

Horsley's Intradural Method.—An opening is made into the middle fossa of the skull, the dura is opened, and the ganglion is found and removed. This operation is easier than the extradural method, but is believed to be more dangerous.

The Frazier-Spiller Operation of Intracranial Neurotomy of the Sensory Root of the Trigeminus.—This operation was first performed by Frazier in 1901. Experience indicates that after division of the sensory root the nerve does not regenerate, The operation must be regarded as a very valuable addition to our resources. This operation is by most surgeons preferred to removal of the ganglion. The patient is placed semi-erect. A horseshoe-shaped flap is made, starting at the middle of the zygoma and ending behind and below the helix. The flap is turned down. The temporal fossa is exposed, the bony wall is trephined at a point slightly posterior to that used by most surgeons to reach the ganglion. The center of this opening is on a line with the point at which the sensory root joins the ganglion. The trephine opening is enlarged to the infratemporal crest by the use of a rongeur. The dura is separated from the base of the skull to the foramen spinosum. The meningeal artery is found, tied and divided. The dura is divided over the third division and is separated from the upper surface of the ganglion posteriorly. The dural envelope of the ganglion is opened, separated, and the sensory root exposed. The sensory root is then picked up on a blunt hook and divided or avulsed. It is frequently possible, Frazier tells us, to separate the sensory root from the motor root. When the sensory root has been divided the anesthetic is put aside as the parts are now anesthetic. As soon as the reflexes return test the conjunctival reflex to be certain that no sensory fibers retain their continuity. Suture the flap and use a drain of rubber tissue. In this operation we avoid the venous hemorrhage from the foramen ovale and foramen rotundum

which is apt to be encountered when removing the ganglion, escape the bleeding which always occurs when the ganglion is lifted from its seat, and are free from the danger of injuring the cavernous sinus, the third, fourth, and sixth nerves, and the motor root. Frazier has had great success with this operation, is convinced that the sensory root does not regenerate, and that ulceration of the cornea is less common than after removal of the ganglion.

Abbe's Operation of Intracranial Neurectomy of the Second and Third Divisions.—This operation is preferred by Charles A. Ballance, who opposes exposure of the ganglion or division of the sensory root unless the first division of the nerve is the seat of pain. He advocates this in spite of knowing full well that the pain may return in a few years. He advocates it because of its safety, its simplicity, its freedom from serious hemorrhage, its avoidance of opening the intradural space and of all danger of corneal anesthesia, and also because if pain returns the operation can be repeated. The operation is performed as follows: Ligate the external carotid artery of the diseased side, make a vertical incision over the middle of the zygoma down to the bone. An opening into the skull is made by a mallet and gouge, and this opening is enlarged by a rongeur until it is 1½ inches in diameter. The dura is lifted from the middle fossa and the nerves are exposed. Each nerve-trunk is clamped, is divided near its foramen of exit, and is separated from the ganglion by cutting or twisting with the forceps. A strip of sterile rubber tissue is laid over the round foramen and the oval foramen and is pressed into place by gauze. In a few moments the gauze is withdrawn and the ganglion is allowed to descend upon the rubber tissue. The wound is then closed. (See Robert Abbe in "Annals of Surgery," Jan., 1903.) The rubber tissue is used to block the foramina of exit and prevent, or at least retard, future emergence of regenerating nerves. Mayo Robson blocks the foramina by a thin plate of lead or silver, a knob of the plate entering the oval foramen to prevent displacement. Kanavel uses bone-grafts. Mixter used amalgam.

Division of the Auditory Nerve for Tinnitus Aurium and for Aural Vertigo.—This operation was proposed for tinnitus by Krause in 1902. Ballance did it on the right side with success in a most distressing case of painful tinnitus. When the cerebellar hemispheres were displaced by sponges the nerves of the posterior fossa were brought into view. He divided the eighth nerve, but made no attempt to preserve the nerve of Wrisberg. Five months after operation the patient was well except for deafness and deviation of the tongue to the left. (See Ballance in "Lancet," 1908, vol. ii.) Frazier has divided the auditory nerve for aural vertigo, with partial relief.

Operation for Facial Paralysis of Extracerebral Origin (Facio-accessory Anastomosis and Faciohypoglossal Anastomosis).—(See "Remarks on the Operative Treatment of Facial Palsy of Peripheral Origin," by Chas. A. Ballance, Hamilton A. Ballance, and Purves Stewart, "Brit. Med. Jour.," May 2, 1903; and also the "Surgical Treatment of Facial Paralysis by Nerve Anastomosis," by Harvey Cushing, "Annals of Surgery," May, 1903.) In 1898 Furet suggested to Faure that he should anastomose the peripheral end of a divided facial nerve to that portion of the spinal accessory nerve which goes to the trapezius muscle. Faure did this, but the operation failed. Robert Kennedy, of Glasgow, did the first successful operation. He divided the facial for the relief of spasm and at once anastomosed the cut end of the distal segment to a partly divided spinal accessory nerve. The procedure first employed by Ballance was, after noting by galvanism that muscular fiber still remained, to expose the facial nerve at its point of exit from the stylomastoid foramen, to cut the nerve-trunk across as high up as possible, to expose the spinal accessory, and to suture the distal end of the facial into the trunk of the spinal accessory. The spinal accessory was cut half through to make a bed for the end of the facial. The paper of the Ballances and Stewart above referred to recommends end-to-side anastomosis between the divided facial and the hypoglossal. The authors have operated five times for facial palsy. Cushing, Keen, Hackenbruch, Körte, Currie, Beck, Vidal, Girard, Lund, Alt, Frazier, and others have done similar operations. Marked improvement may follow operation even if palsy has lasted for a considerable time. Improvement followed operation in Currie's case, although the palsy was nearly a year old. The period when improvement should be expected is uncertain. Signs of improvement may not be evident for six months or longer. In Cushing's case they began in thirteen days; in Kennedy's case, in seven days. In most cases operation restores facial symmetry when at rest and in many cases during volitional movements. The patient will often become able to close the eye and raise the angle of the mouth. Curious associated movements may occur. In

Currie's case when the patient lifted his shoulder there was contraction of the occipitofrontalis muscle ("South African Med. Record," 1907). Grant operated upon a case of traumatic facial paralysis over four months after the injury. He anastomosed the facial to the spinal accessory and the peripheral end of the accessory to the descendens hypoglossi. At the end of fifteen weeks there were feeble association movements of the face and shoulder, which later disappeared. At the end of a year the result was most gratifying ("Jour. Amer. Med. Assoc.," Oct. 22, 1910).

Facio-accessory anastomosis does not restore emotional movements, but facio-hypoglossal anastomosis may restore them. Küster reports a case which confirms this.

Operation is indicated when a complete facial palsy is of such duration that recovery is not to be hoped for by longer delay. Ballances and Stewart believe that when palsy has lasted six months without sign of recovery, operation is indicated. A paralysis due to traumatism gives a much better prognosis after operation than does a paralysis due to a septic process (Chas. A. Ballance, Hamilton Ballance, and Purves Stewart in "Brit. Med. Jour.," May 2, 1903). Murphy has collected 33 cases of anastomosis of the facial nerve with the spinal accessory, hypoglossal, or glossopharyngeal, and Joseph Beck has added 5 cases of his own in which he performed faciohypoglossal anastomosis.

The hypoglossal is preferred to the accessory. Its trunk is larger and its cortical center is adjacent to the facial cortical area. After such an operation associated movements are not observed when the mouth is kept closed, and, if Gowers is correct, the fibers of the facial, which supply the muscles closing the mouth, may take origin from the hypoglossal nucleus (John B. Murphy in "Surg., Gynec., and Obstet.," April, 1907). Murphy points out that an anastomosis may be end to end, implantation of the facial into a slit in the other nerve, implantation of the facial into a partial transverse division of the other nerve, or end to side (Ibid.).

Frazier's Operation of Anastomosis of the Descendens Hypoglossi with the Peripheral Part of the Divided Recurrent Laryngeal Nerve.—Professor Frazier, of the University of Pennsylvania, devised this operation for bilateral paralysis of the recurrent laryngeal nerves following thyroidectomy. (Chas. H. Frazier in "Annals of Surgery," Feb., 1924).

Sometimes in this palsy the dyspnea is so great that tracheotomy is required. The chief sign may be a husky voice without aphonia, although with impaired phonation. Frazier's case is extremely promising.

Operation for Brachial Birth Palsy.—(See article by L. P. Clark, A. S. Taylor, and T. P. Prout in "Amer. Jour. Med. Sciences," Oct., 1905.) These authors report 8 cases of operation, with some notable improvements and with 2 deaths. In these cases they found great thickening of the fascia, and in some cases fibrous tissue almost completely obscured the remains of lacerated trunks or roots. They advise that the patient be placed recumbent, with a sand-pillow beneath the shoulders and with the head extended and bent toward the opposite shoulder. An incision is made at the posterior border of the sternocleidomastoid and the plexus is exposed and explored. Sharpe reports 56 cases upon which he operated ("Jour. Amer. Med. Assoc.," March 18, 1916). He makes a transverse skin incision above and parallel to the clavicle and over the supraclavicular space of the posterior triangle. If the lesion is above the clavicle, it is at once attacked; if below that bone, the incision is carried down and the bone is sawed in two. The scar tissue with the lacerated nerves is removed and the nerves or nerve-roots are sutured. The wound is closed, the clavicle being wired if it has been divided. After dressings are applied the head is bent toward the shoulder of the damaged side and fixed with plaster of Paris.

I operated on a case for Dr. Charles S. Potts in the Philadelphia Hospital. The roots were not torn, but were found embedded in a thin layer of scar which it was possible to remove. The result was good. Nerve anastomosis may be necessary if exsection of scar leaves an unbridgable gap or if nerve-roots have been divided within the foramina.

Operation for Avulsion of the Brachial Plexus.—(See page 706.)

XXII. DISEASES AND INJURIES OF THE HEAD

Diseases of the Head

In approaching a case of brain disorder, first endeavor to locate the seat of the trouble; next, ascertain the nature of the lesion; and, finally, determine the best plan of treatment, operative or otherwise. In all operations upon the brain the surgeon

must be able to determine accurately the situations of certain fissures and convolutions, the finding of the situations of these convolutions and fissures comprising the science of *craniocerebral topography*.

The *regional terms* used in craniocerebral topography are derived from Broca (Fig. 605). The middle meningeal artery is found at the *pterion*, 1¼ inches posterior

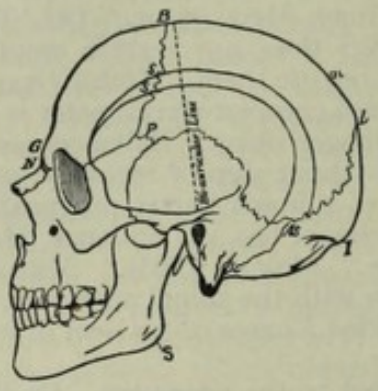


FIG. 605.—Skull, showing the points named by Broca: *As*, Asterion (junction of the occipital, parietal, and temporal bones); basion, middle of anterior wall of foramen magnum; *B*, bregma (junction of the sagittal and coronal sutures); *G*, ophyron (on a level with the superior border of the eyebrows, and corresponding nearly to the glabella, the smooth swelling between the eyebrows); *g*, gonion (angle of the lower jaw); *I*, inion (external occipital protuberance); *L*, lambda (junction of sagittal and lambdoidal sutures); *N*, nasion (junction of the nasal and frontal); *Ob*, obelion (the sagittal between the parietal foramina); *P*, pterion (point of junction of great wing of sphenoid and the frontal, parietal, and squamous bones—this may be H-shaped or K-shaped or "retourné," in which the frontal and temporal just touch); *S*, stephanion (or, better, the superior stephanion, intersection of ridge for temporal fascia and coronal suture); *S'*, inferior stephanion (intersection of ridge for temporal muscle and coronal suture).

to the external angular process, on a level with the roof of the orbit (Fig. 606). The fissures and convolutions of the brain are shown in Figs. 607, 608, 609. The *fissure of Bichat* is marked by a line on each side drawn from the *inion* to the external auditory process. A line from the *glabella* to the inion overlies the median fissure and the superior longitudinal sinus. The *fissure of Rolando* (Figs. 607, A and 608, 1) is very important, as marking the posterior limit of the motor region of the brain. It begins near the median line, ½ inch posterior to the middle of the distance between the inion and glabella (Thane). This fissure runs downward and forward at an angle of 67.5° for

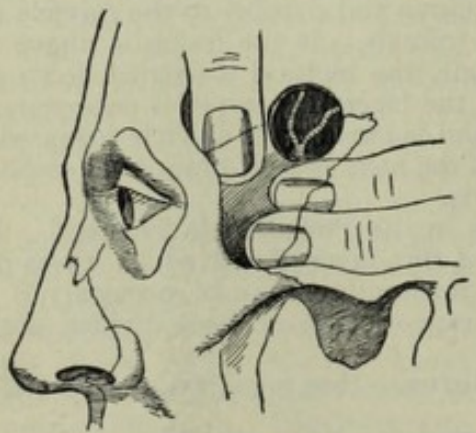


FIG. 606.—The meningeal artery exposed by trephining (after Esmarch).

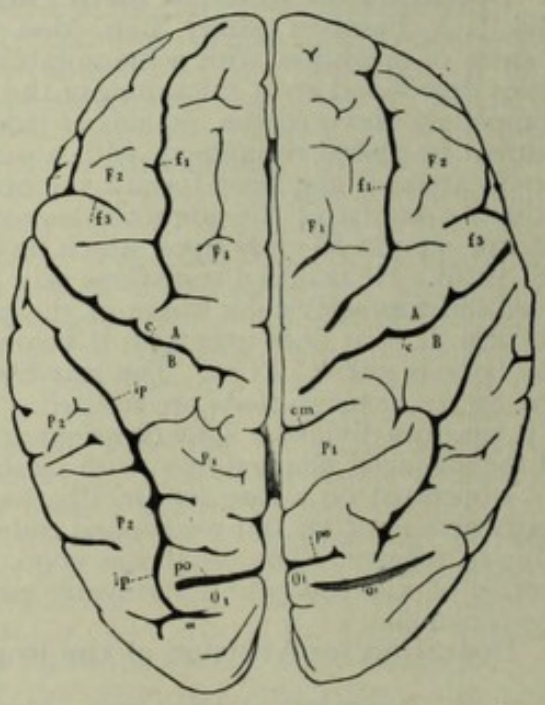


FIG. 607.—View of the brain from above (Ecker).

a distance of 3⅜ inches. Chiene finds the fissure of Rolando by the following method: He takes a square piece of paper and folds it into a triangle (Fig. 610, 1); the angle B–A–C of this triangle is 45°; the edge D–A is folded back on the dotted line A–E; the angle D–A–E

equals half of 45°, or 22.5°, and the angle C–A–E equals the same (Fig. 610, 2); the paper is unfolded in the line C–A; in the figure thus formed B–A–E = 45° and E–A–C = 22.5°; E–A–B

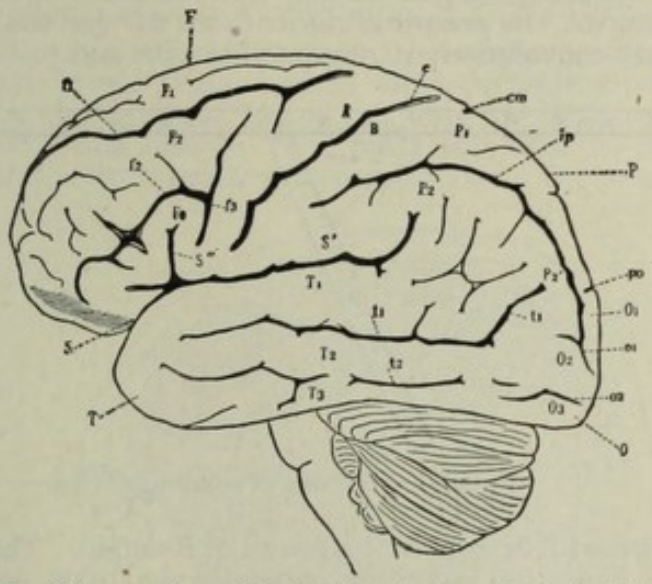


FIG. 608.—Outer surface of the left hemisphere of the brain (Ecker).

= 67.5°, which is the angle desired. Place the point A in the midline of the head, over the point of origin of the Rolandic fissure; the side A–B is laid along the middle line of the head, and the line A–E corresponds to the fissure of Rolando.[1] Horsley determines

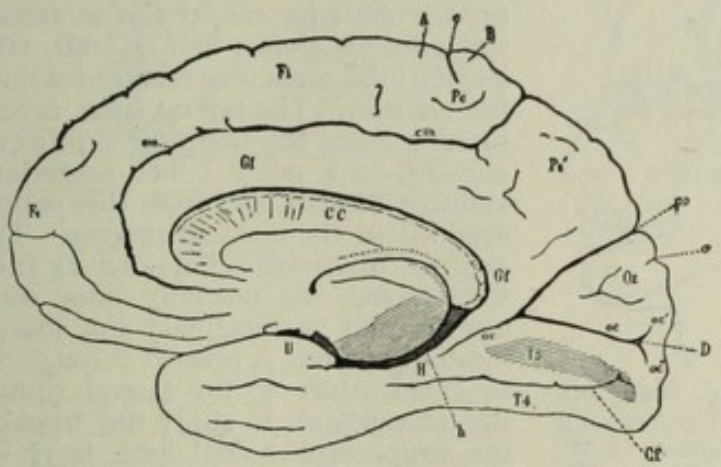


FIG. 609.—Inner surface of the right hemisphere of the brain (Ecker).

the situation of the Rolandic fissure by the use of his metal cyrtometer (Fig. 611). He places the point marked zero over the inioglabellar line and midway between the inion and the glabella. The arm winds downward and forward from ½ inch posterior to 0

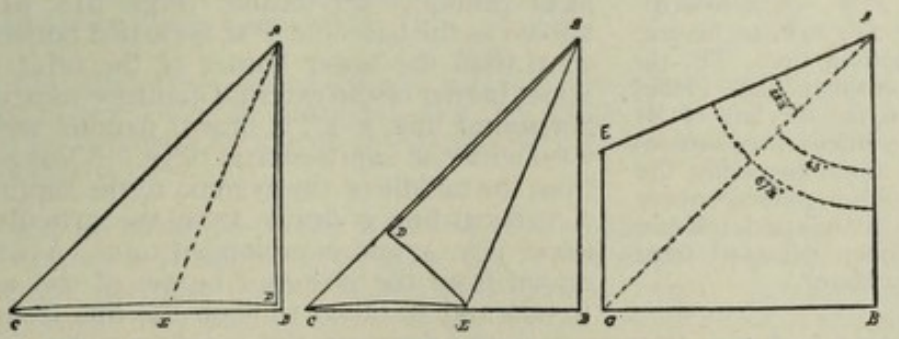


FIG. 610.—Chiene's method of fixing position of Rolandic fissure ("American Text-book of Surgery")

at an angle of 67.5 degrees. To find the *fissure of Sylvius* (Fig. 608, *S*, *S'*, *S''*), draw a line from the external angular process to the occipital protuberance. The fissure of Sylvius

[1] "American Text-book of Surgery."

begins on this line 1⅛ inches behind the external angular process; the main branch of the fissure runs toward the parietal eminence; the ascending branch of the fissure corresponds to the squamosphenoidal suture, and continues upward in the same line ½ inch above the suture. The *precentral sulcus* (Figs. 607 and 608, F1) limits anteriorly the ascending frontal convolution; it runs parallel with and just behind the coronal

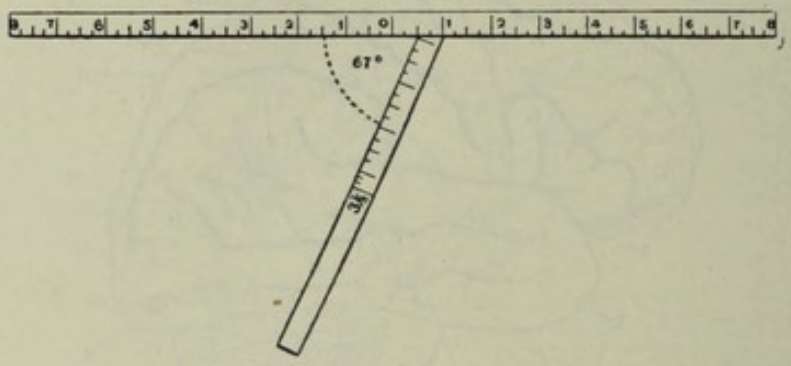


FIG. 611.—Horsley's cyrtometer.

suture, and a fingerbreadth in front of the fissure of Rolando. The *intraparietal fissure* (Figs. 607, 608, *ip*) limits the ascending parietal convolution posteriorly. It begins opposite the junction of the lower and middle thirds of the fissure of Rolando, passes upward in a line parallel with the longitudinal fissure and midway between the Rolandic fissure and the parietal eminence, passes by the parieto-occipital fissure, and downward and backward into the occipital lobe. The motor areas, which on the outer surface are adjacent to and in front of the fissure of Rolando, are shown in Figs. 607, 608.[1] The superior longitudinal sinus is overlaid by a line from the inion to the glabella. The lateral sinus is indicated by a line running from the occipital protuberance horizontally outward to a point 1 inch posteriorly to the external auditory meatus, and from this point by a second line dropped to the mastoid process. The *suprameatal triangle* of Macewen is bounded by the posterior root of the zygoma, the posterior bony wall of the auditory meatus, and an imaginary line joining the two. The mastoid antrum is opened through *Macewen's triangle* to avoid injury to the lateral sinus. *Barker's point*, the proper spot to apply the trephine for abscess of the temporosphenoidal lobe, is 1¼ inches above and 1¼ inches behind the middle of the external auditory meatus. Figure 612 shows clearly the main points of craniocerebral topography obtained by methods approved by many scientists.

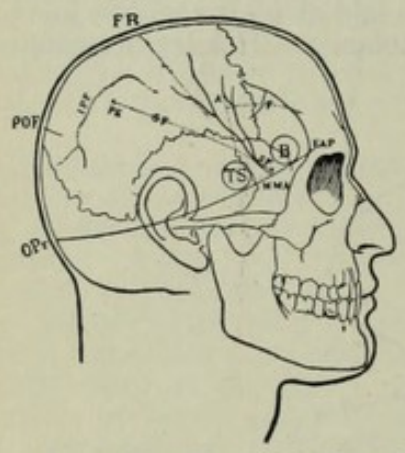


FIG. 612.—Head, skull, and cerebral fissures: B corresponds to Broca's convolution; EAP, external angular process; FR, fissure of Rolando; IF, inferior frontal sulcus; IPF, intraparietal sulcus; MMA, middle meningeal artery; OPr, occipital protuberance; PE, parietal eminence; POF, parieto-occipital fissure; SF, Sylvian fissure; A, its ascending limb; TS, tip of temporosphenoidal lobe. The pterion (to the left of B) is the region where three sutures meet, viz., those bounding the great wing of the sphenoid where it joins the frontal, parietal, and temporal bones (adapted from Marshall by Hare).

Krönlein's method for localizing certain areas is the most generally serviceable (Figs. 613, 614). A line, known as the base line, Z–M, is carried horizontally backward from the lower border of the orbit through the upper border of the external auditory meatus. Another horizontal line, K–K′, is drawn parallel with this, on a level with the supra-orbital ridge. A line Z–K is erected from the middle of the zygoma to the supra-orbital line. A vertical line is drawn from the articulation of the lower jaw, A, and is prolonged to R. A vertical line is drawn from the posterior border of the mastoid base (M–K′) and is taken to P, on the line from glabella to inion. A line is drawn from K to P, and between the points R and P′ it overlies the fissure of Rolando. The angle P–K–K′ is bisected by the line K–S, which corresponds to the fissure of Sylvius from its point of bifurcation to its posterior termination; K marks the bifurcation of the fissure of Sylvius. To reach the

[1] Recent studies indicate that the motor region is entirely in front of the Rolandic fissure.

anterior branch of the middle meningeal artery trephine at κ; to reach the posterior branch, trephine at κ′.

Head Injuries During Labor.—Caput Succedaneum.—This condition is edema of the scalp due to prolonged pressure. The edema is circular and circumscribed and occupies the part not subjected to continued pressure during the uterine contractions of labor. The circular area of tissues around which circumferential pressure is exerted by the ring of the os uteri projects like a cup into the birth canal. The veins become congested and edema results. The parts subjected to pressure may appear normal or may exhibit ecchymoses or even excoriations. The pressure is usually made

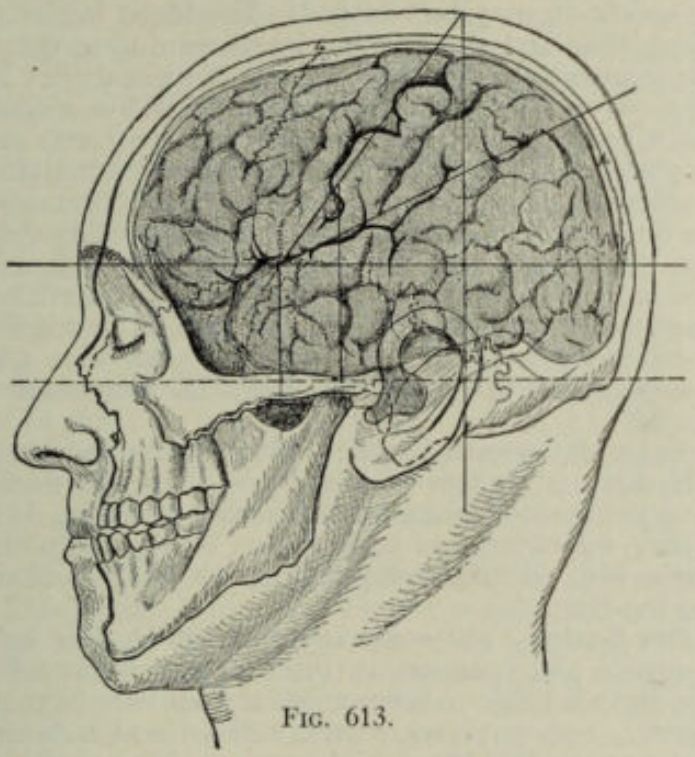


FIG. 613.

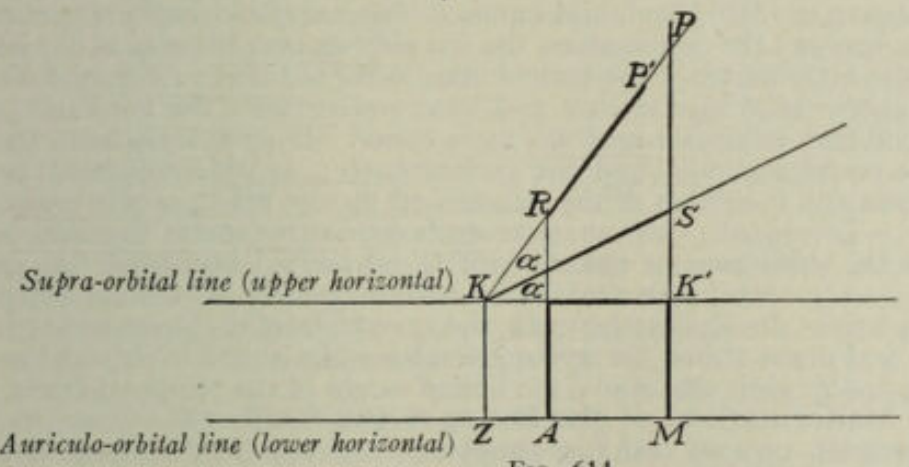


FIG. 614.

FIGS. 613, 614.—Krönlein's method of locating the fissure of Rolando (*R–P′*) and Sylvius (*K–S*); Krönlein's point of trephining for hemorrhage from the middle meningeal (*K–K′*); and von Bergmann's region for trephining for abscess of the temporosphenoidal lobes (*A–a–K′–M*) ("American Text-book of Surgery").

by the os, and its situation varies with the presentation, but because the most frequent presentation is left occipito-anterior the common position of the caput is over the superior and posterior portion of the right parietal bone. In a face presentation great disfigurement may occur. It is seldom that a double caput is encountered. It always means that the presentation has shifted. The worst cases of caput follow prolonged labor. The edematous swelling is present at birth, contains bloody serum, pits on pressure, does not fluctuate, is not limited to the outline of one bone, and the skin above it is usually discolored by ecchymoses. No treatment is necessary, as the condition will disappear in from a few hours to three days.

Cephalhematomata.—By this term we mean extravasations of blood beneath the untorn pericranium. It is supposed by many to be due always to pressure and venous congestion, as is a caput succedaneum. As Cushing points out, the condition cannot result from the venous stasis of prolonged pressure alone. If it did it would always exhibit above it a caput succedaneum, "and this is far from our actual experience" (Harvey Cushing in "Keen's Surgery," vol. iii). It is certainly due in some cases to bending or breaking of a cranial bone. The condition is said to occur in 1 labor out of 200. In most cases there is but one cephalhematoma, but there may be two, three, or even four. The commonest situation is over the right parietal bone (the common seat of caput succedaneum), and caput succedaneum may be associated with a cephalhematoma. The condition may be bilateral. The blood begins to flow beneath the pericranium during labor and the swelling increases during the first few days after birth; in fact, it is frequently not noticed for two or three days. The swelling is tense and smooth, with a convex outline and when recent feels like a cyst. It may cover but a small portion of a bone or an entire bone, but never extends beyond the bounding sutures. This limitation is due to the fact that the pericranium is attached to the sutures. In the course of a couple of weeks the raised and irritated periosteum usually begins to produce bone, and if it does, a ring of hardness will be detected at the margin of the lump due to the formation of new bone. Bone-plates usually develop over the surface of the swelling. If plates form, crepitus can be detected. A shell of bone may eventually surround and cover over the clot, an area of permanent bony thickening remaining. In other cases no bone forms, but the clot gradually disappears. Extradural and even subdural hemorrhage may be associated with subpericranial bleeding.

Cephalhematomata unassociated with cerebral symptoms usually disappear without operation. If there is no sign of subsidence after two weeks, follow Cushing's rule, evacuate by a puncture-like incision and apply pressure. If suppuration occurs, incision is necessary. Suppuration may occur if the scalp has been excoriated. In cephalhematoma with cerebral symptoms operation is indicated (incision of the scalp and opening the cranium).

Diseases of the Scalp.—The scalp is composed of skin, subcutaneous fat, the occipitofrontalis muscle and aponeurosis, the subaponeurotic cellular tissue, and the pericranium. The scalp is liable to inflammation from various causes, and also to certain diseases, namely, tumors, cysts, warts, moles (local cutaneous hypertrophies), cirsoid aneurysm (see page 380), nevi, and lupus. *Abscesses of the scalp* are common. If an abscess forms beneath the pericranium, the pus diffuses over the area of one bone, being limited by the attachment of the pericranium in the sutures. In cranial osteomyelitis pus may gather between the dura and bone and between the bone and pericranium. The condition is known as *Pott's puffy tumor*. If an abscess forms in the tissue between the occipitofrontalis and the pericranium, it is widely diffused, being limited by the origins and insertions of the muscle and by the origin of the temporal fascia on each side. Treves calls this subaponeurotic connective tissue "the *dangerous area*." Abscess of the subcutaneous tissue is apt to be limited because of the great amount of fibrous tissue. Abscess is treated by instant incision at the most dependent part, and drainage. In abscess beneath the occipitofrontalis aponeurosis it is necessary to open and drain above the eyebrows, above the superior curved line of the occipital bone, and at each side above the line of origin of the temporal fascia.

Diseases and Malformations of the Bones of the Skull.—The bones of the skull are liable to caries, necrosis, osteitis, periostitis, osteomyelitis, atrophy, hypertrophy, tumors, etc. (See Diseases of Bones.)

Cranial Pneumatocele.—This rare condition is a result of perforation of a bone which permits air to collect beneath the periosteum. It may occur in the mastoid or occipital region or over the frontal region. These protrusions vary greatly in size; and as their shape depends upon the periosteal attachment to sutures in the neighborhood, they vary in shape. The overlying tissues are natural in appearance. The protrusion is tense, but may lessen or disappear on pressure. McArthur ("Jour. Amer. Med. Assoc.," May 6, 1905) points out that if diminished by pressure, the patient may hear a sound like rushing air or water in the ear if the protrusion is occipital or mastoid; and in the nose, if it is frontal. An elevated ridge of bone surrounds a pneumatocele. The protrusion is tympanitic on percussion. The condition is due to perforation of the bony wall of an air sinus by disease, injury, or rupture. McArthur points out that in half of the reported cases the rupture was not preceded by any history of inflammation or injury. The condition is not dangerous.

Treatment.—Incision, finding the opening in the bone, enlarging it, removing osteophytes; bringing the walls of the cavity together and applying pressure.

Microcephalus.—By "microcephalus" is meant unnatural smallness of the head due to imperfect development. Marked microcephalus is not a common condition, but it is an occasional cause or associate of idiocy. A child may be born with a skull completely ossified even at the fontanels, or the ossification may become complete soon after birth, but in many cases of microcephalus ossification takes place late or not at all. In microcephalus the face is usually fairly well developed; the jaws are prominent; the forehead is flat; the cranium and brain are small; the convolutions of the brain are simpler than is natural; there is apt to be marked asymmetry of the two sides of the brain; internal hydrocephalus may exist; areas of sclerosis and atrophy are common; porencephaly is not unusual. Some patients have perfect motor power; others are slow and inco-ordinate. Epilepsy, chorea, and athetosis frequently complicate the case. Idiots of this type often present deformities such as cleft palate, strabismus, distorted ears, hypertrophied tongue, deformed genitals or extremities, ill-shaped and irregularly developed teeth. They exhibit irregular muscular movements, are frequently paralyzed in childhood (infantile paraplegia or hemiplegia), and suffer from subsequent contractures. They are apt to be active, destructive, excitable, and are liable to be violent and almost demoniacal. As Clouston says, they look impish and unearthly.

Treatment.—Skilled training in a school for the feeble-minded or in an institution for idiots is necessary in treating microcephalic idiocy. Idiots have but little power of attention, and sensory impressions give rise to but few concepts, and these are feeble and fleeting. In order to educate the idiot it is highly desirable that speech be acquired, and "the more strongly the attention can be aroused, the more perfect does speech become" (Kirchhoff). The principle of the education of idiots is to stimulate, co-ordinate, and guide sight, hearing, feeling, taste, and smell.

Lannelongue, of Paris, suggested an operation for idiocy with premature ossification (see Linear Craniotomy, page 792). In this procedure the author has no confidence. Idiocy is a general disorder and not a local brain disease. Soft parts mold bone, and bone does not control soft parts. The cranium does not enlarge because the brain stops growing. There is no evidence that the brain is being compressed; in fact, the simplicity of the convolutions suggests the contrary. In many typical cases of microcephalic idiocy there is no synostosis even years after birth. The operation has been much abused. It is sometimes fatal, and, although a fatality may gratify the family, a surgeon should not be a legal executioner. The remarkable improvement which has been reported in some cases is wrongly supposed to be due to the operation. As a matter of fact, the new surroundings, the strange faces, the firm discipline, the effect of the anesthetic, and the shock of the operation attract the feeble attention and rouse the sluggish senses. Many cases are brought for operation because they are for the time being unusually intractable and excitable, and the return to the usual level of conduct after operation is regarded as a permanent gain, when it is often but a temporary alleviation. We believe that scientific training is the proper treatment, and that the efficiency of training is not increased by the previous performance of craniotomy, and we follow the precept of Agnew, that a surgeon might as well cut a piece out of a turtle's back to make a turtle grow as to cut a piece out of the skull to make the brain grow. It would be as wise to take a piece out of the dome of a cathedral to increase the stature of the dean and chapter.

Diseases and Malformations Involving the Brain.—Cephaloceles.—A cephalocele is a congenital protrusion of intracranial contents through a defect in the skull. These protrusions are covered by skin. The defect through which the protrusion occurs is always in the median line, although in some cases (as at the inner angle of the orbit) the visible protrusion may be at the side. Nearly all such protrusions are either frontal or occipital, although now and then one presents in the pharynx, having emerged from the skull between the body of the sphenoid and the ethmoid.

Frontal cephaloceles are divided into:

1. Nasofrontal—those which are in the region of the glabella.
2. Naso-orbital—those at the inner angle of the orbit (Fig. 615).
3. Naso-ethmoidal—those below the nasal bone.

Each one of the above forms passes through the horizontal plate of the ethmoid.

Occipital cephaloceles are divided into:

1. Superior—those above the external occipital protuberance. In them the bony gap may join the posterior fontanel.

2. Inferior—those below the external occipital protuberance. In them the bony gap may join the foramen magnum.

The above regional classification is that advocated in von Bergmann's "System of Practical Surgery" (translated and edited by Wm. T. Bull and Walton Martin).

The commonest form is hydrencephalocele, and all other forms result from retrograde change in this.

Hydrencephalocele.—This is by far the commonest and is also the most dangerous form encountered. The protrusion consists of pia-arachnoid, a layer of brain tissue, and a cavity containing ventricular cerebrospinal fluid and connected with the lateral ventricle. It is, in reality, a protrusion of the lateral ventricle. It is covered by skin—natural skin—unless the protrusion is very large, in which case the skin is more or less atrophied. Beneath the skin is fascia, and beneath this, arachnoid. The pericranium and dura do not cover it, but each has a gap in it and these two tissues join each other around the bone margins.

Encephalocele results from retrograde changes in a hydrencephalocele. The protrusion of the ventricle has become reduced and the hernia consists of a portion of brain covered by pia-arachnoid. Encephalocele is only seen in the nasofrontal region. If there is any fluid in this protrusion it is not in its interior, but on its surface, and results from a cyst of the arachnoid.



FIG. 615.—Frontal meningocele (author's case).

Meningocele.—We formerly understood by a meningocele a protrusion of the membranes alone; we now regard it as a condition resulting from retrograde changes in an encephalocele. The brain tissue of the latter disappears; beneath the arachnoid is a layer of cells identical with those which line the ventricles; the connection with the ventricle is entirely or almost completely cut off; a cyst may form in the subarachnoid tissue, and thickened pia surrounds the cyst. (See "System of Practical Surgery," by E. von Bergmann, vol. i, translated and edited by Wm. T. Bull and Walton Martin.)

Diagnosis.—The congenital origin and situation make certain that the condition is cephalocele. The bony gap can usually be felt; whether it can or cannot, an *x*-ray picture should be taken. Such a picture may indicate that the mass contains brain matter. The protrusions vary greatly in size and shape. Some are rounded, some are flattened, some are stalked. The skin covering them may be natural, atrophied, filled with vessels, scarred, or ulcerated. Sometimes the cephalocele is very tense; sometimes it is loose. In naturally hairy regions the skin over the summit of the protrusion is bald, but that around the base is hairy. If there is connection between the interior of the protrusion and the ventricle, the mass can be diminished in size by compression. If it shrinks rapidly from compression, the opening into the ventricle is large. In such cases compression of the mass quickly causes signs of cerebral pressure. Lumbar puncture may cause the protrusion to diminish in size; crying may cause it to increase in size. Large cephaloceles fluctuate and perhaps pulsate. Meningocele feels and looks like a cyst (is translucent and fluctuates); it does not usually pulsate, it has a small base, it becomes tense on forcible expiration, and some cases can be very slowly diminished by compression.

Encephalocele is small, opaque, does not fluctuate, has a broad base, does pulsate, becomes tense on forced expiration, and attempts at reduction fail and cause pressure symptoms.

Hydrencephalocele is larger than a meningocele, is translucent, fluctuates, rarely pulsates, is pedunculated, is rendered a little tense on forced expiration, and can be lessened in size by compression, but cannot be reduced.

Treatment.—In von Bergmann's "System of Practical Surgery" we are cautioned to attempt no operation for an occipital protrusion beneath the protuberance when the cleft enters the foramen magnum and is associated with cleft of the cervical vertebræ—for a condition in which the soft parts are defective and the brain is exposed (*cranioschisis*)—on a case complicated by hydrocephalus or on a case complicated

by some other condition which is of necessity fatal. We no longer refuse to operate because the cleft enters the foramen magnum, the vertebræ being sound (I succeeded in such a case), because the mass contains some brain matter, or because it communicates with the ventricle, although if it does so, the prognosis is much worse. For a large hydrencephalocele nothing can be done and early death is inevitable. In rare instances an encephalocele is converted into a meningocele, and the bony aperture closes, thus bringing about a cure. Among the expedients for treating meningocele are electrolysis, injection of Morton's fluid (10 gr. of iodin, 30 gr. of iodid of potassium, 1 oz. of glycerin), pressure, and excision. In cases of cephalocele, when portions of the nerve-centers are not contained in the sac, A. W. Mayo Robson advises the performance of a plastic operation. He ligates the neck of the sac, excises the sac, sutures the skin-flaps separately, and leaves the stump outside the line of superficial sutures. It is usually possible to tell by palpation if nerve-centers are in the sac, but if in doubt, make an exploratory incision, and sweep the finger around inside of the sac.[1] Meningoceles should be operated upon by Robson's plan.

Spurious Meningocele.—It occasionally happens, after a fracture of a child's skull, that cerebrospinal fluid gathers beneath the pericranium and bulges the pericranium and scalp. This condition is called spurious meningocele. When a spurious meningocele forms, the bone must have been broken and the dura and arachnoid ruptured. This protrusion fluctuates, pulsates, and is influenced by respiration. In some cases there is communication with the ventricles of the brain. The parietal and frontal regions are the most usual seats of the trouble. The opening in the skull may close; it may remain stationary; it may actually enlarge by bone absorption. In some cases the spurious meningocele undergoes spontaneous cure; in some cases rupture occurs; in other cases death takes place as a result of the cerebral injury. (See Joseph Sailer on "Spurious Meningocele," "University Med. Magazine," Sept., 1900.)

Treatment.—Close the opening by a plastic operation.

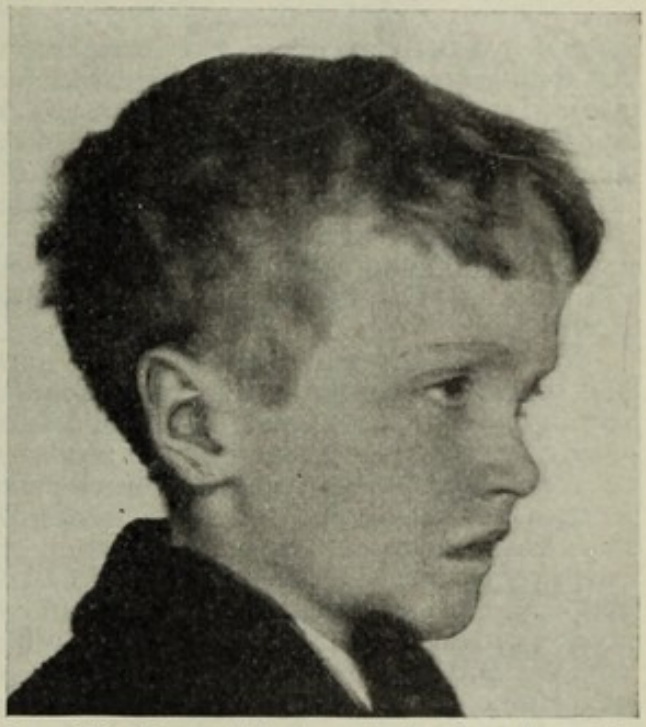


FIG. 616.—Internal hydrocephalus (brought to Dr. DaCosta's clinic by Dr. Lucas).

Hydrocephalus.—In *external* hydrocephalus the fluid is on the surface of the brain; in *internal* hydrocephalus the fluid is in the ventricles. Hydrocephalus may be *acute* or *chronic*, *congenital* or *acquired*.

Acute hydrocephalus is usually internal, but may be external. It results from meningitis—usually tuberculous meningitis of the base. The symptoms are headache, elevated temperature, delirium, stupor, convulsions, paralysis, and choked disk.

Treatment of acute hydrocephalus by medical means is of no avail. Tapping of the ventricles may be tried. Drainage of the cisterna magna has been suggested.

Chronic internal hydrocephalus is usually congenital, but may arise after birth in children under seven. In congenital hydrocephalus the condition may be due to circulatory disturbances in the brain of the embryo resulting from uterine disease or injury during pregnancy. Syphilis and alcoholism in parents seem sometimes to be responsible. Chronic acquired hydrocephalus may result from inflammation, especially tuberculous inflammation. A tumor pressing on the veins of Galen or blocking the aqueduct of Sylvius may cause it. In chronic acquired internal hydrocephalus there is overproduction or underabsorption of cerebrospinal fluid and perhaps both conditions may exist. As absorption is from the subarachnoid space, any block which keeps ventricular fluid from reaching that space causes hydrocephalus. The usually causative condition of congenital hydrocephalus is an inflammation of the interior of the ventricles,

[1] "Amer. Jour. Med. Sciences," Sept., 1895.

particularly of the choroid plexuses, and as a consequence venous return is obstructed and oversecretion occurs. In very rare cases one or both foramina of Monro may be closed, and if only one is closed, unilateral hydrocephalus may arise (Alfred S. Taylor in "Amer. Jour. Med. Sciences," Aug., 1904). The aqueduct of Sylvius may be blocked. The foramen of Magendie and the foramina of Luschka, or the central canal of the cord may be, but seldom are, occluded. Guthrie ("Practitioner," July, 1910) studied 182 cases of meningitis at autopsy. In about 40 per cent. of the tuberculous cases and in 56 per cent. of the non-tuberculous cases hydrocephalus existed. A tumor may cause hydrocephalus by directly obstructing the flow of fluid from the ventricles, but a tumor far away from such a position may cause it by so increasing the intracerebral tension that the brain stem is forced down into the foramen magnum. Such a position of the pons and cerebellum cuts off the flow of cerebrospinal fluid between the subarachnoid spaces of the brain and cord. Thomas produced internal hydrocephalus in animals by injecting into the ventricles an insoluble material known as aleuronat. Chronic inflammation ensued, obstruction and hydrocephalus followed ("Jour. of Exper. Med.," 1914, xix). Thomas says the obstruction may occur in the foramen of Monro or the aqueduct of Sylvius but occurs most frequently in the foramen of Magendie. Dandy and Blackfan ("Beitr. z. klin. Chir.," 1914, xciii), after elaborate experiments, concluded that an obstruction placed in the Sylvian aqueduct causes internal hydrocephalus even after extirpation of both choroid plexuses. This proves that fluid is produced within the ventricles more rapidly than it can be absorbed from them. Internal hydrocephalus also results from ligation of the great vein of Galen near its point of origin, but does not from distal ligation of the vein or from ligation of the straight sinus (collaterals save the situation). The chief but not the only sources of cerebrospinal fluid are the choroid plexuses of the ventricles. It is formed by processes of secretion and filtration. The amount of the fluid is increased by venous congestion and by the administration of pilocarpin. Hydrocephalus then may be due to a block or to oversecretion (in cardiovascular disease, renal disease, or chronic inflammation).

Production and absorption should go on hand in hand, the entire amount of the fluid should be changed within twenty-one hours, the lymphatics play only a small part in absorption, the bulk of the fluid is taken up by the venous sinuses from the subarachnoid space. There is almost no absorption from the ventricles. If there is not free communication between the ventricles and the subarachnoid space the just balance between absorption and formation is destroyed and fluid accumulates in and distends the ventricles. The communication is made by the valveless foramina in the fourth ventricle, the foramen of Magendie and the two foramina of Key and Retzius (called also the foramina of Luschka). In congenital hydrocephalus the cranium enlarges enormously and the bones of the skull are widely separated before closure of the fontanels and ossification of some of the sutures. The head becomes globular. At birth Holt considers 14 inches as the normal circumference of the head and at one year of age 18 to 19 inches. In a case of hydrocephalus the circumference at four months was 24 inches. The brain is distended and thinned and the sulci are obliterated. The broad, high forehead overhangs the eyes; the fontanels are elevated (in rickets they are depressed). The fontanels are open and pulsate, and the sutures are open. Normally the posterior fontanel cannot be felt after the second month, the anterior, after the eighteenth month. In hydrocephalus these natural gaps enlarge. The head usually exhibits a scanty growth of hair and the scalp veins are large. In marked cases the head is translucent and fluctuation can be elicited. For a considerable time intelligence is but little impaired, but if the case progresses idiocy is almost certain. There may be nystagmus, squint, deafness, optic atrophy, convulsions, flaccid paresis, or spasticity. Ninety per cent. die in the first year or so of life. The child cannot support the head as early as the normal child. Normally at the fourth month a child can sit erect if the trunk is supported, and by the seventh month can sit erect and support the trunk for several minutes. The patient learns to walk late if at all. Speech development is slow. The pupils are usually sluggish. In a very few cases hydrocephalus is arrested and the person grows up. In such a person there is usually weakness of mind or actual idiocy. If a block exists between the lateral ventricles and the subarachnoid space, material injected into a ventricle will appear late in the fluid of the subarachnoid space of the spinal cord. A solution of phenolsulphonephthalein is injected into the ventricle by way of the anterior fontanel. Normally it appears in the cord fluid in five minutes. If there is a block it will not appear for thirty to fifty minutes. A block can be located by injecting air into the ventricles and

taking a skiagraph. Indigocarmin, which rapidly colors the fluid, may be used instead of phenolsulphonephthalein. It is much less irritant. If there is no block we decide that the condition is due to insufficient absorption. In 1918 Dandy, of Johns Hopkins, described a valuable method for detecting early hydrocephalus. Air is injected into the ventricles and *x*-ray pictures are taken. If a block exists its situation is indicated ("Annals of Surgery," July, 1919). The child is mentally weak or is an idiot, and very often does not learn to walk or to talk. Convulsions, palsies, and contractures are common, and blindness is frequently present. Such children usually die young. Any case of chronic hydrocephalus may develop evidences of hypopituitarism. In such a case it is probable that the distended third ventricle presses upon the hypophysis. There may be adiposity, undeveloped genitalia, scantiness of hair or some hairy overgrowth, and optic atrophy. Hemianopsia does not occur, a fact which at once marks off these cases from tumors of the hypophysis. (See Lewis J. Pollock in "Jour. Amer. Med. Assoc.," Jan. 30, 1915). Temple Fay and Francis C. Grant ("Jour. Amer. Med. Assoc.," Feb. 17, 1923) have examined the interior of the ventricle in cases of hydrocephalus and have actually taken photographs of it. They employed an operating cystoscope which was introduced through the thinned cortex in a silent area.

The *treatment* of chronic hydrocephalus is rarely of much avail. Pressure by strapping with adhesive plaster has been tried. Tappings through a fontanel may be performed by means of a trocar (only 2 or 3 oz. of fluid being withdrawn at a time). If much fluid is allowed to flow out, the head must be strapped with adhesive plaster afterward. If the skull ossifies, the lateral ventricles may be tapped after trephining. It has been proposed to drain by tapping the theca of the spinal cord (Quincke). This last operation is called *lumbar puncture* (see pages 829, 830). It will, of course, fail if the foramina in the roof of the fourth ventricle or if the aqueduct of Sylvius are blocked. Even if they are open, the operation is of little service. The operation which promises most was devised by Sutherland and Cheyne, and is known as *intracranial drainage* ("Brit. Med. Jour.," Oct. 15, 1898). Their theory is that in hydrocephalus fluid distends the ventricles because the channels of communication between the ventricles and the subarachnoid spaces are closed. Prove this first as directed on page 732. The subarachnoid spaces communicate directly with veins, hence fluid cannot collect under pressure in these spaces. Intracerebral drainage establishes a communication between the subarachnoid space and one ventricle. It is not necessary to operate on both sides in bilateral hydrocephalus, because the lateral ventricles communicate. A small opening is made in the skull. The dura is incised. A number of strands of catgut, which are tied together, are pushed through the brain substance so that one end of the catgut mass lies in a ventricle and the other end is placed beneath the dura. The dura and scalp are then sutured. Brewer makes an osteoplastic occipital flap, also a dural flap, lifts the cerebral lobe, and pushes a drain of rubber tissue into a lateral ventricle.

The elder Senn passed a rubber tube into the ventricle and put the outer end of the tube beneath the skin of the scalp.

Alfred S. Taylor ("Amer. Jour. Med. Sciences," Aug., 1904) makes an osteoplastic flap with its base over the right mastoid, cuts a dural flap, passes a slender aspirating needle through the second temporosphenoidal convolution into the lateral ventricle, draws off a *little* fluid, and measures the thickness of the brain. He then takes 6 strands of No. 2 forty-day catgut, each strand $\frac{1}{2}$ inch longer than the thickness of the brain. The strands are tied together with a spiral of catgut, $1\frac{1}{4}$ inches of the loop being left free. Three layers of Cargile membrane are wrapped about the shaft, but the tip remains free. It is carried into the ventricle along the needle track by thumb forceps, and the loops are slipped here and there, but chiefly downward, under the dura. Cargile membrane is placed between the loops and dura and the dura and skin are sutured. Taylor operated on 6 cases and 2 recovered, with relief of all signs of pressure.

The cisterna magna may be drained. Cotterill actually opened the foramen of Magendie, and the patient distinctly improved ("Lancet," Nov. 12, 1910). Dandy put a drain in the aqueduct of Sylvius.

Cushing, after determining by lumbar puncture that the ventricles can be emptied, obtains retroperitoneal drainage by laparotomy, trephining of a vertebra, and thecostomy. Marmion establishes drainage from the ventricles into the highly lymphatic tissues about the parotid gland ("Zentralbl. f. Chir.," Aug. 12, 1911), and Payr, with the internal jugular vein, by means of a transplanted artery or vein ("Arch. f. klin. Chir.," Aug. 26, 1911).

Puncture of the corpus callosum has been recommended by Anton, Ringel, Tillmann, Stieda, Bramann, and others. The operation is called *ventriculostomy*.

The mortality is said to be less than 2 per cent. Any relief must be temporary, as the puncture cannot be kept open. The operation is performed as follows, according to Bramann: Expose the skull 1 inch posterior to the coronal suture and in the middle line. Make a small opening in the skull and make a small dural opening near to the margin of the sinus. Pass a cannula or sinus forceps into the longitudinal fissure. Carry it vertically downward guided by the falx and push it through the corpus callosum. Open the blades of the forceps or remove the mandrin of the cannula, enlarge the opening by moving the instrument gently to and fro, remove the instrument, and close the scalp wound (Binnie's "Operative Surgery").

In cases in which there is oversecretion from the choroid plexus thyroid extract may be given. Frazier and Peet showed that this material lessens secretion ("Amer. Jour. of Phys.," March, 1915).

Injuries of the Head

One of the most important subjects in surgery is that of head injuries. The frequency of their occurrence, their great fatality, the extraordinary recoveries that are sometimes encountered, the common difficulty in diagnosis, the drama which often leads to or accompanies them, combine to surround these cases with a peculiar interest.

Gross says: "It was long ago remarked by Mr. Pott, and the observation has been verified a thousand times since, that there is no lesion of the head so trifling, on the one hand, as not to endanger life, or so severe, on the other, that it may not be followed by recovery "("A System of Surgery").

Liston, in his Lectures on the "Operations of Surgery," sets forth the same idea more concisely. He says: "It has been said, and truly, that no injury of the head is too slight to be despised, or too great to be despaired of."

After every injury of the head an *x*-ray examination should be made. In many cases a fracture cannot be detected by any other method.

After any head injury symptoms and signs of compression should be watched for most carefully. If they arise and progress they are to be regarded as commands for surgical interference. Dilated retinal veins and increased pressure of fluid in the cord theca are early and important signs of pressure.

Lumbar puncture should be performed after head injuries. Bloody cerebrospinal fluid is very significant, though we can obtain clear fluid in some cases of early tapping after subdural hemorrhage.

Caput Succedaneum.—(See page 727.)

Cephalhematoma.—(See page 728.)

Scalp wounds bleed profusely because the scalp is very vascular, because many of the blood-vessels are in fibrous tissue and cannot contract and retract, and because even blunt force splits the scalp almost like an incision. Scalp wounds are treated as are other wounds. Even a large piece of scalp with only a narrow pedicle may not slough; hence try to save any piece that has an attachment. In a scalp wound always shave a wide area and disinfect the shaved area and the wound. Arrest hemorrhage, and exercise great care in cleansing the wound and the parts about it. Stitch the wound with silkworm-gut. Very few sutures are needed if the wound is longitudinal, but many are required if it is transverse. If the aponeurosis is divided, suture it with a layer of catgut sutures. Deep vessels are ligated. The permanent arrest of hemorrhage from the skin and subcutaneous tissue is rarely effected by ligatures, but rather by sutures judiciously placed. If drainage is required, use a few strands of silkworm-gut; but drainage is rarely used unless we know the wound to be grossly infected or unless the dangerous area (under the aponeurosis) was invaded. Wet antiseptic dressings are used for the first few days and moderate pressure is applied by wet gauze bandages. Avulsion of the Scalp is discussed on page 728.

Contusions of the Scalp.—Scalp swelling from hemorrhage is usually considerable. The patient may be stunned or dazed. The swelling of *hematoma of the scalp* must not be mistaken for *fracture* with depression. In hematoma there is a central depression; hard pressure on the center finds bone on a level with the general contour of the bone, and the margin of a hematoma is circular, is not quite hard, and is elevated above the general contour. In depressed fracture the edge is on a level with the general bony surface, the central depression is below the level of the general bony contour, and the margin is sharp and irregular. The **treatment** is by bandage pressure. Should suppuration arise, at once incise.

Concussion of the Brain.[1]—For Contusion and Laceration, see page 740. For many years it was customary to regard concussion as a condition produced by molecular vibrations in the nervous substance of the brain. Duret's classical observations profoundly modified surgical thought, and led to the opinion that in concussion of the brain there is injury to the brain itself, a rupture of cerebral vessels brought about by the advance and recession of waves of cerebrospinal fluid. The initial wave, it was thought, flowed in the direction of the force. Keen says that there may be slight brain injuries which can properly be called "concussions," but it is better to consider concussion as synonymous with laceration of the brain. Kocher considers concussion as identical with *contusion of the brain*. It seems, however, highly improbable that slight cases of concussion are accompanied by vascular rupture or organic mischief; the symptoms are too transitory and reaction too rapid and complete to permit of any such view. Experiments on animals show we can develop concussion without laceration or contusion. Autopsies have been carefully made in some cases of death from concussion, and no organic lesion has been discovered. It is quite true that the same force which causes the concussion may cause contusion, laceration, or multiple hemorrhages, and a severe force is apt to do so. But we are not then justified in assuming that concussion is contusion or laceration; we should rather conclude that the individual had both concussion and a demonstrable injury. Both conditions arise from violence, but the two conditions are not identical. I believe, with von Bergmann, that there is such a condition as concussion, which may be pure concussion or may be associated with organic damage, and even if a man dies and is found to have an organic injury, the concussion may have caused or, at least, have hastened the fatal result. I believe, with von Bergmann, that it is not repeated waves of force from the blow, but the concussion of the blow itself that does the harm. The brain is momentarily displaced by the blow. The blow acts on the entire brain; the centers are first stimulated and then depressed, and in fatal cases are not only depressed, but are paralyzed. The cause of concussion is violent force, either direct (as a blow upon the head) or indirect (as a fall upon the buttocks). This force momentarily displaces the brain, giving rise to stimulation and then to exhaustion of the nerve-centers, and perhaps to rupture of vascular twigs, large vessels, or even the membranes. In the less severe cases concussion only exists; in the more severe cases there is also contusion or laceration, and compression soon arises.

As von Bergmann points out, the entire cortex in concussion is momentarily stimulated and then depressed. The momentary stimulation exists when a man "sees stars" as a result of a blow. The depression or exhaustion is manifested by heaviness, dulness, stupor, perhaps by unconsciousness. The stimulation of the medullary centers, von Bergmann points out, lasts longer, as a rule, than the stimulation of the cortex, and is manifested particularly by a slow pulse. If the pulse grows rapid and weaker, the pneumogastric center is becoming exhausted and the patient is in danger of death. In slight cases of concussion the cortex only may be involved, the medullary centers escaping. In rapidly fatal cases of concussion the medullary centers are quickly paralyzed.

Symptoms.—In a very trivial case the patient "sees stars," is slightly and momentarily dazed and confused, is for a time pale, weak, giddy and nauseated, and the pulse is nearly normal and weak, but he is otherwise unaffected. In a rather slight case of brain concussion the patient may or may not fall; his face is pale; he feels weak, giddy, nauseated, and confused, but he soon reacts, and often vomits. In a severe case he falls down and lies in a state of complete muscular relaxation. He cannot stand up. The extremities are cold; the skin is pale and cold; the pulse is decidedly slow. The face is ghastly, the skin is cold to the touch, and lacks the flush and heat noted in compression. The slow pulse is due to stimulation of the pneumogastric center; the respiration varies, being sometimes deep, sometimes superficial, sometimes rapid, sometimes irregular, but not stertorous. He seems unconscious, but can usually be roused to monosyllabic response by shouting, pinching, or holding a bright light near his face. He does not originate an idea, does not volunteer a word, scarcely moves a muscle. Occasionally, however, there is complete unconsciousness, but in pure concussion it is of brief duration. The urine and feces are often passed involuntarily. The pupils may be unaltered, may be dilated or contracted, may be equal or unequal, but in any case they will react to light. Paralysis rarely exists, but if there be paralysis, it is temporary. The temperature at first is subnormal. In a very severe concussion in which there is great danger of death the pulse is very rapid, small, weak, and probably irregular because of exhaustion of the medullary center,

[1] See the author in "U. S. Naval Bulletin," Vol. x, No. 3.

and the patient is absolutely unconscious because of depression of the cortex. If a patient with very severe concussion and very rapid pulse is recovering, the pulse will become slower. If a patient with severe concussion and a slow pulse is improving, the pulse will become normally rapid; if he is getting worse, it will become abnormally rapid and weaker. Always perform lumbar puncture and make ophthalmoscopic examinations at intervals of from six to twelve hours. Bloody cerebrospinal fluid and dilatation of the veins of the disk are significant: the first, of subdural bleeding, the second, of compression. The pressure of the cerebrospinal fluid is to be taken by means of a mercury manometer. Normal pressure is in a child from 5 to 7 mm.; in an adult from 7 to 9 mm. Elevated pressure of the fluid means cerebral compression. How long may concussion last? As von Bergmann well says: Concussion is transient in its manifestations. It is a matter of a few minutes or, at most, a few hours, and any prolongation of severe symptoms beyond this time, especially if they are intensifying as time goes on, indicates an associated injury. When the patient reacts from concussion he will probably vomit. Within twenty-four hours he usually improves greatly, but is feverish and complains of headache and lassitude, sometimes becomes delirious, and in rare cases develops mania. If the patient in concussion recedes from, instead of advances toward, recovery, coma will set in or inflammation may develop. The prognosis is always uncertain. Any force producing more than very temporary unconsciousness has almost surely caused a serious injury, and considerable contusion or laceration has probably occurred. Recovery from concussion may be complete and permanent, but, on the contrary, the entire nature may undergo a change. Such a change, which may not be evident for weeks or months, is apt to be manifested by egotism, selfishness, censoriousness, mendacity, great irritability, outbreaks of violent rage about trivial things, and forgetfulness. The forgetfulness is particularly as to recent events (see below). There are headaches, flushing of the face, insomnia, attacks of depression, lassitude, and vertigo. Such a patient is very susceptible to alcohol, the heat of the sun, and physical or mental strain. He can do nothing requiring mental effort, and cannot attend to business. He may get in trouble with the authorities by committing violent assaults or other criminal acts.

After a head injury a patient may develop hysteria, epilepsy, chorea, athetosis, amnesia, or actual insanity. A condition resembling Korsakow's psychosis may develop (a condition of confusion with gaps in memory which are filled up spontaneolusy by fabrications, the patient perhaps also having multiple neuritis), confusional insanity, or mania may arise, or a condition like hallucinatory paranoia or mental weakness, which may resemble paresis. Concussion may pervert or wipe out all memory of the causative accident and also, strange to say, of a varying period preceding the accident. The loss of memory of the accident is permanent; the amnesia for a period preceding the accident may be permanent or may only be temporary. Statements made regarding an accident by one who has had concussion must be received with many grains of salt. A man may tell a story he believes himself, and yet it may be a mass of dream fancies without a word or with scarcely a word of truth. Victims of arteriosclerosis are particularly apt to develop mental trouble and neurasthenia. Régis insists upon this.

After concussion we may find sugar in the urine. We may find it also from fracture of the skull, compression of the brain, tumor of the brain, etc. It used to be thought that *traumatic diabetes* was the result of vasomotor disturbances which flooded the liver with blood and took quantities of glycogen into the circulation. From the islands of Langerhans in the pancreas comes a secretion which exerts control over carbohydrate metabolism. If that secretion is absent or is present in small amount the tissues cannot assimilate carbohydrates, those materials appear in the blood, the tissues break down, the glycogen stored up in the liver is swept into the circulation and diabetes exists.[1] The administration of adrenalin puts sugar in the urine, so does pituitary disease, so may thyroid disease.

Hypersecretion from these glands antagonizes the internal secretion of the pancreas and so causes diabetes. Traumatic diabetes is probably due to inco-ordination between the ductless glands. In all probability sugar in the urine after a head injury means that there is irritation of the floor of the fourth ventricle and also to the nerves that go to the suprarenals, and that as a result there is an increased formation of suprarenal secretion.

Traumatic diabetes is usually temporary. If it should last for a long time organic disease of the pancreas may arise and genuine diabetes begin.

Traumatic polyuria is common after head injury. Polyuria results from jarring,

[1] The author in U. S. Naval Bulletin, vol. 10, No. 3, 1916.

compression, or irritation of the posterior portion of the hypophysis cerebri. The excess of secretion causes polyuria. Traumatic polyuria is more common after fracture of the base than after pure concussion. When it occurs after fracture of the base there may have been actual laceration of or compression upon the pituitary body.

Treatment.—In treating brain concussion bring about reaction by the administration of aromatic spirits of ammonia (no alcohol, as this agent excites the brain) by pouring a few drops of ammonia on a handkerchief and holding it near the nose, by surrounding the patient (who lies in bed with his head on a pillow) with hot bottles, by hot irrigation of the head, by the application of mustard over the heart, and by the administration of enemata of hot coffee or of hot saline fluid. Do not pour fluid into the patient's mouth until he becomes able to swallow easily. If he cannot easily swallow, rely on hot enemata and hypodermic injections of strychnin. Place the patient in bed in a quiet room and watch him. If reaction is inordinate, apply cold to the head, give arterial sedatives and diuretics, and purge. For some days or for some weeks, according to the case, insist on a very quiet life. For many weeks after a grave concussion a patient must be kept away from business and be watched, because of the possibility of disturbance of the brain arising, and because of the liability of such patients to develop hysteria, neurasthenia, or insanity. Give a plain diet containing a minimum of meat, administer an occasional purgative, and secure sleep. Sleep can often be obtained by some simple expedient, such as the administration of warm milk, placing a hot-water bag to the abdomen or feet, or applying a mustard plaster for a short time to the back of the neck. In cases in which obstinate wakefulness exists, it becomes necessary to give bromid, chloral, sulphonal, trional, veronal, or some other hypnotic. Morphin is avoided because it is thought to increase venous congestion of the brain, but the elder Gross often used it, especially in cerebral irritation. If signs of compression arise, it is best to trephine, as the compressing agent may be a clot (see page 740). If inflammation arises, some surgeons will not trephine; but most regard it as wise and proper, especially if the damage seems to be localized, to incise the scalp and inspect the bone. If a fracture is discovered and the symptoms are serious, perform an exploratory trephining, open the dura, and secure drainage for inflammatory products. Personally, I believe that trephining for drainage is indicated in such cases even when there is no fracture.

In any severe concussion of the brain with contusion of the scalp the surgeon should at once incise the scalp and inspect the bone.

Compression of the Brain.—The combination of symptoms indicative of cerebral compression may be present in a number of different conditions. We find these symptoms in abscess of the brain, tumor of the brain, intracranial hemorrhage, foreign bodies, inflammatory exudate, fracture of the skull with marked depression, laceration of the brain, contusion of the brain, and edema of the brain. The symptoms of compression are expressive of impairment of the functions of the entire brain by insufficient and imperfect circulation of blood, this impairment of circulation being the result of a lessening in capacity of the cavity containing the brain, its membranes, the blood-vessels, and the cerebrospinal fluid (von Bergmann). Duret injected wax within the cranium of an animal and showed that a diminution of 5 per cent. in the intracranial capacity produced somnolence, and a diminution of 8 per cent. caused death. If a brain tumor, abscess, blood, blood-clot, cerebrospinal fluid, products of edema, or a portion of depressed bone occupies space previously given to brain matter, vessels, etc., there is less room within the skull to contain the special structures. The bones cannot yield, the brain is incompressible, so the cerebrospinal fluid is displaced, the vessels are squeezed, and the circulation is greatly impeded. Pressure upon either arteries or veins causes the condition called compression (Figs. 617, 619). This condition of cerebral pressure or compression is one of anemia. In reality it is compression of the vessels which feed the brain with blood, and such compression grievously disturbs the normal relationship between the blood-supply of the brain and the circulation of cerebrospinal fluid. Compression begins in obstruction to the onflow of venous blood. It extends gradually to the arteries. The circulation is slowed, and because of slow circulation the activity of the centers is finally inhibited. It is stated by Cushing that the rise which occurs in the blood-pressure is conservative and is expressive of nature's effort to maintain the circulation in the compressed medullary centers. Increased vascular tension is made manifest by estimating the blood-pressure and observing venous stasis in the optic disk. Increased tension of cerebrospinal fluid is shown by lumbar puncture. The fluid flows out rapidly or jets out. The cortex is temporarily stimulated and then depressed, because of impairment of nutrition.

The medullary centers are first stimulated. The respiratory center is stimulated by retention of CO_2 in the blood, then the vasomotor center is stimulated, then the vagus, and finally, perhaps, the convulsive center (von Bergmann's "System of Practical Surgery"). The stimulation of the cerebral centers is followed after a time by weakening or actual paralysis. The centers are said to suffer in regular order, viz., the cortex, the corona radiata, the gray matter of the cord, and, finally, the medulla (Huguenin). As von Bergmann points out, by the time the convulsive center becomes stimulated the cortex is usually exhausted and the patient is unconscious. In compression the sensitive cortex first feels the effect and feels it most gravely, and the cortical impairment may last long after other trouble has passed. In some cases the cortex alone seems to be distinctly involved. When the vagus center is stimulated the pulse becomes slow; later, as the center becomes exhausted, it becomes rapid and weak, and this change has the same unfavorable significance as in concussion. If death occurs it results from paralysis of respiration and not of circulation. The displaceable cerebrospinal fluid is a great safeguard against compression, but Cushing has shown us that in intracranial obstruction of the venous circulation the flow of cerebrospinal fluid into the space about the cord may be prevented because the medulla and cerebellum are jammed down in the foramen magnum.

Symptoms.—*Pressure symptoms* are divided into those occurring during the period of stimulation and those occurring during the period of increasing exhaustion. The symptoms of the first stage are headache, vomiting, flushing of the face, contraction of the pupils, choked disk, mental excitement, elevation of blood-pressure, restlessness, and slowing of the pulse. The pulse becomes slow, regular, and strong. The symptoms of the second stage are heaviness, dulness, drowsiness, passing into stupor, and finally into coma. The respirations are stertorous and after a time become Cheyne-Stokes. The pulse becomes weak, intermittent, compressible, and increasingly rapid. There are involuntary evacuations of feces and urine, and finally paralysis of respiration which causes death, the heart beating for a time after respiration has ceased (von Bergmann's "System of Practical Surgery").

The *headache* usually present in the first stage of compression is intense, persistent, sometimes general and sometimes more or less localized, and often aggravated by percussion of the cranium. It persists even in delirium, and the patient ceases to appreciate it only when unconsciousness begins. The *vomiting* is usually without nausea and is due to stimulation of the medullary center. At first vomiting may arise from taking food, but it soon continues independent of food. The tongue is probably clean. Cerebral vomiting is usually associated with severe headache. *Restlessness* is a pressure symptom in the stage of stimulation, and the patient rolls his head, tosses his body, and groans with pain. The *heart* does not begin to slow until the patient begins to be dull and drowsy, or until stupor arises, when the pulse slows and the tension rises. Finally it becomes very slow—perhaps less than 50 or even 40 in a minute. A very slow pulse is ominous, as edema of the medulla is apt to arise. If the condition grows worse, the slow pulse after a time suddenly becomes rapid and of low tension, instead of slow and of high tension, a most unfavorable sign, indicating exhaustion and approaching paralysis of the vagus. In the stage of stimulation the patient is excited, unstable, delirious, and the condition of delirium gradually gives way to drowsiness, stupor, and coma. In some cases of compression there is distinct protrusion of the eyeballs. Before the patient becomes unconscious the pupils are contracted. When the patient is comatose, they are usually dilated, but may be contracted. In coma the pupils respond slowly to light or not at all. If the conjunctival reflex is gone, they will not respond at all (Gowers). In a lesion making unilateral compression toward the base the pupil on the side of the compressing cause is apt to be much dilated and even immobile. *Choked disk* begins in the stage of stimulation and continues to the end. That choked disk is due to intracranial pressure seems demonstrated by numerous operation reports, especially by Cushing, of Harvard, in which relief of pressure lessened the degree of choked disk (see page 770). The existence of choked disk is determined by the use of the ophthalmoscope. In every case of traumatism repeated ophthalmoscopic examinations should be made. In traumatic cases dilatation of the veins and blurring of the disk margins may be observed and finally choked disk. Some observers regard ophthalmoscopic examination as giving the earliest evidence of compression. I believe that a lumbar tap gives very valuable early evidence. If compression exists the fluid shows elevated pressure and will spurt from the needle. A lumbar tap may give valuable information, but is not free from danger. Patients have died from it. In such unfortunate cases death has resulted from depriving the brain of its

water-bed so that the organ rests on bone, or from the brain stem being jammed down in the foramen magnum. In an adult the normal pressure of the cerebrospinal fluid is from 7 to 9 on the mercury manometer. In a child it is from 5 to 7. The respirations become stertorous or snoring as coma develops because of the vibrations of the relaxed palate in the air-current, and the cheeks flap during expiration. As the activity of the respiratory center fails from increasing anemia, the respirations become shallow and infrequent, or, perhaps, of the Cheyne-Stokes type. Gowers defines Cheyne-Stokes breathing as "alternating periods of decreasing and increasing depth of breathing, separated by a pause" ("Lectures on Diseases of the Brain"). The *unconsciousness of compression* may be sudden or gradual, may be partial or complete. Apoplexy and many traumatisms cause immediate unconsciousness; the irritation of such a sudden lesion at once inhibits the cortex. A meningeal hemorrhage causes a gradually increasing unconsciousness. A brain tumor may cause heaviness, dulness, stupor, or, perhaps, after a long time, even coma. If compression comes on gradually, the brain more or less accommodates itself, and unconsciousness, if it occurs at all, is considerably deferred. A sudden increase of pressure may produce immediate unconsciousness. *Stupor* is partial unconsciousness, a condition in which a person lies as though asleep, though he may be aroused partially and temporarily when spoken to loudly and positively. In profound coma the limb reflexes are usually but not always diminished or lost. The superficial reflexes are impaired or lost. The muscles are flaccid and swallowing is impossible. In coma there is incontinence of feces and either incontinence or retention of urine. There may be the incontinence of retention. The *temperature* of a patient suffering from compression varies. In traumatic cases it may be at first subnormal and later normal or elevated. In inflammatory conditions it is elevated, except in abscess of the brain, in which it is subnormal, for a time at least, in half the cases. After an apoplexy it is for a time subnormal, but as shock passes away it becomes somewhat elevated. Any sudden compression causes shock and temporarily subnormal temperature. Lesions of the pons and medulla cause elevation—perhaps remarkable elevation—of temperature. In great or sudden brain compression complete coma always exists and there is no voluntary movement. In cerebral compression *paralysis* may exist, which may be very limited (monoplegia), may be of one side (hemiplegia), or may be general. In hemorrhage into the interior of the brain the unconsciousness is immediate or nearly so. In bleeding from the middle meningeal artery a period of consciousness intervenes between the injury and the coma, during which period blood collects and the coma comes on gradually. In compression from depressed fracture or from a foreign body the symptoms usually come on at once, but they may be deferred for some hours. Compression from inflammation or pus begins gradually after a considerable time has elapsed. The symptoms described as pressure symptoms are those of pure compression. When traumatism causes the condition the compression symptoms are mingled with those of concussion, or perhaps of contusion or laceration. The brain adjacent to any lesion causing compression suffers more than the brain distant from it. The blood-supply of the entire brain is affected, but the adjacent brain has its capillaries particularly and directly compressed. Hence limited paralysis is sometimes produced by compressing lesions. The course of compression depends on the nature and persistence of the cause. Great temporary pressure may produce no permanent harm. Moderately severe pressure may be recovered from even after weeks of stupor. Great pressure, sufficient to induce coma, if not relieved quickly, will cause death. Persistent cerebral symptoms after a head injury, when no obvious lesion can be made out, are probably due to edema of the brain.

Determination of the Cause of Coma in a Patient.—A diagnosis must be made between coma due to brain injury and the comatose condition of apoplexy, uremia, epilepsy, hysteria, diabetes, opium-poisoning, gas-poisoning, meningitis, lobar pneumonia, and alcoholic intoxication. In hospital practice cases of unconsciousness without a known history are frequent. In attempting to diagnosticate, examine carefully for any evidence of traumatism, and inquire as to accident, as to how and where the patient was found, if any fit occurred, and if a bottle or a pill-box was found near by or in the pockets. The surgeon should himself examine the pockets. Smell the breath to notice alcohol or opium, but always remember that an alcoholic is often a victim of Bright's disease, that a man with Bright's disease is liable to apoplexy, that a man may be stricken with apoplexy while he is drunk, and may fracture his skull by falling when under the influence of opium or of alcohol. The odor of acetone on the breath or in the urine indicates the existence of diabetes. Draw the urine with the catheter if any water is in the bladder. Examine the urine for albumin, acetone, and sugar,

and take the specific gravity. In doubtful cases of coma have an ophthalmologist use the ophthalmoscope. He might find optic atrophy, indicative of Bright's disease, or dilated retinal veins or even choked disk, indicating compression. The cerebrospinal fluid obtained by lumbar puncture should contain blood a few hours after a head injury if hemorrhage has taken place beneath the cerebral dura or in a ventricle of the brain. This test is valuable in fracture of the base of the skull, for in this condition cerebrospinal fluid is usually bloody, but it also becomes bloody after an ordinary apoplexy. If there is compression the manometer, used by means of lumbar puncture, records increased pressure of the cerebrospinal fluid. In *postepileptic coma* the temperature is never below normal, there are no unilateral symptoms, the condition resembles sleep, and after a time the patient can be aroused or comes to of himself. *Hysteric coma* occurs in boys and women; there are no objective symptoms, and the patient, though swallowing what is put into his mouth, cannot be aroused. In *uremia*, besides the condition of the urine (and always remember that a person with albuminuria is apt to develop apoplexy), there is a persistent subnormal temperature, and convulsions are prone to occur. There is perhaps edema of the legs, but paralysis and stertor are absent. In *apoplexy* hemiplegia exists, and the initial temperature is for a short time subnormal. A single convulsion may have ushered in the case. *Alcoholic unconsciousness* is often diagnosticated when apoplexy really exists. A man will smell of alcohol who has had one drink, but one drink will not produce coma. The temperature is subnormal. In any case of doubt some hours of watching will clear up the diagnosis. Regard a doubtful case as serious until the truth is clear. In *opium-poisoning* the pupils are contracted to a pin-point, the respirations are usually slow, shallow and quiet, and may be stertorous, but there is no paralysis. Always remember that hemorrhage into the pons will produce pin-point pupils, but it also causes paralysis (crossed paralysis if in the lower half of the pons) and high temperature with sweating. In opium-poisoning the temperature is subnormal. In *diabetic coma* the pupils will react to a very bright light, the temperature is subnormal, and the breath and the urine smell of acetone. (See Acidosis, page 106, and Diabetic Coma, page 105.) An ophthalmoscopic examination and lumbar puncture may furnish explanations of a doubtful case.

Treatment of Brain Compression (see page 741).—The treatment of brain compression depends on the cause. Hemorrhage (extradural or subdural) requires trephining and arrest of bleeding; coma from depressed fracture demands trephining and elevation; foreign bodies must be removed; abscesses must be evacuated; some tumors are to be removed. In many tumor cases the growth is not removed, but a decompression operation is performed (see page 793). In cerebral compression, if death is threatened by respiratory failure, institute artificial respiration and at once trephine over the supposed region of compression. Horsley has shown that irrigation of the head with hot water is of great value in bringing about reaction from shock in cases of brain injury.

Contusion and Laceration of the Brain.—In contusion blood-vessels have been ruptured and blood extravasated. In laceration cerebral tissue has been torn. Sometimes the brain is terribly torn or pulpified. There may or may not be a fracture. If there is a fracture, the brain injury is probably on the side of the bone injury. Without a fracture the brain injury may be on the same side, is often on the opposite side, but there may be injury on both sides. In some cases of laceration hemorrhage may cause compression. In any severe contusion or laceration edema soon occurs, medullary symptoms arise, and it becomes evident that compression has developed. The rather leisurely development of compression in edema cases is the reason why changes in blood-pressure are not so marked as in hemorrhage cases. Sachs points out that it is only when cerebral pressure increases rapidly that marked changes take place in blood-pressure ("Jour. Amer. Med. Assoc.," Dec. 29, 1923). An ophthalmoscopic examination may disclose tortuous veins and edematous disk margins. The pressure of the cerebrospinal fluid is elevated, as is shown by a spinal manometer. The patient may emerge partly from a concussion, may wander mentally, may be stuporous or unconscious. The pupils may or may not be irregular, the reflexes may or may not be aberrant on one side or on both sides, there may be an ocular palsy. Focal symptoms are rare. Commonly we find slow pulse and irregular or stertorous respiration. If the case is very grave the respirations become Cheyne-Stokes. If the patient is not unconscious there may be vomiting. If there is a basal fracture blood may drip from the ear, nose, or vault of the pharynx, or the stain of blood may be noticed back of the mastoid process or under the conjunctiva. If there is a severe cortical laceration there will be twitching and even general convulsions, or the patient will lie curled up

with the limbs flexed and eyelids shut, and will resist all attempts to open his eyes or mouth or to move his limbs (A. Pearce Gould's "Surgical Diagnosis"). Erichsen called this condition "cerebral irritability."

Treatment of Traumatic Compression.—No operation should be undertaken until shock passes off. Operations done upon patients *in extremis* can do no good, and are a reproach to surgery. Focal symptoms call for operation. If there is a compound or a depressed fracture, operation is necessary. Before operating on a case with severe compression bear in mind that after the dura has been incised the brain will bulge, and in so doing may tear itself disastrously. This may be perhaps prevented by a spinal tap (which in grave compression is dangerous), byat once tapping a ventricle, or, preferably, by the intravenous injection of a hypertonic solution of common salt as is practised in Prof. Frazier's clinic in the Hospital of the University of Pennsylvania. The method is as follows (Temple Fay in "Jour. Amer. Med. Assoc.," May 19, 1923): It is used when rapid reduction of pressure is imperative. Salt in the blood-stream withdraws fluid from the ventricles and tissue space, but the benefit is temporary and in a few hours pressure symptoms return. The salt solution may be given immediately before operation or when very high pressure is observed during operation. Fay says (Ibid.): "The intravenous injection of from 50 to 150 c.c. of a 15 per cent. sodium chlorid solution, covering a period of twenty minutes, has been found a great adjunct in exploratory craniotomies, especially when the dura is tightly distended and ventricular puncture is unsatisfactory or cannot be effected." As the effect of salt intravenously is transient, after an operation, if great pressure was found, Epsom salts by rectum should be used to keep pressure down (see below). Weed and McKibbon, in 1919, were the first to recommend hypertonic salt given intravenously for pressure. Fay (Ibid.) says that Foley and Putman confirmed these observations, and Haden, Cushing and Foley, and Sachs confirmed them clinically. The operation performed for many severe cases of compression is decompression. A compound fracture, of course, requires débridement and a depression demands elevation. Most fractures of the bone should be decompressed. The cases difficult to decide are the cases of brain edema with moderate pressure, the patient being mentally heavy, occasionally delirious, or in a state of cerebral irritability. In such a case repeated spinal punctures are of great value. Spinal puncture is dangerous if pressure is very high. I do not regard it as particularly dangerous when pressure is moderate. The amount of fluid to be withdrawn depends on the degree of pressure. Usually from 10 to 20 c.c. are withdrawn at a tap. The object is to lower the pressure to or approaching to normal. To do this it may be necessary to withdraw 30 c.c. or even more. If the next day the pressure is found to have risen, tap again. Taps are continued daily until pressure remains normal. Six or eight taps may be made, one each day and then one every second or third day until pressure remains normal (see article by Harry Jackson in "Jour. Amer. Med. Assoc.," Oct. 21, 1922). In addition to doing lumbar puncture give Epsom salts by enema every three hours for twenty-four hours. The solution used in Prof. Frazier's clinic consists of 3 ounces of crystals of magnesium sulphate dissolved in 6 ounces of water. It is introduced through a small, soft catheter (Temple Fay in "Jour. Amer. Med. Assoc.," May 19, 1923).

Intracranial hemorrhage may be either *spontaneous* or *traumatic*. In the vast majority of instances spontaneous hemorrhage comes from the lenticulostriate artery (Charcot's artery of cerebral hemorrhage), and produces apoplexy, a disease in the province of the physician, except in some ingravescent cases, for which ligation of the common carotid on the same side as the rupture has been advised. In adults traumatism is almost always the cause of a meningeal hemorrhage. The blood may flow from a sinus, from the middle meningeal artery or one of its branches, or from vessels of the pia. Traumatism during delivery is an occasional cause of hemorrhage from the middle meningeal artery (Richardiére) and a not unusual cause of hemorrhage from cortical veins. Violent paroxysms of coughing in whooping-cough occasionally produce extradural hemorrhage or subdural hemorrhage. George S. Brown reported such a case. He diagnosticated the condition and operated successfully ("New York Med. Jour.," April 25, 1903).

Traumatic Intracranial Hemorrhage.—Hemorrhage may take place: (1) between the bone and the dura (*extradural*); (2) between the dura and the brain (*subdural*), and (3) in the brain substance (*cerebral*).

Extradural meningeal hemorrhage arises usually from the middle meningeal artery or from one of its branches. A spicule of bone may penetrate a venous sinus and produce extradural hemorrhage, or a sinus may rupture. Rupture of the meningeal

artery or one of its branches is usually, but not always, accompanied by fracture (Fig. 617); in fact, in some cases not even a bruise can be found on the scalp. The ruptured vessel may be upon the opposite side to that on which the force was applied, hence the evidence of scalp injury is not a certain sign of the side of the skull involved. The accident may or may not cause temporary unconsciousness; but even if it does, from this unconsciousness the patient almost always reacts unless there are other grave injuries, and there is usually a *distinct period of consciousness* between the accident and the lasting coma, the coma being due to pressure from a continually increasing mass of extravasated blood (Fig. 619). If the main trunk or a large branch has been ruptured the period of consciousness will be short; if a small branch has been ruptured the period of consciousness will be prolonged for hours or perhaps for days. As the clot forms and enlarges the patient becomes heavy, dull, stupid, and sleepy; he sleeps so soundly he can scarcely be aroused, and snores loudly, and finally passes into stupor and then into coma. The other signs of this condition are paralysis of the side opposite the blood-clot (not necessarily of the side opposite the point of application of the force, for the artery may rupture from contrecoup on the uninjured side); this paralysis is apt at first to be localized, but it gradually and progressively widens its domain. If the clot extends toward the base, the pupil on the same side as the clot dilates widely and ceases to react to light (the immobile pupil). If the clot be on the left side of a right-handed man, aphasia may be noted. As the clot enlarges adjacent centers become involved. The face becomes paralyzed, then the arm, and finally the leg. Not unusually epileptiform attacks occur, starting in discharges from the centers which are irritated by the advancing clot before their function is abolished by pressure. The pulse becomes full, strong, usually slow, but occasionally frequent; the breathing becomes stertorous; the temperature rises, that of the paralyzed side exceeding that of the sound side. In a compound fracture the pressure of escaping blood may force brain matter out of the wound. In extradural hemorrhage from a sinus the symptoms cannot be differentiated from those produced by arterial rupture. If there is no free bleeding beneath the dura the fluid obtained by lumbar puncture will be clear. The ophthalmoscope and lumbar puncture disclose early and reliable signs of pressure. The *x*-rays make a fracture evident.

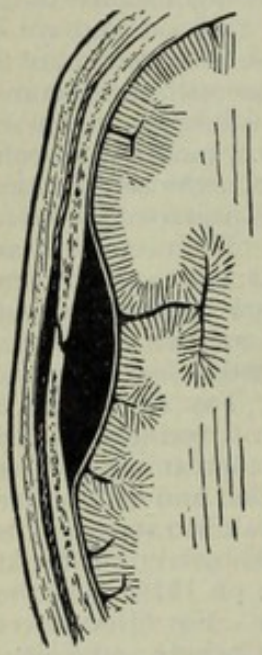


FIG. 617.—Fracture of skull with middle meningeal hemorrhage. Compression of brain by blood (Scudder).

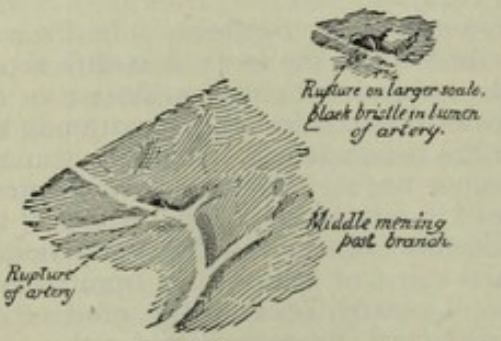


FIG. 618.—A case of rupture of the middle meningeal artery. Preparation of dura. In the Warren Museum. The specimen is viewed from the outer side (Scudder).

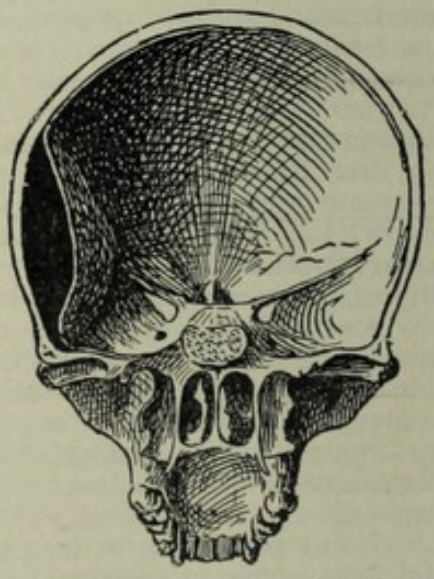


FIG. 619.—Frontal section of skull. Middle meningeal hemorrhage. The dura bulges inward toward the skull cavity (diagram) (Scudder).

Treatment.—In treating extradural hemorrhage localize the clot not by the seat of the wound or contusion, but entirely by the symptoms. In a doubtful case endeavor to bring about reaction; but if the state of shock deepens or does not improve and if pressure symptoms increase, operate at once. To reach the middle meningeal artery

or its anterior branch trephine 1¼ inches back of the external angular process, at the level of the upper border of the orbit (see Figs. 606, 613, 614). If the incision does not expose the clot, trephine again at the level of the upper border of the orbit and just below the parietal eminence (see Figs. 613, 614). The first incision gives access to the main trunk and to the anterior branch; the second incision exposes the posterior branch. If signs indicate that the clot is traveling to the base, the trephine should be used ½ inch lower than the point first directed. Arrest bleeding by silver clips, by suture ligature, by plugging the foramen spinosum, or by packing, and always open the dura and inspect the brain. By this procedure we may discover a subdural hemorrhage which otherwise might be missed. Drainage must be employed.

Subdural meningeal hemorrhage is usually due to depressed fracture and rupture of the middle cerebral artery or of a number of small vessels.

The *symptoms* are identical with those of extradural bleeding, but are usually very rapid in onset and are accompanied by a more distinct drop in temperature and graver depression. The cerebrospinal fluid obtained by lumbar puncture is usually bloody, but, strange to say, is sometimes clear for some hours.

I have fancied that headache is more violent before the onset of unconsciousness than it is in extradural hemorrhage. Pressure is detected early by ophthalmoscopic examination and by the lumbar tap.

The *treatment* is trephining for exploration at a point 1¼ inches back of the external angular process, enlarging the opening upward and backward by a rongeur, opening the dura, and allowing the blood or clot to run out. Hemorrhage is arrested by light pressure with a piece of freshly cut muscle laid upon the open vessel, or by ligating the bleeding point on each side of the tear. Elevate any depression of bone and stitch the dura with catgut. Hemorrhage from internal pachymeningitis requires the same treatment.

Cerebral Hemorrhage.—The *symptoms* of cerebral hemorrhage are identical with those of apoplexy. The *treatment* is the same as that for apoplexy, except in ingravescent cases, when the common carotid on the same side as the clot may be ligated.

Rupture of a sinus may arise without a bone injury, but is usually due to a fracture. A sinus may be wounded during a brain operation. The **treatment**, if the rupture happens from fracture, is trephining. Enlarge the bone opening by the rongeur, cut a piece of muscle from the temporal or some other muscle and hold it for a time against the bleeding point. If this fails, apply a lateral ligature or a suture ligature or catch the rent with hemostatic forceps, leaving them in place for three or four days. A gauze plug is a last resort. Its use may cause palsy and be followed by infection. Elevate depressed bone. If during an operation a sinus should be wounded, use a lateral ligature, a suture ligature, or, as a last resort, control hemorrhage by packing.

Intracranial Hemorrhage in the Newborn.—Ehrenfest shows that in at least 40 per cent. of all careful and thorough autopsies made of infants stillborn or those who died during the first few days after birth, some intracranial injury is disclosed ("Gynecology and Obstet. Monographs." Published by D. Appleton & Co.). Certainly most of the cases of birth palsy seen in children are the result of subdural and subarachnoid hemorrhage at birth and damage of the cortical motor area. In such conditions there is spastic paralysis of the hemiplegic type, or if both hemispheres suffered there is spastic diplegia and usually amentia (Cushing in "Amer. Jour. Med. Sciences," Oct., 1905). In some cases there is hemorrhage beneath the tentorium due to rupture of that shelf at its junction with the falx, the result of lateral squeezing. It has only recently been the custom to operate for hemorrhage in the newborn; most of the cases do not die, but remain for life weakened and paralyzed, choreic, epileptic, or idiotic.

The hemorrhage in cases of birth palsy is, as Cushing points out, usually venous and due to "rupture of some of the delicate and poorly supported venous radicles of the cerebral cortex" (Ibid.). It may result from traumatism due to bone overlapping or forceps pressure during parturition, or may arise during asphyxia after birth. Cushing discovered in examining stillborn infants and infants that died soon after birth that many of them died from cortical hemorrhage. In some the extravasations were very large, in fact, completely overlying a cerebral hemisphere. In some they were much smaller. In one the clot was in the cerebellar fossa.

The vessels usually torn are on one side and are often the unsupported venous radicles which enter the longitudinal sinus, hence the leg center of one side is the cortical area most apt to be gravely damaged. If the vessels of both sides are torn a bilateral cortical lesion results. The sinus itself may be ruptured.

Symptoms of Hemorrhage in the Newborn.—In Cushing's masterly paper (Ibid.) the symptoms of recent hemorrhage are set forth. There is the history of a long and

difficult labor, forceps perhaps having been used, or a history of postpartum asphyxiation. The head of the child may be unusually large. The birth-canal may be unusually small, as is found in contracted pelvis. Pituitrin may have been injudiciously ordered. Perhaps hyoscin, by delaying labor, has been responsible by rendering forceps necessary. The non-distensible soft parts of a primipara in middle life may be responsible. Syphilis and eclampsia are said to predispose. In some cases none of the above-named causes are evident. In them the condition may result from the alteration in pressure when the head emerges from the os uteri. In hemorrhage of the convexity the fontanel bulges and usually does not pulsate. Pressure upon the fontanel increases the respiratory embarrassment, makes the child scream, and may cause convulsions. The fluid obtained by lumbar puncture made a number of hours after birth contains altered blood-corpuscles or is stained by blood. There is usually twitching and, as a rule, convulsions occur. They may occur soon after birth or several days later. When they occur soon, they are apt to be general; when they occur later, they may be unilateral. Paralysis is rare in the early days after birth. There may be alterations in the circulation and respiration. Pupillary alteration and ocular palsy seldom occur. The child may squint and nystagmus may occur. H. C. Camerson says ("The Lancet," Dec. 15, 1923): "The ophthalmoscope has now entered the lying-in chamber, and it is said that 60 per cent. of the cases show retinal hemorrhages and that edema of the disk may appear. Inequality of the pupils, squinting, and nystagmus are common. The infants, as a rule, exhibit extreme restlessness and constant screaming, or there may be stupor and immobility. The increased tone of the muscles is very striking in most cases. There may be generalized rigidity with opisthotonos, trismus, clonic twitchings of individual muscles or groups of muscles, or generalized convulsions. If any part is stimulated with a slight flick, a characteristic violent twitch of the whole body results. But that which indicates most clearly the serious state is the impairment of the two reflexes vital to the child, the sucking reflex and the breathing reflex. The breathing may be slow and stertorous, or it may be rapid and shallow, or there may be ominous pauses in which the pulse continues to beat strongly. Some degree of asphyxia is the rule in all severe cases. Suction is not only poor and clumsy, as happens in many feeble, or premature, or excited, or mentally deficient infants, but the reflex is entirely absent. Pressure upon the dorsum of the tongue fails to produce the usual suction response." If the hemorrhage is below the tentorium the fontanel still pulsates, the neck muscles are rigid, stupor exists, and the respirations are very irregular. Of course a lumbar tap shows bloody fluid. If the child is not operated upon it may die or it may apparently recover. If it apparently recovers after a considerable hemorrhage, several months may pass before ominous symptoms are recognized. The late manifestations of the disease may be "spastic palsies, or blindness, or deafness, or feeble-mindedness, or, in severe cases, even complete amentia" (Cushing). Epilepsy may be a result.

Treatment.—If the motor area is involved, osteoplastic craniotomy should be performed in the parietal region, on one side or both, according to the unilateral or bilateral nature of the hemorrhage; the procedure consists in opening of the dura; washing out and turning out the clot; suturing the dura and closing the scalp without drainage. Both sides may require operation. Cushing reports 16 cases of operation, with 7 recoveries. He says chloroform should be given and that the soft parietal bone can be cut with blunt, curved scissors. If the hemorrhage is beneath the tentorium no operation is recommended, although some surgeons advise lumbar puncture.

For slight cases of spastic paralysis following hemorrhage tendon lengthening may be all that is required. Those late cases, "particularly of the hemiplegic and paraplegic types, which show signs of increased intracranial pressure by an ophthalmoscopic examination, are the cases that can be very much improved" by cranial decompression. Ramisectomy may amend spasticity.

Fractures of the Skull.—There may or may not be a wound or contusion of the scalp. A fracture may be *simple, compound, depressed, non-depressed,* or *punctured. Fracture by diastasis* means separation of a suture or of sutures by violence. A fracture of the skull may be produced by a *bending* force (Fig. 620), by a *bursting* force (Fig. 624), or by the force of a projectile (see Gunshot Wounds).

A bending force is usually applied by the forcible impact of a body of small area. It produces a fracture and seldom causes distant injuries. The fracture may be of the inner table only, or of both tables. If both tables are fractured the broken bone is displaced and remains so.

In fracture by bursting, lines of fracture run to distant points from the seat of ap-

plication of the force. Such an injury is inflicted by the impact of a flat surface of considerable area. In some cases we have a force which first is bending in character, but causes bursting also to occur, because there is no rebound.

Falls of large heavy objects or falls on the head, blows on the head from large flat objects, crushes in railroad accidents, etc., may burst the skull. In bursting fracture there is often wide-spread injury. The skull may be fractured during labor.

Fractures are divided into fractures of the *vault*, usually due to direct force or to extension from a fracture of the base, and fractures of the *base*, due to extension of fractures of the vault, to indirect violence (a fall upon the feet, the buttocks, or the vault), to forcing of the condyles of the lower jaw against or through the base, or to foreign bodies breaking through the orbit, vault of the pharynx, the ear, or the roof of the nostrils. *Fracture by contrecoup* was the name long given to a fracture which was supposed to occur on the side opposite the point of application of the violence. It is very doubtful if such a fracture ever occurs. I have seen meningeal hemorrhage by contrecoup, but not fracture. Contusion of the brain by contrecoup is common. Fractures of the skull are uncommon in early youth, but they are much more frequent in the aged. Usually the entire thickness of the bone is fractured, but either the outer or the inner table alone may be broken. In complete fractures the inner table is broken more extensively than is the outer table (Fig. 620), because the inner table is the more brittle, because the force diffuses, and also, as Agnew taught, because the inner table is part of a smaller curve than is the outer table, and violence forces bone elements together at the outer table, but tears them asunder at the inner table (Figs. 621, 622). The danger from a fracture of the skull does not depend upon the extent of bone injury, but does depend upon the amount of intracranial damage and the intensity of infection.

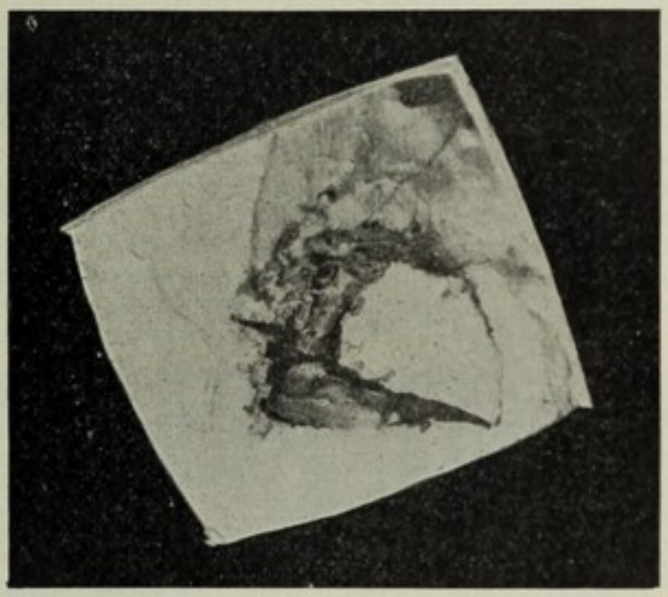


FIG. 620.—Fracture of the vault by bending force with extensive depression of the inner table ("American Text-book of Surgery").

Fractures of the Vault.—There is usually, but not always, severe concussion. Concussion symptoms are of brief duration. In every suspected fracture examine

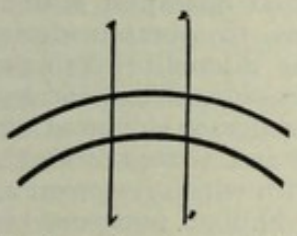


FIG. 621.—Section of outer and inner tables, with two parallel lines (after Agnew).

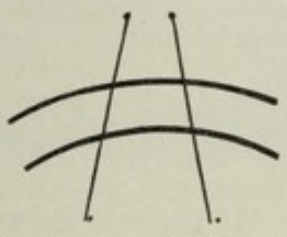


FIG. 622.—Greater yielding of the inner table than of the outer after the application of violence (after Agnew).

with the *x*-rays and *suspect* fracture in every head injury. A fracture may involve the vault alone, but in over 60 per cent. of vault fractures the base is involved. A fracture of the vault of the skull may be simple and undepressed, or it may be depressed (Fig. 620), compound, or comminuted (Fig. 623). A mere crack may exist in a bone, and if a rent exists also in the soft parts, a bit of dirt or a hair may be caught in the crack. Fractures of the vault arise from direct force. A *fissure* may escape recognition, although in some cases percussion gives a "cracked-pot" sound. This is known as *Macewen's sign*. The stethoscope is placed upon the glabella. Percussion with fingers or percussion hammer is begun over the parietal eminence and approaches the stethoscope. The same procedure is carried out on the opposite side of the head. Those who

would employ this method must make a study of percussion of normal skulls at different ages, etc. (see H. B. Wilcox in "Arch. Pediatrics," 1915, xxxii. He has thoroughly discussed this sign). Any considerable depression can be detected. In simple fracture occasionally, especially in children, the cerebrospinal fluid collects under the scalp and forms a tumor which pulsates and becomes tense on forcible expiration (see Spurious Meningocele, page 731). Compound fracture can be readily recognized, but do not mistake a suture, a wormian bone, or a tear in the pericranium for a fracture. A fracture bleeds, a suture does not. Even a narrow fracture is marked by a dark line of blood which *sponging will not remove*. Fracture of the inner table alone can only be suspected unless the *x*-rays make it evident. The prognosis of fracture of the vault depends upon the extent of intracranial injury rather than upon the extent of bone injury. Simple fractures may unite by bone; compound fractures with loss of bone unite by fibrous tissue only. The dangers may be *immediate* (hemorrhage, brain injury, and septic inflammation) or be *distant* (change of character, epilepsy, insanity, or persistent headache). In an open fracture the danger of infection is added to the danger of brain injury. A spinal tap may give valuable information. Bloody fluid means bleeding into the subarachnoid space or into a ventricle. Blood may not be found by an early tap, and yet be discovered by a tap made six to eight hours after the injury. The earliest sign of compression is increase of pressure as shown by a mercury manometer after a spinal tap. Another early sign is dilatation and tortuosity of the retinal veins. In simple fracture if we decide against immediate operation, have an ophthalmologist watch the eye-grounds for signs of beginning pressure, and if symptoms call for it, determine pressure by a lumbar puncture and a manometer. Pressure may be due to hemorrhage (extradural or subdural) or to edema of the brain. The fracture may be associated with hemorrhage from a sinus, the middle meningeal artery, pial veins, contusion of the brain, laceration of the brain, or multiple hemorrhages of the cortex. In any case brain edema may arise. Edema of the medulla causes slow and high tension pulse and respiratory disturbance.

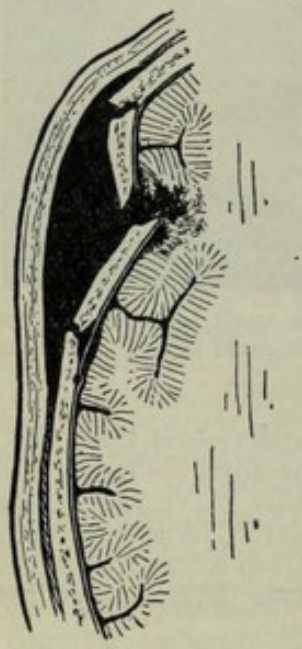


FIG. 623.—Comminuted fracture of skull with depressed fragments. Compression of brain by bone (Scudder).

Treatment.—The mortality of fracture of the skull was formerly much greater than at present. Before the days of antisepsis it was 51 per cent. (Harte). Trephining is performed much oftener than was once the custom, and is vastly safer. Out of 26 trephined cases, 3 died (Harte). In any case of fracture of the skull endeavor to bring about reaction before operating, unless the signs of pressure continue or increase. The prognosis is better in children than in adults and operation is not required as frequently. It is useless to operate during severe shock. Such operations bring discredit upon surgery. A *simple fracture without depression* and *without brain symptoms* is treated expectantly (by rest, quiet, low diet, moderate elevation of and cold to the head). *A simple fracture with moderate depression* and *without cerebral symptoms* is treated expectantly, and so also is a *simple fracture* with which *symptoms existed, but are abating*. If there is elevated pressure shown by lumbar puncture make daily spinal taps, and give enemas of Epsom salts every four to six hours (1½ oz. of the salt to 6 oz. of water). *Simple fracture with marked depression* requires immediate trephining, even when brain symptoms are absent. We make an exception in young children, and wait a while before trephining, in the expectation that the expansile brain will lift the depressed but elastic bone up to the level. Trephining in cases in which no symptoms exist, although there is marked depression, often prevents disastrous consequences arising in the future, and is known as *preventive trephining* (Agnew, Keen, Horsley, Macewen, von Bergmann, and others). In all *compound fractures* shave and cleanse the entire scalp, enlarge and excise the scalp wound, and explore the bone. Excise the margins of scalp and bone damage (débridement). If a fissure exists, it must be asepticized, and if a hair or other foreign body is found in it, in order to effect removal and secure asepsis the outer table of the skull at this spot must be cut away by a chisel, the fissure being thus converted into a broad groove. If there is a fracture, trephine if distinct symptoms exist. In punctured wounds of the brain (*punctured fractures*)

always trephine, open the dura, and disinfect (débridement). In a comminuted fracture the usual custom is to remove loose fragments. Schaak has recently advocated their reimplantation ("Archiv für klin. Chir.," April 6, 1912). My usual custom has been to remove them. In any case of fracture of the vault for which trephining has been performed it is wise to open the dura and examine the brain. In an open fracture and after every operation of trephining in which the dura has been opened administer urotropin in order to make the cerebrospinal fluid bactericidal.

Fractures of the Base.—A fracture of the base of the skull may exist in only one of the three fossæ, in two of them, or it may involve all. Figure 624 shows an extensive fracture of the base of the skull. The middle fossa is oftenest involved. Fracture of the posterior fossa is the most fatal. These fractures may be due to direct violence, to indirect force, and to extension of a fracture of the vault. Extension from the vault is always by the shortest route. Fractures of the base may extend up into the vault, and do so in over 80 per cent. of cases. Fracture by direct violence may arise from the penetration of the nasal roof, the orbital roof, or the pharyngeal roof by a foreign body. The posterior fossa may suffer from a fracture by direct violence applied to the neck. Fractures by indirect force may arise from blows upon the frontal bone (the orbital portion of the frontal or the cribriform process of the ethmoid breaking), from falls upon the chin (the condyle of the jaw breaking the middle fossa), or from falls upon the buttocks, the knees, or the feet (fracture occurring in the posterior fossa). The base is not broken by contrecoup.

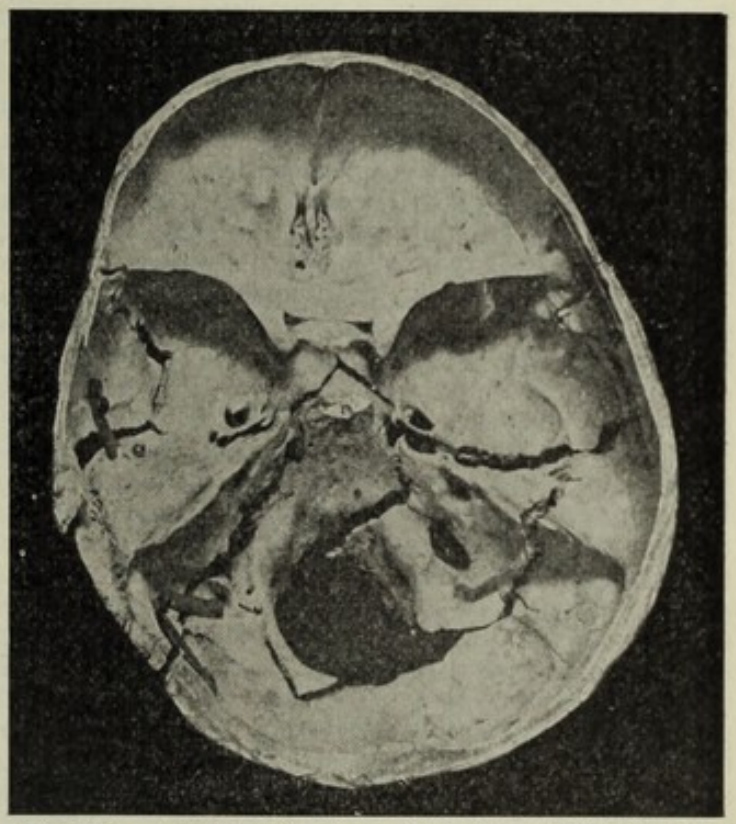


FIG. 624.—Extensive fracture of the base of the skull by bursting force ("American Text-book of Surgery").

Symptoms.—Fractures of the base of the skull are apt to be compound. A solution of continuity in the pharynx, roof of the nares, orbit, or ear permits access of air to the seat of fracture and allows blood and cerebrospinal fluid to flow externally. In *fracture of the anterior fossa* the fracture may be compound because of laceration of the mucous membrane of the nares or of the conjunctiva. Blood may run from the nose, its source being the vessels of the mucous membrane or the dura, the fracture being compound. Epistaxis does not prove the fracture to be compound, but only suggests it; but if the epistaxis is prolonged, the probability is greatly increased; and if the flow of blood is succeeded by a flow of cerebrospinal fluid the diagnosis of compound fracture is positive. A flow of cerebrospinal fluid from the nose is seldom observed or at least the fluid is seldom recognized. Cerebrospinal fluid appears only when the mucous membrane, the dura, and the arachnoid are all lacerated. In fractures of the anterior fossa blood is apt to flow into the orbit, producing *subconjunctival ecchymosis*, and perhaps pushing the globe of the eye forward. Some blood is often swallowed and vomited. In the middle fossa the bones are very thin and fractures are far more common in this region than in other parts of the base. In *fractures of the middle fossa* blood may flow from one ear or both ears. Blood obtains exit through a tear in the tympanum, its source being the vessels of the tympanum, the meningeal vessels, or a sinus. Blood may flow through the eustachian tube and come from the nose, may be spat up, or may be swallowed and vomited. In some cases a quantity of cerebrospinal fluid flows from the ear, the discharge being increased by expiratory effort and a position which favors gravity. Cerebrospinal fluid is at first blood stained, but later becomes clear. The flow of clear cerebrospinal fluid occurs in only a small

minority of the cases. The cerebrospinal fluid must not be confused with either blood-serum or liquor cotunnii. The cerebrospinal fluid, if it flows at all, is always present in large amount; the liquor cotunnii can be present only in minute amount. Blood-serum is highly albuminous; cerebrospinal fluid is a serous fluid of very low specific gravity, it is devoid of formed elements, never shows more than a trace of albumin, and contains considerable chlorid of sodium and a carbohydrate now known to be a dextrose which reduces the copper of Fehling's solution and reacts to Trommer's and to Moore's tests, but does not refract polarized light nor easily ferment with yeast. Treves[1] states that cerebrospinal fluid cannot flow from the ear in fractures of the middle fossa—(1) unless the line of fracture crosses the internal meatus; (2) unless the prolongation of the membranes into the meatus is torn; (3) unless a communication exists between the internal ear and tympanum, and (4) unless the drum membrane is torn. Miles, of Edinburgh,[2] claims that bleeding from the ear followed by a flow of cerebrospinal fluid is not pathognomonic of fracture of the middle fossa of the base. He maintains that when the drum is ruptured we may have these signs even when bone is not broken, the chief source of the blood being the vessels of the pia and temporosphenoidal lobe, the blood and cerebrospinal fluid flowing inside the sheath of the auditory nerve, passing into the vestibule, through the lamina cribrosa, and from the vestibule into the middle ear, finding exits from this space by way of the Eustachian tube and also through the rent in the drum membrane. Profuse mucous discharge may flow from the ear after an injury without fracture when the drum is ruptured, the fluid coming from the cells of the mastoid. It must be understood that fracture of the base may exist when there is no flow of blood or of serous fluid externally. A fracture of the middle fossa is usually compound, made so, even when the drum is not ruptured, by the Eustachian tube, and there is often paralysis of the seventh or eighth nerve or of both of them. In *fracture of the posterior fossa* there is usually respiratory derangement and blood accumulates beneath the deep fascia and produces discoloration in the line of the posterior auricular artery (*Battle's sign*), the discoloration first appearing near the tip of the mastoid. The discoloration appears in the line of nerves and vessels which emerge from the deep fascia, the vessels passing through openings and the extravasated blood emerging from the same openings. Fractures of the posterior fossa are apt to be compound through the pharynx, and in such cases the patient spits or vomits blood. Fractures of the posterior fossa are more fatal than fractures in either of the other fossæ because of the adjacency of vital centers. Fractures of the base are apt to be associated with *paralysis of cranial nerves*. The palsy indicates the situation of the fracture. In fracture of the anterior fossa the olfactory nerve may suffer. In fracture of the middle fossa the facial nerve most often suffers. The eighth is sometimes injured. Other nerves which may suffer alone or in combination in fracture of the base are the abducens, the motor oculi communis, the trigeminus, the pneumogastric, the optic, the spinal accessory, the hypoglossal, and the glossopharyngeal. *Optic neuritis* often arises after the first week. In fractures of the base the temperature is subnormal during the shock, rises to 100° to 101° F., falls again to about normal, and remains normal or subnormal unless there is inflammation or sepsis. Lumbar puncture may obtain bloody fluid. Such a finding means ventricular or subarachnoid bleeding and in the latter case indicates fracture. In any fracture injury of the brain may exist. Such an injury will be made manifest by symptoms, and we may or may not be able to diagnosticate and localize it. The prognosis is greatly influenced by the location, nature, and the extent of the intracranial damage. Harte ("Annals of Surgery," Oct., 1901) has collected 46 positive cases of fracture of the base of the skull from the records of the Pennsylvania Hospital; 35.5 per cent. recovered. Ransohoff collected 190 cases of fracture of the base of the skull. The mortality was 65 per cent. Over one-half of the fatalities were within twelve hours. Only 15 per cent. died after the second day. Of 98 cases with profound coma and respiratory disturbance, 70 per cent. died ("Annals of Surgery," July, 1910). According to Hartley, in cases treated expectantly the mortality is 90 per cent., in cases treated by operation it is less than 35 per cent. ("Amer. Jour. of Surgery," Dec., 1910).

Treatment.—In fracture of the base I now perform a subtemporal decompression, usually on both sides, as Cushing advocates. This is, first of all, exploratory, and may disclose a bleeding meningeal artery. After the dura is opened it enables us to evacuate fluid causing pressure and in which bacteria could multiply, and to prevent recurrence of pressure after the wound has been closed. If there is bleeding under the dura the

[1] "Applied Anatomy."

[2] "Edinburgh Med. Jour.," Nov., 1895.

brain should be lifted to let the blood out, and a drain of rubber tissue should be inserted. If there is only brain edema no drain is required. In some cases drainage has been obtained from the anterior fossa by breaking through the cribriform plate and introducing a tube by way of the nostril (Allis), and from the middle fossa by trephining above and behind the external auditory meatus. In a compound fracture of the orbit disinfect and drain. It may be necessary to trephine the roof of the orbit to secure drainage.

In addition to performing decompression I always give urotropin, as advised by surgeons in Johns Hopkins Hospital (S. J. Crowe in "The Johns Hopkins Hospital Bulletin," April, 1909). This drug renders the cerebrospinal fluid bactericidal. Other methods of treatment are secondary to the above. My experience is that this plan saves many cases which would otherwise perish. In treating a compound fracture of the base of the skull disinfect any cavity involved. In fractures of the middle fossa with ruptured drum clean the ear mechanically, wash it out by a stream of warm salt solution (turn the head toward the affected side while washing, so that the solution will not run down the Eustachian tube), insufflate iodoform, insert a piece of iodoform gauze, and apply an antiseptic dressing. Several times daily the ear is to be irrigated and insufflated with iodoform. The nasopharynx must be frequently irrigated by normal salt solution or boric acid solution and insufflated with iodoform. The conjunctival sac is to be frequently irrigated by boric acid solution. If after a head injury blood accumulates back of the drum, this membrane should be incised to permit of drainage and disinfection. In fractures of both the middle and anterior fossa and in fractures of the posterior fossa communicating with the pharynx, the nasopharynx must always be cleansed. The exact method depends on the choice of the surgeon. We may wash out these cavities frequently with hot water, next with peroxid of hydrogen, and finally with boric acid solution, or can simply use normal salt solution. After washing, insufflate the nasopharynx with iodoform. Repeat the cleansing at regular intervals and also cleanse the conjunctival sac frequently. In fracture of the posterior fossa examine to see if the fracture is compound, into the pharynx, and if it is, cleanse with great care the nasopharynx and mouth, as previously directed. In a very extensive fracture of the base, besides use of the methods set forth above, the entire head should be shaved and a plaster-of-Paris cap applied. A patient with fracture of the base must be put into a quiet and darkened room and kept upon a low diet, sleep being secured, and the bowels and bladder being attended to. If we are uncertain as to whether a fracture exists or not, keep the patient quiet, in a darkened room and on a low diet. Attend to the bladder, keep the bowels loose, examine the nasopharynx with a mirror and the ear-drum through a speculum, and make a lumbar puncture.

Obstetric Depressions of the Skull.—These lesions seem to have been first studied by Danyau in 1849. The depression may be of the parietal or frontal bone and may or may not be accompanied by fracture. It may have been caused by the promontory of the mother's sacrum or by obstetric forceps. Out of 25 cases of depression reported by Gfroerer and Hofmeier, 24 were breech deliveries and most of them were after version (Hugo Ehrenfest in "Gynecol. and Obstet. Monographs." Published by D. Appleton & Co.). The question to be determined is whether or not there is intracranial bleeding. Bleeding with or without fracture usually calls for operation. A slight depression does no harm, because it is gradually and spontaneously corrected. A marked depression, especially if accompanied by fracture, places the child in danger of epilepsy, idiocy, and non-development of body, and requires treatment. The usual treatment is trephining and elevation. Some claim to elevate by an apparatus making pneumatic suction, an absurdly inefficient plan. Some make a small incision, insert a screw (Heine's screw), and elevate by making traction on the screw, a very dangerous method, as the screw may go through the bone and injure the membranes or the brain. Hanch elevated by means of a corkscrew. (See Frazier in "Progressive Medicine," March, 1913.) It is tragically ridiculous to reshape the head by squeezing between the knees.

Wounds of the brain are produced by violence and especially by foreign bodies (knives, bullets, etc.). Except when due to penetration of a fontanel in a child or of a parietal foramen in adults, wounds of the brain are accompanied by fracture of the skull. These wounds are very dangerous; foreign bodies (bone, hair, clothing, etc.) are often lodged in the brain, hemorrhage is usually severe, and without proper treatment sepsis is almost inevitable. Such cases are very fatal, though some astonishing recoveries are on record. Figures 625 and 626 show gunshot fractures of the skull.

The **symptoms** of a brain wound may be slight and long deferred or may be im-

mediate and overwhelming; they depend upon the site and extent of the injury. Localizing symptoms may exist, and encephalitis with coma is apt to arise. Abscess may follow.

In treating wounds of the brain always shave the entire scalp and examine the weapon, if possible, to see if a piece has been broken off. Antisepticize, enlarge the wound, excise the wound in the soft parts, excise the wounds in bone and dura, remove foreign bodies, arrest bleeding and drain as directed on page 753, apply sutures, dress, and administer urotropin.

Wounds in War.—When the bullet of a military rifle, fired at very close range, crosses the brain it may blow the skull into fragments, but often it does not, but produces fracture of the skull and wound of the brain. The "explosive effect" is far less marked in the head of a living man than in the head of a corpse and may even be absent when the range has been only 100 yards. At moderate range, at the point of initial contact of the bullet with the skull, a fracture is produced, the opening is slightly larger than the bullet, and short fissures commonly radiate from it. Fragments from the internal table are usually displaced and driven into the brain. The

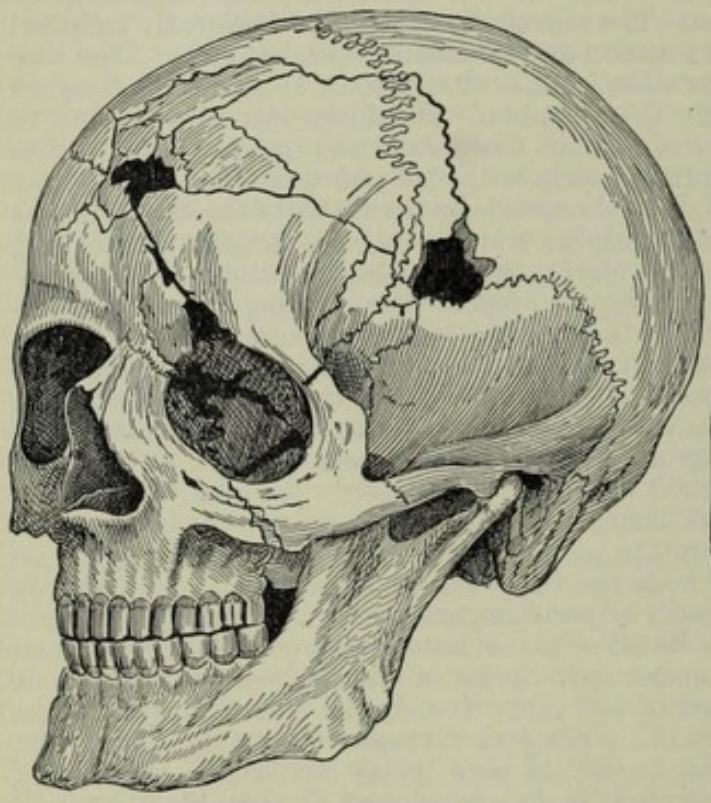


FIG. 625.—Extensively comminuted gunshot fracture of the skull (after von Bergmann).

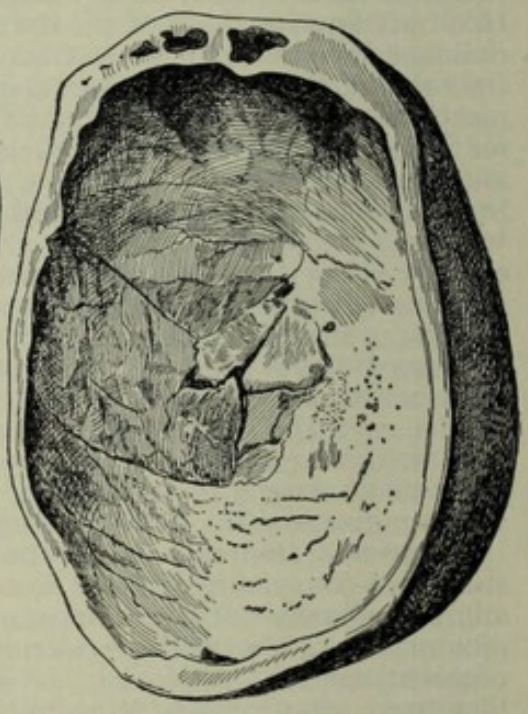


FIG. 626.—Gunshot fracture of internal table of the skull (after von Bergmann).

wound of exit is more irregular and is apt to exhibit more and longer fissures than the wound of entrance. When a bullet strikes a glancing blow (*tangential wound*) it may fracture the outer table alone; it may produce a "gutter-fracture" (two scalp openings, and "a gutter ploughed" through one or both tables of a portion of the skull, as O'Reilly expressed it), *very seldom* a fracture of the inner table only, *penetration* of the skull, and lodgment of the bullet, or *perforation* of the skull, the bullet passing through the head and emerging. Nearly half the cases are instances of perforating wound. A piece of Shrapnel case, a bit of explosive shell, or a Shrapnel bullet may fracture the skull, may lodge or may tear all the way through the head. The base may be fractured by a penetrating or a perforating wound or fracture of the vault may track into the base. There is usually much splintering, in which the inner table suffers most. There may be or may not be depression.

In all of these injuries there are usually great shock and concussion, but concussion symptoms may be absent. Some of the patients walk to the first dressing station. The patient may die at once or almost at once, but if he be alive a few hours after the injury he has still to face the chances of hemorrhage and the danger of infection and resulting inflammation. The danger depends on the brain injury and the amount

of infection and not on the extent of the bone damage. The symptoms vary according to the part of the brain injured and the extent of the damage. In some cases there are no brain symptoms.

In practically all cases bone fragments are driven, like a shower of hail, into the brain, and as the scalp is a dirty region, all wounds are more or less infected. All wounds received in trench warfare are regarded as infected. All wounds from shell fragments, even those inflicted in open fighting, are infected.

Injuries of sinuses, especially of the superior longitudinal sinus, are not uncommon. Serious injury may be caused directly by the projectile or may be due to bone fragments. Injury of the superior longitudinal sinus is due in most cases to tangential wounds in which there is usually a gutter-fracture, the inner table being splintered more extensively than the outer table. A bullet or shell fragment which merely grazes the bone may produce a gutter-fracture.

A tangential injury of the vertex may give rise to a symptom which Holmes and Sargent ("Brit. Med. Jour.," Oct. 2, 1915) called the *longitudinal sinus syndrome.* There may or may not be fracture or depression and the sinus or some of its large tributaries may or may not be torn. In some cases there is contusion of the brain and in consequence anemia of a considerable area or of considerable areas. In some cases there is no hemorrhage, but the blood in some of the parasinoidal sinuses and large cerebral veins is in a condition of stasis. The characteristic symptom is bilateral spastic paraplegia coming on at once after the injury, the lower extremities being more seriously involved than the upper extremities.

In a tangential injury by a rifle bullet there is practically always a fracture. In a tangential injury by a shell fragment there may or may not be a fracture.

A bullet lodged in the brain may remain fixed, or may shift its position with the movements of the patient. In a case of my own a bullet which lay in the longitudinal fissure against the falx cerebri made a half revolution on its short axis when the patient became recumbent and resumed its former position when the patient sat up. Dr. Manges demonstrated these movements by *x*-ray studies. A bullet in the brain may gradually shift its position and come to inhabit a location a considerable distance away from its original habitat. Probably it could not do this in an undamaged brain, but it may do it in a damaged brain. As a patient usually lies supine the bullet usually tends to move toward the occiput. Villvandré and Morgan ("Archiv. of Radiology and Electrotherapeutics," June, 1916) report a number of cases in which *x*-ray pictures, taken from time to time, showed that bullets did move. The above facts show that *x*-ray localization must be practised just before operation and with the patient in the exact position he is to occupy during the operation.

The mortality from these injuries is very large. In the war between the States 4350 cases were recorded in the Northern hospitals and the mortality (including mortality from late complications) was 59.2 per cent. In the Franco-Prussian War it was 51.3 per cent. In the Boer War among the British it was only 33.1 per cent., a very notable improvement. (See "Military Surgery," by Surgeon-General Robert M. O'Reilly, U. S. A., in "Keen's Surgery," vol. iv.) In the Russo-Japanese War the mortality seems to have been something over 37 per cent. The mortality from cranial injuries in the World War does not seem to have been better than that of forty odd years ago, and it was far greater than that of the Boer and of the Russo-Japanese Wars. Rehn calls the brain surgery of this war "a sad chapter."

In estimating mortality those killed outright and those dying before reaching the hospital are not counted by makers of statistics. Much brain matter may ooze out from such a wound. There may be severe or fatal hemorrhage. Meningitis or abscess may follow. Cerebral hernia (Fig. 630) and fungus cerebri (Fig. 631) are common after these injuries, especially if much bone was destroyed by the injury or removed by the surgeon. Various late complications may develop (abscess, softening, paralysis, epilepsy, insanity, aphasia, etc.).

Treatment of Wounds in War.—During the World War enormous numbers of men received head injuries in spite of steel helmets (about one-fourth of those wounded in the trenches). About 25 per cent. of head injuries were injuries of the cranium. A great majority of those who received cranial wounds by bullets or shell fragments perished at once or very soon. Comparatively few of those with such wounds reached the first-aid station. Fewer still reached the field hospital and fewer still the evacuation hospital, because many died in transit. Cushing believes that not more than 25 per cent. of those with cranial injuries were operated upon.

Tuffier claims that 50 per cent. of those operated upon recovered, but admits that

an unknown number died later from secondary troubles ("Surgery, Gynecology, and Obstetrics," 1915, xxi).

In Lapointe's 127 cases the mortality was 58.75 per cent. (cited by Cushing in "Military Surgery," June, 1916). It is true that some reports show a remarkable improvement on the ghastly figures cited above, but the general conclusion must be that the mortality has been enormous. In cases operated upon *early* and *completely* the results have been better. Gayet ("Lyon. Chir.," 1915, xii) reports 198 cases operated upon within six hours of injury and claims 100 recoveries. Cushing speaks of them as "presumptive recoveries" (Ibid.).

Early in the war many fractures were overlooked. Roberts tells us that over 40 per cent. of cases supposed to have scalp wounds only had fractured skulls ("Brit. Med. Jour.," Oct. 2, 1915). In many cases of fracture the symptoms at first may be so trivial that the patients walk to the first dressing station. If the fracture escapes recognition it is probable that a grave, perhaps a fatal, condition will arise. As a general proposition the earlier operation is done the better, provided the operation can be done completely. In the first dressing station and in a field hospital thorough operation is impossible. It is seldom possible in an evacuation hospital, and even if possible the patient must be moved in a day or two, which is too soon for safety. It has been found safer

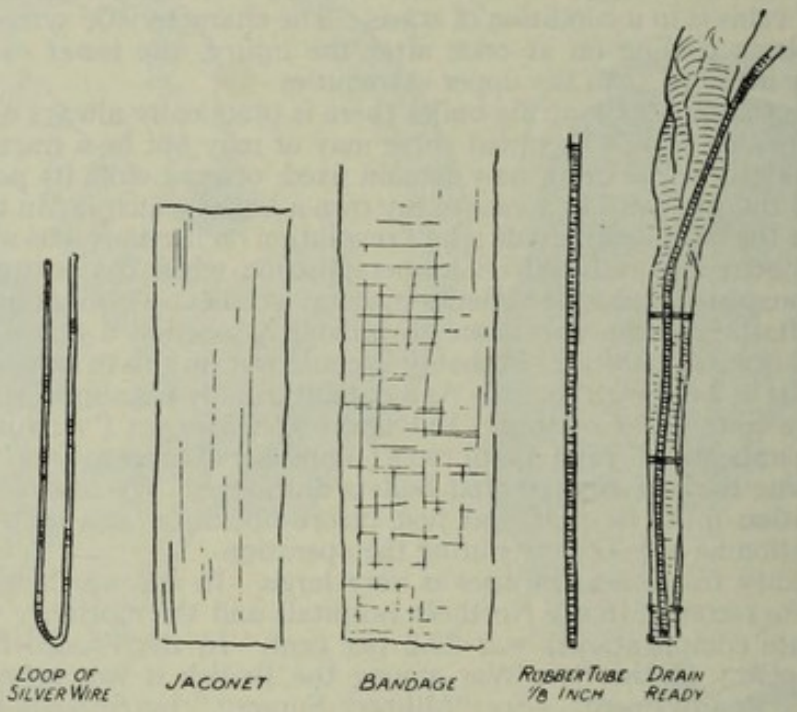


FIG. 627.—Materials for making capillary drains for drainage of the brain (Hull, "Surgery in War").

to move victims of skull injury upon whom no operation has been done than to move them soon after a trephining. The rapid pulse and the lowered tension of those upon whom operation has been performed recently militate strongly against recovery.

The custom among most surgeons was to operate very early, even in the absence of an *x*-ray apparatus. The method was to enlarge the wound, trephine if necessary, elevate depressed fragments, remove as well as possible all bone fragments lodged in the brain, drain with iodoform gauze, and as soon as possible send the patient to a rear hospital. When such a case reaches a base hospital there may still be a lodged projectile, there may be bone fragments yet in the brain, infection may have developed or be developing, and infection will probably prove fatal. Such an operation was incomplete and delayed the transfer of the patient to a place where a complete operation could have been done. Preliminary operations have had a mortality of over 45 per cent. Cushing (Ibid.) says "preliminary and necessarily incomplete measures," taken when "the field hospital equipment is primitive," gravely lessen the chance of permanent recovery. When such a preliminary operation has been done the surgeon in the base hospital finds it a most difficult problem to determine what should be done, a difficulty enhanced by the usual absence of records showing what has been done, information essential to determine the proper method of treating the case. The operation should be done as soon as the patient reaches a hospital where there is a surgeon

experienced in brain work, where there is ample equipment (*x*-ray apparatus, electromagnet, etc.), where there are experienced assistants, where there are trained nurses, where a neurologist can be consulted, and where the patient can be kept in bed the proper time (about three weeks). If these things can be had near the front operate near the front. If they cannot be obtained until a base hospital is reached send the man to the base hospital. By following this plan cases will seldom be operated upon until between two to four days after the injury, yet in spite of the delay the results are better than those of imperfect operations done promptly. Before operation an *x*-ray should be taken and if a projectile is lodged it should be located. The scalp should be shaved and antisepticized. Many operations are done under local anesthesia. The wound in the scalp (including the pericranium) should be excised by elliptic incisions. A large flap (with the excised wound within its margins) should be laid down to permit of exploration. The old custom of enlarging the original wound should be abandoned. The exploration through a large opening is necessary. It enables the surgeon to see a fracture. In 40 per cent. of supposed scalp wounds fracture exists. The excision of the wound in the dura, in the bone, and the wound in the scalp is imperative. Extirpate completely both the scalp wound and the bone wound. Cushing removes the entire wound in the bone, cutting completely around it. It prevents infection from pus organisms, gas bacilli, etc. When the wound is not excised late infection is common. If extirpation of the wounds is delayed for three or four days it is of little use. Excision enables us to dispense with drainage in many cases. Without excision prolonged drainage is always necessary. Brief drainage combats infection. Prolonged drainage opens the doors to infection. If drainage is prolonged until the hair grows above the skin, infection is inevitable. If a wound injures the dura and involves the brain drainage is always necessary. A metal tube blocks up. A rubber tube blocks up and, sooner or later, is forced out upon the dressings. Gauze dams up pus and thus aids in the development of meningitis or abscess. Drainage may be made by rubber tissue. It should emerge from the angles of the flap and not from the region of the gunshot wound. The most serviceable drain is made as follows (see "Surgery in War," by Major Hull, R. A. M. C.):

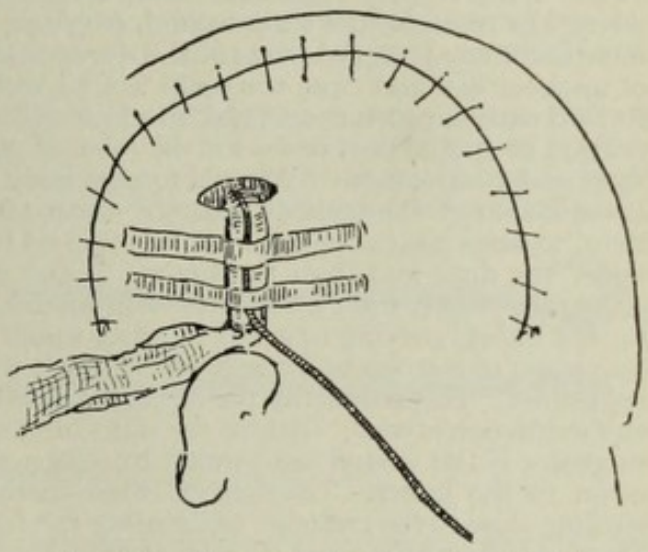


FIG. 628.—The drain has been bent to the required depth and fixed to the scalp by plaster. Two sutures placed about 3 inches from the wound form a better method of fixing the drain. By placing the sutures at a distance from the wound the drain is made very flexible and moves freely with the pulsating brain without exerting injurious pressure (Hull, "Surgery in War").

Take a piece of stout silver wire much longer, when doubled, than is necessary to reach the depth of the wound. Bend it into the shape of a hair-pin. Wrap it with rubber tissue. Surround it with a gauze bandage, and let the free end of the bandage be long. Fix to the bandage by ligatures a Carrel tube. Carry the appliance to the depth of the wound, bend the free end so as to keep the other end from stabbing the brain under the instigation of movements, fix the bent part to the scalp by adhesive plaster to keep the appliance from being forced out and from slipping out. At intervals run hypertonic salt solution (5 per cent.) through the tube. The saline fluid is delivered in the very depths of the wound, attracts to that region currents of water and fluid proteins from the tissue, establishes a flow of infection from the brain into the wound rather than from the wound into the brain, and takes the infected material to the surface by capillary attraction (Figs. 627, 628).

In a case in which there are no cerebral symptoms and in which after excision of the wound inspection of the bone shows no sign of fracture it is not necessary to open the skull unless cerebral symptoms develop.

In a tangential wound with a gutter-fracture of the outer table it is practically certain that the inner table is splintered and trephining should be done. Tangential wounds of the vertex are often responsible for the condition manifested by the *sinus*

syndrome. Clots form in the parasinoidal sinuses and perhaps in the longitudinal sinus. There may be hemorrhage caused by bone fragments tearing the vessel. In some cases there is paralysis of one or both legs. In other cases there is spastic paraplegia. If the damage is in front of the fissure of Rolando sensation will be normal. If it is back of the fissure wide areas of anesthesia may exist.

If sure no fracture exists, operation is not required. If fracture exists, trephine. If there is a depressed fracture without dural injury, trephine, remove depressed bone, and close without drainage the wound left by excision. Hull ("Surgery in War") points out the indications for opening an unlacerated dura. He tells us to open it if there are definite signs of "interference with brain function, or of increased intracranial pressure, if the dura, on exposure, is found to be muddy looking, if there is loss of pulsation, or if there is circumscribed loss of elasticity." In such a case brain matter is probably pulpified and may cause pressure by acting as a foreign body, may lead to abscess, and may lead to the formation of a large and irritating scar. A small crucial incision is made in the dura and the disorganized brain matter runs out. If sound brain matter does not bulge, close the dura and scalp wound without drainage. If there is marked intracranial pressure shown by great bulging, do a decompression.

When the skull is fractured and the dura lacerated, but there is no foreign body in the brain, we may regard the brain wound as aseptic. In such a case Hull (Ibid.) advises us to excise the scalp wound, trephine, enlarge the opening, remove bone fragments, cut away ragged parts of the dura, close the dural gap by suturing in it a piece of aponeurosis, and close the scalp wound without drainage. If operation is not performed early on such cases fatal infection will arise. Hull says (Ibid.): "A larger proportion of cranial operations for the relief of gunshot wounds come under this heading than under any other." When a foreign body has entered into the brain sepsis arises. Localization of the body is made by the *x*-rays. The scalp wound and the skull and dural wounds are excised, the skull is opened freely, bone fragments are removed from under the dura and from the brain. If the wound in the brain is large enough to admit the finger, the custom has been for the surgeon to insert the finger, *gently* seek for the bullet, striving to avoid injuring sound brain tissue, and to remove the bullet by means of a scoop or forceps. It is much wiser to remove the missile under direct inspection. This is done by use of the fluoroscope. The surgeon sees bullet and forceps and extraction is easy. Before the days of the fluoroscope it was the custom of many surgeons, if the wound were small, to pass a small, soft catheter along the track and down to the bullet. The forceps were carried along the catheter as a guide. By sticking close to the catheter while using the forceps damage to the brain was avoided. The wound is disinfected by dichloramin-T. Such a case must be drained (see Figs. 627 and 628). If the bullet was shown by the *x*-rays to have crossed the brain and to lie near the skull of the opposite side, it is usually wise to trephine the opposite side, and remove the foreign body. If a bullet or shell fragment passes right through the head, trephine each side and drain from each side.

Trephining may be necessary after any head injury because of hemorrhage. In most cases hemorrhage can be arrested by cutting out a piece of muscle, laying it on the bleeding point, and holding it there for a time with light pressure. In other cases a suture-ligature, a ligature, or a lateral ligature is used. Gauze pressure is to be used under the dura only if we are driven to it. If after any cranial operation high intracranial pressure becomes evident, and if lumbar puncture and saline enemata fail to control it, perform decompression. Abadie is an advocate of the extraction of projectiles in two stages ("Bull. Soc. de chir. de Par.," 1916, xlii). If the bullet is far from the point of entrance, or if for any reason the point of entrance is not the correct route for approach, he trephines over the projectile, opens the dura, temporarily closes the wound, and in a day or two searches for the bullet with aid of a fluoroscope. For the second operation ether is not given.

Wounds from Revolver Bullets.—The bullet may strike the skull and glance (if fired at an angle) with or without the production of a fracture. A small bullet (No. .22) may even strike perpendicularly and fail to enter, sometimes causing a fracture and sometimes not doing so. Even a No. .22 may enter the skull. I removed a bullet of this size which had entered and crossed the skull and lodged beneath the cortex on the opposite side of the brain. A bullet may cause a "gutter-fracture"—may enter the cranium and lodge—or may cause a complete perforation. A revolver bullet is much more apt to lodge than the bullet of a military rifle.

The wound of entrance is small; the wound of exit is larger. At the wound of entrance the inner table is more extensively fractured than the outer table; at the

wound of exit the outer table is more widely broken than the inner table. In these cases there is always great shock and usually concussion, and concussion symptoms may exist even when the bullet has not entered the brain. In moderate concussion the action of the heart is retarded; in severe concussion it is accelerated (see page 735). A bullet may be lodged within the cranium when merely a fracture without a bullet hole can be detected. In these cases the bullet produced a fracture and entered the cranium, and then the depressed bone flew back into place (von Bergmann). In such cases, if complete perforation occurs, the one existing opening in the bone is the opening of exit. A bullet may lodge in the bone, between the dura and the bone, between the dura and brain, in the brain, between the dura and the brain or the dura and the bone of the opposite side, or in the bone of the opposite side, in the nasal fossa, maxillary antrum, or orbit. Always examine the side of the head opposite to the wound of entrance to determine if there is a wound of exit or any bulging or fracture. A bullet may pass across the brain and some think it can be deflected from the inner surface of the skull. Ruth does not believe the bullet can rebound from the opposite wall.[1] If certain regions are injured, localizing symptoms may arise. Much brain matter may ooze out from the wound. Loss of brain matter sometimes causes great impairment of function, sometimes little or none. The secondary **symptoms** of gunshot wounds of the head are varied and uncertain, and may not arise at all before death. Fowler wisely points out that a patient with a gunshot wound of the head may have also received other injuries, and the other injuries may be in part, at least, responsible for cerebral symptoms.

Treatment of Wounds from Revolver Bullets.—Endeavor to bring about reaction (see Concussion). In severe cases apply heat to the head and make artificial respiration. It will sometimes be necessary to operate while artificial respiration is being made. In treating gunshot wounds of the head shave and antisepticize the whole scalp,

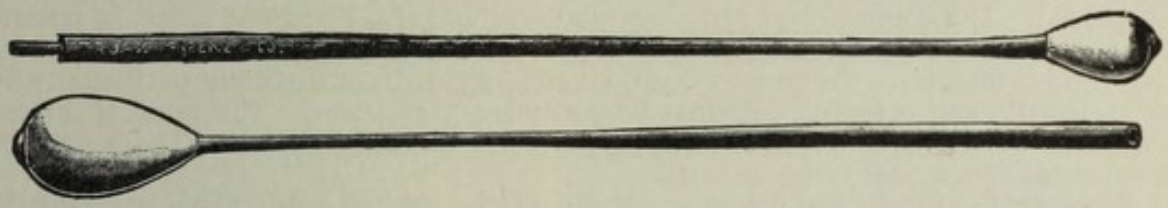


FIG. 629.—Senn's modification of Nélaton's bullet probe.

excise the wound, turn down a large flap, and proceed as indicated on page 753 and disinfect the entire track of the ball, and arrest hemorrhage at the wounds of entrance and exit, using the rongeur to expose the bleeding points if the bullet be large, employing the trephine if it be small. If the bullet has emerged and has been picked up, examine it to see if it is entire. The bullet, if retained, is to be sought for. The *x*-rays are invaluable in locating the missile. Place the head in such a position that the track of the ball will be vertical, then introduce Fluhrer's aluminum probe or Senn's probe, and let it find its way by gravity. The probe may find the ball near the wound of entrance, in which case extract the ball with forceps; or the probe may find the ball near the opposite side of the head, in which case make a counteropening through the bone at a point the probe would touch if it were pushed entirely across. Take a new and *clean* rubber catheter (No. 9 French), insert a stylet, and carry the catheter through the wound (Keen). Knowing the depth of the ball, search for it around the catheter tube as an axis, and, when found, extract it. In some cases it is advisable to search for and remove the ball with the aid of the fluoroscope. After extraction drain the wound as shown in Figs. 627, 628. When a counteropening exists, drain from each side. If the ball cannot be detected, drain from the depths of the wound. After dressing always place the head in a position favorable to drainage. Fluhrer tells us that when a counteropening fails to disclose the bullet, use the new opening as a doorway through which to search for the ball. He believes the bullet is not unusually deflected. The angle of deflection is somewhat greater than the angle of incidence, and the bullet is apt to fall a little toward the base. Splinters of bone and bits of lead are often driven into the brain by a bullet, and these should be removed whether the ball is found or not. Several varieties of probes have been recommended. Fluhrer uses a large-sized aluminum probe. Senn used an instrument shaped like the Nélaton probe, but of the same diameter as the bullet (Fig. 629). If this probe touches a lead bullet it

[1] See the instructive article by Fowler in "Annals of Surgery," Nov., 1895.

acquires a black mark. (Of course, the porcelain probe will not show a black mark from contact with a hard-jacketed bullet.) Fowler uses a graduated pressure probe; so long as the pressure is within the limits of the spring, as shown by the scale, the probe is in the bullet track. Girdner's telephonic probe has been used as an aid to localization. Bullets are now certainly located by the Roentgen rays. There can be no doubt that many gunshot wounds have been recovered from without operation, and it is beyond question that many deaths have followed operation (about 33⅓ per cent., according to Hahn). Von Bergmann was so impressed with these facts that he did not operate when cerebral symptoms were absent. I usually operate.

Traumatic Pulsating Exophthalmos.—This condition is an occasional result of a gunshot wound, a punctured wound, or a basal fracture (we are not considering cases due to aneurysm of the internal carotid or ophthalmic arteries, orbital tumor, brain tumor, or tumor of the nasal sinuses which has broken into the orbit. Two-thirds of the cases are traumatic). The internal carotid is torn or punctured and arterial blood is forced into the cavernous sinus (arteriovenous aneurysm). Nearly 90 per cent. of the cases are unilateral. Over 200 traumatic cases have been reported.

Symptoms may begin at once or soon after the injury, but in some cases have been strangely postponed. There may or may not be headache. Pain, if present, may be unilateral or general. The bruit is heard by the patient and can be heard by the surgeon if he places his stethoscope over the forehead, temple, or involved eyeball. Sometimes the sound is audible all over the head. The bruit has been described as roaring, hissing, humming, or buzzing. It may be systolic or may be continuous, being accentuated during the cardiac systole. It is intensified by stooping and is modified or arrested by pressure upon one or both carotids. The orbital veins dilate and the veins at the inner angle of the orbit and perhaps those of the forehead soon share in the dilatation. We may feel a thrill in the veins at the inner orbital angle. The lids swell greatly. Perhaps they cannot be closed. Perhaps they are even everted. The cornea swells markedly (chemosis). The conjunctival veins are much distended. The globe is felt to pulsate and is pushed downward and outward. There may be palsy of one, two, or all of the extra-ocular muscles. Vision may be impaired by keratitis or iritis, but particularly by optic neuritis and atrophy. Retinal hemorrhages may occur. The pupil is dilated and reacts slowly or is fixed. Accommodation is impaired or lost. There may be impairment of hearing, taste, or smell.

Treatment.—Ligate the common carotid of the injured side. This will cure 50 per cent. of cases and will improve half of the remainder. The mortality is not inconsiderable and hemiplegia sometimes follows (page 437). If carotid ligation fails, open the orbit and tie or excise the dilated superior ophthalmic vein, which empties into the cavernous sinus. If the inferior ophthalmic vein empties, as it usually does, into the pterygoid plexus, the operation will probably succeed. If it empties into the cavernous sinus it may fail. It seems probable that an intra-orbital operation must increase the risk of involvement of the other eye if a clot fails to form in the sinus and the blood-stream be driven forcibly across through the circular and transverse sinuses. Should this second operation fail, the common carotid of the opposite side may be tied.

Prolapse of the Brain and Hernia of the Brain.—In a compound fracture, especially a gunshot fracture, with torn dura, arachnoid, and pia, brain matter may emerge from the wound. In fracture of the base, brain matter may enter the orbit, the nose, or the ear. A flow of brain matter may continue from a wound for many hours. A week or more after an injury a portion of the brain may protrude or prolapse. To this condition the term *prolapse of the brain* should be applied. In many instances the protrusion is covered with pia, but if the pia has been torn or cut, it will not be a covering. This protrusion emerges from the opening in the skull, mounts up, growing larger and larger, until it may become the size of a fist. It usually pulsates. When bare it is soft, lobulated, of a dirty white color, pulsating, painless to the touch, often bleeding, and sometimes discharging cerebrospinal fluid. Death may soon follow such protrusion, but the protruding mass may become necrotic and slough off, a granulating surface remaining, which heals. *Hernia cerebri* (Fig. 630) sometimes follows operations upon the brain or injuries of the skull and dura, when large pieces of bone have been removed or when the dura has been widely cut or torn and has not been carefully sutured. It is due to brain edema. The protrusion may become strangulated in the dural opening or adherent to the margins of the opening. The hernia begins a few hours after the injury. Many cases of gunshot wounds develop herniæ. It is most common in the parietal region and is uncommon in the frontal and occipital regions. The condition is not due entirely to increased pressure, else lumbar puncture would be distinctly instead

of slightly beneficial. The chief lesion is congestion and edema of the damaged and protruding brain. In some cases abscess exists. Hernia of the brain is protrusion through the dura, but not through the scalp, the scalp wound being healed above the protrusion. In a decompression operation we deliberately create a hernia of the brain. Prolapse of the brain is treated by antiseptic dressings and perhaps by a decompression operation. Skin-grafting benefits some cases. Pressure is dangerous. Excision by the knife or cautery seldom does any good. Hernia in some cases can be treated by repeated lumbar punctures, in some others by a decompression operation on the opposite side of the skull. Probably the best treatment is removal of bone fragments and incisions of the dural margin of the opening, followed by the use of Dakin's oil and by compression. If epileptiform convulsions arise make repeated lumbar punctures (Marchack in "Presse Méd.," 1916). If abscess exists it must be drained.

Fungus Cerebri (Fig. 631).—When the brain is exposed a granuloma may grow from the neuroglia and fungate through the opening in the skull. This condition is fungus cerebri and is not composed of brain matter. It is due to infection of the brain, and is most frequent when a bit of bone or some other foreign body is retained. A fungus is soft to the touch, is livid in hue, bleeds easily, frequently contains multiple foci of suppuration, and pulsates. It often attains the size of a small orange. It is treated by removing the granulations and any foreign body, and applying, with mod-

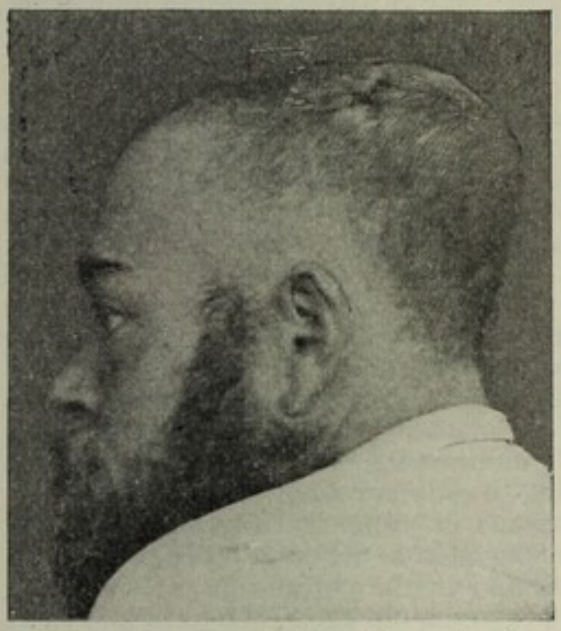


FIG. 630.—Hernia cerebri under scalp after operation for brain tumor (W. W. Keen).



FIG. 631.—Fungus cerebri (W. W. Keen).

erate pressure, aseptic dressing soaked in alcohol. After healing a depression marks the site of the fungus.

Traumatic inflammation of the brain and its membranes is divided into *encephalitis* or *cerebritis*, inflammation of the cerebrum; *cerebellitis*, inflammation of the cerebellum; *meningitis*, inflammation of the meninges; *arachnitis*, inflammation of the arachnoid; *pachymeningitis*, inflammation of the dura; and *leptomeningitis*, inflammation of the arachnoid and pia.

Meningitis.—Of recent years our views regarding meningitides have changed. We no longer regard each form as a separate and distinct disease, but we regard all the forms as different phases of one disease, that disease being a reaction to infection on the part of the membranes of the brain and cord. We must still, for clinical convenience, classify meningitides into many types. We speak of meningitis as serous or purulent, local or diffuse. We speak of it as basilar, leptomeningitis, etc., or as tuberculous, meningococcic, etc. But, after all, meningitis is an infection for which many varieties of bacteria may be responsible, and in which there are many different routes for the entrance of the causal micro-organisms, but the effects of these organisms upon the tissues are similar, and the variety of the symptoms produced depends upon the region diseased and the power and nature of the toxins.

This view has been most ably set forth by Kopetzky ("The Laryngoscope," June, 1912). The same careful observer points out that in every form of meningitis there

is increased tension of the cerebrospinal fluid and poisoning of the central nervous system by toxins and products of tissue metabolism.

The chief factors in causing increased tension of cerebrospinal fluid are edema of brain tissue and edema of the membranes.

Kopetzky ("The Laryngoscope," June, 1912) further points out that very early in the progress of every case of meningitis there is a disappearance from the cerebrospinal fluid of the copper-reducing substance dextrose. Bacteria are greedy for carbohydrates and eat up dextrose. The disappearance of dextrose from the cerebrospinal fluid is highly significant of the existence of meningitis. Its reappearance indicates abatement of the inflammation.

Treatment.—Kopetzky (Ibid.) in acute cases advocates the administration of serum or antitoxin and the early performance of an operation to reduce intracranial tension. If operations were done early, before pus had time to be imprisoned between the convolutions, results of operation would be much better. Lumbar puncture is of high diagnostic, but of small therapeutic value. The fluid obtained by puncture contains polymorphonuclear leukocytes. Drainage of the spinal theca by lumbar laminectomy is practised by some. The most promising operation is that advised by Eagleton (page 795). Radical drainage has saved lives.

Pachymeningitis Externa.—Inflammation of the external layer of the dura is called *pachymeningitis externa*. It may arise from tumor, caries, necrosis, middle-ear disease, sunstroke, or traumatism. Syphilis is a not unusual cause. The other membranes may become involved. Suppuration may arise, having extended by contiguity from neighboring parts.

The **symptoms** of pachymeningitis externa are uncertain. They resemble often those of leptomeningitis (see below). Pressure symptoms may arise. Headache is always present. Paralysis may or may not exist. If pus forms, the ordinary constitutional symptoms of suppuration are evident (high temperature and sweats), not the usual symptoms of abscess in the brain. In a severe case the other membranes become involved.

The **treatment** consists in removing the cause (carious bone, pus, middle-ear disease). In pachymeningitis from traumatism it is sometimes advisable to trephine in order to drain inflammatory products; in a case with localizing symptoms always trephine; in an ordinary case, without pus, without localizing symptoms, and with no evidences of traumatism, use wet cups back of the mastoid processes, apply an ice-bag to the head, and purge by means of calomel. Administer iodid of potassium in most cases. If sunstroke is the cause, treat according to ordinary medical rules.

Pachymeningitis Interna.—This term means inflammation of the inner layer of the dura. Inflammation may extend from the pia or from the outer layer of the dura. The disease is most often met with in infants and in the chronic insane, but may occur in those not insane in late middle age or beginning old age. The form known as *hematoma of the dura mater*, or *pachymeningitis interna hæmorrhagica*, may arise during infectious disease (typhoid fever or rheumatism), in persons of the hemorrhagic diathesis in diseases causing atrophy of the brain, in chronic diseases of the heart and kidneys, and in syphilitics. Among the exciting causes are traumatism, inflammation in adjacent parts, and, especially, the abuse of alcohol. In this disease blood is extravasated on the inner surface of the dura. Many observers do not class hemorrhagic pachymeningitis as inflammation, but regard the hemorrhage as primary.

The **symptoms** of internal pachymeningitis are very chronic, come on gradually, are not characteristic, and may be absent. They consist usually of mental irritability or excitement, followed perhaps by hebetude and persistent headache; and apoplectiform attacks, with contraction of the pupils, slow pulse, and vomiting; there may also be muscular rigidity and spasm of the extremities. Choked disk is not infrequent; localizing symptoms may sometimes be made out, and coma is apt to arise. Cranial nerves are seldom affected.

The **treatment** is operation, which removes the clot. This is unpromising, but Munro saved 1 case out of 5 ("Chicago Med. Recorder," Dec., 1902).

Acute leptomeningitis is a purulent inflammation of the soft membranes of the brain. The pathologic changes can be noted in the pia and in the brain substance. The brain is edematous, the pia purulent, the convolutions are flattened, the ventricles are distended with fluid, and hemorrhages occur into the brain substance. Pus may be localized upon the pia, but it is usually diffused over one hemisphere or over both. The cerebrospinal fluid becomes infected, hence infection is carried to all parts, into the ventricles, the cisternæ of the base, and into the spinal cord, throughout the cortex.

Various organisms may be found, especially streptococci, staphylococci, and pneumococci. In some cases we find the Bacillus pyocyaneus or the Bacillus pyocyaneus fœtidus, which is identical with the colon bacillus and with the Bacillus meningitidis purulentæ (Park). Saprophytic organisms are occasionally present. This disease may be acute or chronic, and a severe case is spoken of as *encephalitis*. *Secondary leptomeningitis* is apt to affect the convexity; *primary leptomeningitis* is apt to affect the base.

The **causes** of leptomeningitis are epidemic cerebrospinal fever, tuberculosis, acute general diseases (pneumonia, typhoid, erysipelas, and rheumatism), bone diseases, traumatism, middle-ear disease, infections of the nasal sinuses, syphilis, and sunstroke. In diplococcic meningitis the tissues of the *pia* and the cerebrospinal fluid contain diplococci identical with pneumococci. Infection may take place by various avenues. It may pass from the pharynx by way of the Eustachian tube to the ear, or from the nose to the frontal sinus or ethmoid sinuses (Hirt), and from these situations to the brain. It may pass from the middle ear or mastoid to the membranes of the brain. In fractures at the base the organisms enter by way of the pharynx and the Eustachian tube, or the ear. Eagleton shows that in the presence of a blood-stream infection (for instance, when sinus thrombosis exists) a lumbar puncture, by disturbing the "relationship between the cerebrospinal fluid and the blood circulatory system," may be provocative of meningitis. (Read before the Med. Soc. of the State of Penna., Oct. 5, 1922.) Very early in the case the lesion, if it arises secondarily to a nasal or ear infection, is limited in area (Eagleton, Ibid.). The **symptoms** of acute leptomeningitis early in the case are: rising blood-pressure (determined by the sphygmomanometer), edema of the optic papillæ, absence of carbohydrates from the cerebrospinal fluid (the fluid obtained by lumbar puncture), "an irritable or clouding sensorium" (Irving S. Haynes in "The Laryngoscope," June, 1912). The same author adds that vagus pulse and respirations irregular in depth and rate may also be present. As the case progresses there are violent headache persisting during delirium, flushing of the face, rigidity of the neck, cerebral vomiting, a pulse usually rapid, intermittent and irregular, but often slow, elevated temperature, leukocytosis, photophobia, contraction and perhaps inequality of the pupils, intolerance to sound, hyperesthesia of the skin and muscles, and delirium passing into stupor and coma. There are rigidity of the muscles of the neck, retraction of the head, retraction of the abdominal muscles (boat-shaped abdomen), inability to extend the legs when sitting up, though it can be done when recumbent. If, while lying down, the thigh is flexed on the belly the leg cannot be extended on the thigh (*Kernig's sign*). If a dull point is drawn along the skin a red line follows it (*tache cérébrale*). A chill or a succession of chills may occur. Choked disk, strabismus, and nystagmus are not unusual. Twitching convulsions or paralyses may occur. Death is the rule within one week. Lumbar puncture shows high pressure. In a case of meningitis the fluid obtained by lumbar puncture may contain bacteria and may be actually purulent. The presence of numerous leukocytes is usual, there being an excess of polymorphonuclear forms in pyogenic infections. Early in the case carbohydrates disappear.

Treatment.—Flexner's serum is valuable in cerebrospinal meningitis, a condition caused by the Diplococcus intracellularis in other conditions. Usually meningococcic serum is given by interspinous injection. Lumbar puncture is of immense diagnostic importance as the fluid contains bacteria, but the operation is useless therapeutically. It is not entirely safe. The rapid withdrawal of fluid may cause death by allowing the foramen magnum to be plugged by the brain stem. Ordinary trephining with tapping of the ventricle is practically useless. An operation which seemed to promise, but which proved disappointing, was the exposure and drainage of the cisterna magna. Late operations are of no avail. Any causal condition, for instance, suppurative otitis media, must be treated by operation and the cerebrospinal fluid in that neighborhood must be removed by drainage. An opening is then to be made in the frontal region and irrigation from that opening into the pia-arachnoid space will drive out a quantity of infected fluid. (See page 795—Eagleton, Ibid.) After operating administer urotropin. Should the patient recover, he must be guarded for a long time from physical exertion, mental excitement, worry, irritation, constipation, and insomnia.

Chronic Leptomeningitis (*or Chronic Encephalitis*).—The causes of chronic leptomeningitis are the same as those of the acute form. If traumatism is the cause, the inflammation arises at a later period than it would in acute encephalitis. The symptoms of concussion follow a head injury. Days, or even weeks, after the accident a series of symptoms may occur, namely, localized pain at the seat of injury, often accentuated by tapping; listlessness; irritability; apathy regarding business affairs

and home obligations, or profound depression and hypochondria with inability to attend to business. Choked disk may exist. In any case acute encephalitis may arise, with or without a chill. The **treatment** of this disease is symptomatic unless local symptoms exist. Always trephine if localizing symptoms are found. Intense local pain justifies trephining.

Tuberculous Meningitis (Acute Hydrocephalus; Water on the Brain).—This inflammatory condition is due to the bacilli of tuberculosis. In a child affected with tuberculous meningitis there is often a record of a fall, the injury acting as an exciting cause by establishing an area of least resistance. Prodromal symptoms lasting several weeks are common (restlessness, irritability, anorexia, loss of flesh, change of character). The attention of the physician is attracted to the meninges by a convulsion or, what is more common, by headache, fever, and vomiting. The fever is persistent, but irregular. The child cries out from pain (*the hydrencephalic cry*) and the bowels are constipated. The pulse is rapid in the beginning, but later becomes slow, irregular, and of high tension. The pupils are contracted, there is muscular twitching, and the sleep is impaired. The temperature is about 103° F. There is usually edema of the optic papillæ and carbohydrate disappears from the cerebrospinal fluid (see page 758). In the second period of the disease the vomiting ceases, constipation becomes more marked, the belly retracts, headache is not so violent, and the patient lies in a soporose condition interspersed with episodes of delirium. In this stage the pupils dilate and are often unequal, the head is retracted, convulsions occur or limited rigidity is noted, the respirations are sighing, and if a finger-nail is drawn along the skin a red line develops (the *tache cérébrale*, due to vasomotor paresis). Kernig's sign is present (see page 759). Squint and consequent double vision are usual. In the last stage coma becomes absolute and general convulsions or limited spasms are apt to occur. Optic neuritis exists, and the child passes to death along a road similar to that of typhoid collapse. In many cases the examination of cerebrospinal fluid withdrawn by lumbar puncture throws light upon the diagnosis. The fluid is turbid, is devoid of carbohydrate, and usually contains an excess of lymphocytes. In most cases it contains the bacilli. It may be sterile. Sterile fluid from a patient with symptoms of meningitis suggests that the condition is tuberculous. In children the base of the brain is usually involved, and the disease is apt to last from two to four weeks; in adults the convexity is usually involved, and death is apt to occur in a few days. When the meningitis is basilar, occipital headache, rigidity of the neck, and vomiting are severe, paralysis of various cranial nerves may occur, and there may be hemiparesis from pressure on the crus. Absence of leukocytosis points to a tuberculous cause for a meningitis. The existence of leukocytosis does not disprove the tuberculous cause of the disease.

The **treatment** is like that for traumatic meningitis. The operation of trephining, perhaps with tapping of a ventricle, seldom offers any chance of improvement, and never does unless the process is limited in area and confined to the convexity. Lumbar puncture is performed for diagnostic rather than for therapeutic reasons. Draining the cisterna magna may be tried (see page 759).

Abscess of the brain is a localized collection of pus the result of local encephalitis. The bacteria which may be found are noted upon page 759 (Acute Leptomeningitis). The **causes** are near or distant suppuration. It is more apt to be caused by a chronic than by an acute suppuration, but if due to an acute suppuration the causal lesion is adjacent (Kerr in "Archives of Surgery," Sept., 1923). About half of the cases are traumatic (punctured fracture of the skull, compound fracture of the skull, or gunshot wounds of the brain). Can a simple fracture or a concussion be followed by abscess? I have never seen a case following a head injury without fracture. I have seen a case following simple fracture. Starr has seen several cases following fracture. Infection may be direct from a nearby area of suppuration (the *adjacent abscess* of Eagleton). It may be due to septic emboli brought from a distance (*metastatic* or *distant abscess*). The former is single, at least in the beginning. The latter condition means multiple abscesses. In the adjacent abscess the brain infection is brought from carious bone or some other focus of infection by phlebitis of tributary veins and by thrombus formation. The causes of adjacent abscess are cranial osteomyelitis, erysipelas of the scalp, subaponeurotic abscess of the scalp, fracture of the skull, wound of the brain, orbital suppuration, suppuration of the nasal sinuses, and particularly suppuration of the middle ear. The distant infections which are sometimes causal are particularly empyema, gangrene of the lung, abscess of the lung, and various focal infections of teeth, tonsils, etc. General infections are sometimes responsible for abscess, for instance, pyemia, tubercu-

losis, and specific fevers. A tuberculous mass may caseate, but this is not a true abscess. As Ballance points out, abscess of the brain complicating head injury is not really an abscess of the brain unless the wounding material entered into the brain substance. In most cases the abscess is "a local meningeal suppuration with participation of the adjacent brain cortex, a *meningocortical abscess* rather than a brain abscess proper" ("Some Points in the Surgery of the Brain," by Chas. A. Ballance). Pus may form between the dura and the skull (extradural), between the dura and brain, adhesions forming and preventing general leptomeningitis (subdural), or in the brain substance (cerebral or cerebellar). Only when the brain substance is involved is the condition a true brain abscess. If no adhesions form about a cortical infection there will be leptomeningitis instead of abscess. A traumatic abscess is generally beneath the area to which the traumatism was applied, but it may be on the opposite side. Roswell Park says infection may pass along blood-vessels, lymph-vessels, nerve-sheaths, or the prolongations of the membranes which extend outside of the skull. An acute inflammation of the middle ear rarely causes abscess, because an acute inflammation in sound tissue causes the formation of granulation tissue, which acts as a barrier to infection. Chronic inflammation of the middle ear is the most frequent cause of abscess. Park tells us that if the roof of the tympanum is involved, it may perforate and abscess of the middle fossa may form; if the tympanum is perforated toward the mastoid antrum, the abscess arises in the temporosphenoidal lobe; if the perforation is toward the sigmoid groove, the abscess forms in the cerebellum.[1]

Chronic bone disease is seldom followed by spreading meningitis, often by abscess. When infection reaches the brain by direct extension from a suppurating bone it must pass through the membranes, but it is usually limited by adhesions. The cortex is very vascular, strongly resists infection, and is seldom extensively destroyed, but the white matter is far less resistant and abscess tends to form in it (Ballance, Ibid.). In some cases of abscess of the temporosphenoidal lobe following middle ear disease the cortex seems normal, in others the membranes and cortex are fused over a narrow area which constitutes the stalk of an abscess in the white substance of the lobe. This is the *mushroom abscess* of Ballance. There may be no definite wall to an abscess of the brain, the surrounding brain tissue being softened, hemorrhagic, and necrotic. Such an abscess spreads rapidly and is soon fatal by rupturing into a ventricle or into the membranes or by causing secondary encephalitis. An abscess may become encapsulated and latent. Latency is usually of brief duration, but may endure for weeks, months, or even years. Sooner or later an abscess, if not operated upon, will cause death by rupture or encephalitis. Abscess is most common in adults and is rare in very young children. It may occur soon after the beginning of an adjacent suppuration, but may not arise for months or years. I operated for abscess on a man sixty years of age, who had had a running ear since early childhood. The most common seat of an adjacent abscess is in the temporosphenoidal lobe, next in the cerebellum, next in the frontal lobe. Cases have been reported involving the pons and the crus. A slowly growing abscess may push aside nerve-fibers as does an encapsulated tumor, but a rapidly growing abscess destroys them.

In the cerebrum multiple abscesses, except in cases of general infection, are seldom seen. In the cerebellum they are not uncommon. One or several abscesses may arise from a primary one. If they are adjacent to the primary one they are called *satellite abscesses* and tend to break into the older purulent area.

Symptoms of Adjacent Abscess of the Cerebrum and of Abscess of the Cerebellum.—Ballance, in considering the onset of abscess, adopts the views as to the types set forth by Brissaud and Souques. These types are as follows (Ballance, Ibid.):

(1) A subacute evolution. In this there is a febrile onset, like the onset of a specific fever, with headache, vomiting, and elevated temperature. After a few days there comes a remission, the period of delusive calm. In this period symptoms are absent or trivial. Though there may be progressive emaciation, there is no elevation of temperature, in fact, the temperature may be subnormal.

Suddenly convulsions occur which are followed by coma, or coma arises without antecedent convulsions. The patient may die in coma or the coma may pass away, "the symptoms indicating a local brain lesion" (Ballance, "Some Points in the Surgery of the Brain"). In this stage elevated temperature may appear again.

(2) Evolution with violent general infection, the symptoms of abscess being merged and usually lost in the symptoms of general infection.

(3) Evolution with complete latency. The patient presents no symptoms until

[1] Park in "Chicago Med. Record," Feb., 1895.

a few hours before death, or he may die suddenly without a symptom having been observed. In this connection Ballance speaks of the difference between "symptoms not noticed and symptoms not present" (Ibid.).

Only when symptoms are not present does he use the term "complete latency" to indicate the condition. Ransohoff reported the case of a boy in whom an abscess in the frontal lobe was latent for three years, and another case in a man, due to gunshot injury, in whom the abscess was latent for four and a half years and in which nearly ten years elapsed between the injury and death ("Annals of Surgery," July, 1909).

(4) Onset not to be distinguished from a brain tumor.

(5) Onset with headache and fever, or with mental excitement. Then the patient appears to get completely well and remains so for weeks, for months, or for a year or more. This condition may occur in abscess secondary to influenza (Ibid.).

The symptoms due to pus formation are as follows: There is an initial rise of temperature, but (except in extradural abscess) the temperature may quickly become normal or even subnormal. Years ago Sir Samuel Wilks called attention to the depression of temperature frequently noted in abscess of the brain. Subnormal temperature is not nearly so common as is supposed. It has been present in about one-half of the cases I have seen. Toward the end of the case the temperature may rise and the fever become linked with delirium. Surface elevation of temperature over the seat of the abscess is occasionally observed. A chill may occur, but seldom does. Anorexia and vomiting are present. Urinary chlorids are diminished and the phosphates are increased (Somerville). Certain symptoms are due to pressure. Headache is the earliest symptom. It is at first general, then local, and grows worse later in the case, and exists even in delirium; this fact distinguishes it from the headache of fever, which ceases in delirium; the pulse is full, regular, and, in the absence of complications, becomes very slow; the respiration tends to alterations of rhythm and the Cheyne-Stokes type; drowsiness lapses into stupor and stupor passes into coma; paralysis of the sphincters takes place; superficial reflexes gradually disappear on the side opposite to the lesion; convulsions are common; sensation is rarely impaired, and paralysis of the basal nerves may occur (third and sixth especially). The pupil on the same side as the abscess is sometimes dilated and fixed. The dilatation is more moderate in degree than in meningitis. Localizing symptoms, spasmodic or paralytic, may arise. In abscess of the temporosphenoidal lobe, hemiplegia of the opposite side may develop. The face is first involved, next the arm, next the trunk, and finally the leg (Sir Victor Horsley, "Lancet," Jan. 27, 1912). In an abscess far posterior the motor palsy may be so slight as almost to escape recognition, but there is loss of the sense of position of a limb and loss of power to localize touch.

Symptoms.—An abscess of the brain is usually first made manifest by a dull headache, occasional vomiting, inability to concentrate the attention, slowness of mental processes, elevations of temperature, chilly sensations, but very seldom a definite chill, malaise, growing weakness, and progressive loss of flesh. If there is ear suppuration the discharge may continue to flow freely or may gradually lessen, then the flow of pus may gradually or suddenly stop. The patient will begin to feel ill, the mental processes will be hampered, and the temperature will probably become subnormal. This is the beginning of the second stage. The first stage lasts from a few days to several weeks. In the second stage the patient is dull and heavy and tends to stupor, although there may be episodes of restlessness and mental irritability. The appearance is septic, the temperature is normal, subnormal, or perhaps irregular. During periods when the abscess is not spreading the pulse may be slow; when it is spreading it may be rapid. A rapid pulse in this stage usually indicates spread. The patient vomits, and the pupils are apt to be unequal. There may be distention and tortuosity of the retinal veins or choked disk (in two-thirds of the cases). There may be increase of deep reflexes and weakness of the facial muscles. Operation performed now gives a reasonable chance of success. In the third or terminal stage, characterized by coma, operation is futile.

The headache of abscess of the brain in some cases is violent, in others moderate. Emphasize the fact that in the beginning the temperature is elevated, that in the second stage it is normal or subnormal; before the end of the case or after a drainage operation the temperature becomes elevated. The emaciation and the sallow septic appearance are notable. If the abscess is near the surface or if the bones are involved, percussion may produce pain. Fascial palsy may be produced by a cerebellar abscess pressing on the pons or by involvement of the fascial nerve in the aqueduct of Fallo-

pius. In some of the cases of abscess of the brain there is no choked disk at all, but we have it at least beginning in two-thirds of the cases in one or both eyes. Compression is slight because the advance of the abscess destroys tissue. Leukocytosis may or may not be high. In a cerebellar abscess the Bárány test indicates trouble underneath the tentorium. In cerebellar abscess there are the Rhomberg symptom, nystagmus, respiratory disturbances, vertigo, occipital headache, rigidity of the post-cervical muscles, vomiting, and perhaps ocular palsies. There may be facial palsy on the same side as the lesion. In a temporosphenoidal abscess we are apt to observe weakness in the lower part of the face. The Babinski reflex and increase of the deep reflexes on the opposite side of the body may be noted. In a temporosphenoidal abscess on the right side of a right-handed person there is no aphasia, but in an abscess of the left temporosphenoidal lobe there may be aphasia. In temporosphenoidal abscess incomplete hemianopsia is common. If the motor area is pressed upon there will be Jacksonian convulsions, followed by weakness and palsy. In frontal abscess we find first no local symptoms, and Eagleton points out there is seldom intellectual involvement, although there may be a change in character and the memory may be much impaired. In frontal abscess there is apt to be marked dulness, slowness of thought, tendency to stupor and headache, although choked disk is rare.

The mortality of abscess is probably 75 per cent. The earlier the operation, the better the prognosis (see Kerr in "Archives of Surg.," Sept., 1923).

Meningitis arises soon after an accident; a *traumatic abscess* cannot arise until more than a week has elapsed after an accident, and many weeks may elapse. Meningitis presents high temperature and the general symptoms before outlined. *Mastoid disease* may occasion cerebral symptoms without abscess, or it may cause abscess. It is curious that in some cases of mastoid disease without brain abscess choked disk arises. In *sinus-thrombosis* there is a septic temperature, the veins of the face and neck enlarge, and a clot can usually be felt in the jugular. A *tumor* grows slowly, may present localizing symptoms, and double choked disk is frequently present. In tumor the temperature is apt to be normal. There is no symptom and no group of symptoms positively significant of abscess in contrast to tumor. If abscess and tumor occur together the diagnosis is impossible. There are 34 such cases on record (Hirschman in "Zeitschr. für Ohrenh.," 1914, lxxi).

Treatment.—If abscess is due to ear disease with implication of the mastoid cells, at once open and clear out the mastoid (see Fig. 646), and after doing this proceed to trephine the skull in order to reach the abscess. In any case, if symptoms of abscess exist, trephine the skull at once. If localizing symptoms are present, open over the suspected region. If localizing symptoms are not present, and the cause is ear disease, trephine at Barker's point (see Fig. 646). If no pus is found between the bone and dura, open that membrane. When the dura is opened, if the abscess is subdural, pus will be evacuated; if the abscess is in the brain substance, the brain will bulge very much and will not pulsate. A blunt and hollow needle is plunged into the brain, in the direction of the abscess, for 2 or 2½ inches. It is pointed to the external angular process of the opposite side. If pus is not found, withdraw the instrument and introduce it near the first point, and point it to the nostril of the opposite side. If pus is not found, withdraw the instrument and introduce it again, pointing it to the angle of the jaw of the opposite side. When pus is discovered, incise the brain with a knife, enlarge the opening by inserting a closed pair of forceps and withdrawing the instrument with the blades open. Scrape away the granulation tissue lining the abscess cavity, irrigate with hot salt solution, and introduce a rubber drainage-tube and suture it to the scalp; stitch the dura, but leave an ample opening for the tube; stitch the scalp and bring the tube out through a button-hole in the scalp, and after the first two days pull the tube out a little every day and cut off a piece. If the first trephining does not find pus, trephine at another point. If we are seeking for an abscess due to middle-ear disease and fail to find it in the temporosphenoidal lobe, seek for it in the cerebellum. In cerebellar abscess make a flap with the base up, and trephine or gouge away the bone just below the line of the lateral sinus. Puncture the brain for exploration as for cerebral abscess.

Brain Disease from Suppurative Ear Disease.—Acute otitis media sometimes, and chronic otitis media much more often, cause meningitis (*otitic meningitis*). This may be a circumscribed inflammation of the dura eventuating perhaps in an extradural abscess, a serous leptomeningitis, or a purulent leptomeningitis. There may or may not be involvement of the mastoid (*mastoiditis*). There are always fever and

pain and tenderness over the region of meningitis. The pain and tenderness are above the zygoma or back of the mastoid (Dench in "New York Med. Jour.," Aug. 27, 1910). With these symptoms there may or may not be signs of mastoid involvement. Dench points out that the occurrence of sudden and profound deafness during middle-ear suppuration usually means beginning meningitis (Ibid.). Chronic disease of the middle ear is apt to destroy the bone between the tympanum and the middle fossa of the skull, and thus produce meningitis, thrombosis of the petrosal or lateral sinuses, abscess of the temporosphenoidal lobe or of the cerebellum, or extradural abscess. In chronic otitis media the reflexes of the opposite side of the body are frequently altered (Russell Reynolds, Sir Victor Horsley). In some cases, even without any other evidence of cerebral involvement, there is choking of the disk. Choked disk may be the earliest symptom of abscess, the other symptoms not having developed. Absence of eye symptoms is not proof that abscess is absent, and their presence is not absolute proof of abscess. In many cases the infection is direct by bone involvement or by the lateral sinus. In many other cases the infection is through the labyrinth. If labyrinthine infection arises, it produces symptoms (disturbances of equilibrium and nystagmus). Chronic otitis media is apt to induce inflammation or suppuration of the mastoid cells (*empyema of the mastoid*). Pus in the mastoid may discharge itself into the middle ear, and from this point into the external auditory canal, through a perforation in the drum membrane (especially in acute cases). In some cases the pus becomes blocked up within the mastoid process. Pus in the mastoid may after a time break into the cavity of the cranium or into the groove for the lateral sinus, or may find its way externally (*postauricular abscess*) and open into the sheaths of muscles arising from the mastoid. It not unusually opens into the sheath of the digastric muscle (*Bezold's abscess*). These facts teach the surgeon that inflammation of the middle ear should never be neglected, but should if possible receive the closest attention of the specialist. If no perforation exists in the drum, the surgeon must make one. In ordinary cases cleanliness and antisepsis are sufficient, the ear being syringed every day with a warm 2 per cent. solution of common salt. If only a small drum perforation exists, 10 drops of pure alcohol or of corrosive sublimate solution (1 : 5000) are dropped into the ear daily; but if a large drum perforation exists, boric acid and iodoform (7 to 1) are insufflated. Never inject alum. A strong silver solution is not safe; if it is used, wash the ear out afterward with warm salt water. If granulations or polypi exist, they must be removed. Some cases require the removal of the drum membrane and the ossicles of the ear. Some cases of mastoid necrosis are due to tuberculosis. If headache, vomiting, and mastoid tenderness exist, open the mastoid (see page 792) in order to prevent abscess of the brain. In acute otitis media it is very rarely necessary to open the mastoid. The middle ear is on a lower level than the antrum of the mastoid, and in most acute cases both the middle ear and mastoid cells drain safely through a drum perforation. Because a man has chronic otitis media it is by no means always necessary to trephine the mastoid. In many cases removal of the ossicles and drum membrane effects a cure. In chronic otitis media, even if the mastoid is trephined, the ossicles and membrane ought to be removed in most cases.

Cerebral abscess from ear disease (see page 760) is almost always in the temporosphenoidal lobe, but may arise in the cerebellum. The **symptoms** are a regular, full, slow pulse (except in complicated cases), a transient rise of temperature, followed in many cases by a normal or subnormal temperature; vomiting; mastoid, frontal, and temporal pain. The mind is dull, and stupor arises which passes into coma; the bowels are constipated; choked disk may be present, and convulsions, spasms or paralyses may exist. Trephine and clean out the mastoid and asepticize (see Operations Upon the Skull and Brain). Also trephine at Barker's point, 1¼ inches behind and the same distance above the middle of the external auditory meatus, open the dura, and seek for pus in the brain. If pus is not found, open the cerebellum.

Extradural Abscess.—The eye symptoms and pain are the same in this as in cerebral or subdural abscess, but the temperature is different, rising to 103° or 104° F., and never being subnormal. There is often considerable tenderness above and behind the mastoid. In extradural abscess following disease of the middle ear trephine and clear out the mastoid; follow up a bone sinus to the abscess, cut away the bone, being careful to avoid injuring the lateral sinus; curet, irrigate, and drain.

Infective Sinus-thrombosis.—Any sinus may be attacked. The disease may result from scarlet fever, smallpox, diphtheria, influenza, typhoid, pneumonia, or any acute suppuration. In erysipelas of the scalp, subaponeurotic abscess of the scalp, and cranial osteomyelitis septic clots may form in the veins which pass through

the bone and reach the longitudinal or lateral sinus. Infective thrombosis of the sinus is thus produced. In carbuncle of the lip and orbital suppuration the cavernous sinus may become involved.

In caries of the basilar portion of the occipital bone the circular sinus or the cavernous sinus may suffer. The veins of the tympanum join the inferior cerebral veins, and one of the inferior cerebral veins empties into the cavernous sinus. The vein of Trolard, which arises on the parietal convolution and empties into the cavernous sinus, receives blood from the diploic veins which communicate with the veins of the tympanum (C. G. Crane in "Laryngoscope," 1916, xxvi). The anatomy of the region shows that cavernous sinus thrombosis may be secondary to middle-ear disease, with or without mastoid involvement (Fig. 632). In caries of the petrous portion of the temporal bone, and in suppuration of the middle ear and mastoid process, infective thrombosis of the lateral sinus may occur.[1]

In any case the symptoms are those of pyemia. The lateral sinus is the one most frequently attacked. In infective thrombosis of the lateral sinus there is usually a history of an old discharge from the ear.

Infective thrombosis of the lateral sinus may result from a specific fever, but is usually due to chronic suppuration of the middle ear associated in most cases with carious bone and pus in the mastoid process. Thrombosis of the lateral sinus occasionally follows an operation upon a suppurating mastoid, or develops in an individual who suffers from middle-ear disease, who has been struck upon the head, who has had the ear syringed with force, or who has had injected a corrosive or very irritant fluid. Tuberculous bone disease is an occasional cause.



FIG. 632.—Dr. Wayne Babcock's case of cavernous sinus-thrombosis beginning as chronic middle-ear disease (of opposite side) and then cavernous sinus involvement. Secondary involvement of right cavernous sinus and of sigmoid sinus. Final abscess of frontal lobe and death.

Symptoms.—In most cases there is a history of chronic ear disease. In children the symptoms are more acute than in adults. In any case the symptoms may rapidly become violent. In some cases there are preliminary symptoms of extradural abscess, pus being lodged in the groove of the sinus. It has been pointed out that pus in the jugular foramen may make pressure upon the pneumogastric, spinal accessory, and glossopharyngeal nerves, producing aphonia, hoarseness, dyspnea, dysphagia, and slow pulse (George F. Cott[2]). Marked headache and often an initial chill usher in sinus-thrombosis. The pain is apt to be localized about the ear and mastoid process, but may become general. There is usually acute tenderness of the mastoid. There is high fever from the start, but when the clot begins to soften and break down, hard rigors develop and the temperature fluctuates violently. The temperature varies greatly each day, fluctuating it may be between subnormal and 106° to 107° F. A chill may occur once or even twice a day, and it lasts from ten to twenty minutes. The pulse is irregular and usually rapid. The patient is nauseated, labors under vertigo, is very restless, is sometimes delirious, may become dull and stupid, and the muscles of the back of the neck are stiff. Tenderness and marked edema are detected over the mastoid, and the veins of the neck and mastoid region may be enlarged. When the clot extends into the jugular vein there is pain on moving the head and on swallowing, the cervical glands are swollen, and a cord-like clot may be felt in the neck. Choked disk exists in about half or perhaps two-thirds of all cases. There is often a profuse discharge of pus from the ear, but in some cases the discharge is found to have abated or ceased. Exophthalmos and swelling of the eyelids point to involvement of the cavernous sinus in the process. In early cases there is thrombosis of the lateral sinus alone or of the lateral sinus and jugular vein. In advanced cases other sinuses become in-

[1] The cavernous sinus may become involved from the lateral sinus by way of the petrosal sinuses.
[2] "Amer. Med.," April 19, 1902.

volved (superior petrosal, inferior petrosal, both cavernous, the lateral sinus of the opposite side, the ophthalmic veins, and the torcular Herophili). In sinus-thrombosis there is leukocytosis unless the patient is profoundly septic. A patient with sinus-thrombosis is in great danger of developing pulmonary metastasis and septic meningitis (Jansen). Septic meningitis is accompanied by abscess about the sinus. Infective sinus-thrombosis is a very fatal disease and usually runs its course in from seven to ten days, but occasionally lasts for several weeks. It is a form of pyemia, and death arises from the causes which have been referred to in discussing that disease.

Infective thrombosis of the cavernous sinus was noted by Duncan in 1821 ("Edinburgh Med. and Surg. Jour.," 17, 1921). It occurs when an infected clot comes from another sinus, from disease of the nasal sinuses, from orbital infection, or from a pyogenic process of the mouth, throat, face, lip, tonsils, ears, or lids. It causes pain and the general symptoms of pyemia, and also edema of the lids, chemosis, and an extreme degree of exophthalmos. There is great congestion of the fundus and may be choked disk. Vision may be normal or impaired. The condition almost invariably spreads to the other eye along the circular sinus. If the pterygoid plexus becomes involved there will be edema of the tonsil and pharynx of that side (Warren S. Reese in "Atlantic Med. Jour.," Oct., 1923—Fig. 632).

Infective thrombosis of the petrosal sinus produces pyemic symptoms, but no characteristic signs.

The **prognosis** largely depends upon early recognition. The surgeon should, whenever it is possible, open a mastoid before sinus-thrombosis arises, and should evacuate an abscess about the sinus before a clot forms in the venous channel, or at least before that clot becomes septic (Jansen).

Treatment.—In 1880 Zaufal proposed the operation now practised, and Horsley did it in 1886. (See article by Geo. F. Cott in "Amer. Med.," April 19, 1902.) Infective thrombosis of the lateral sinus is treated as follows: Open and clear out the mastoid, and expose the sinus by the use of the chisel or rongeur (see Fig. 646). Follow Mr. Ballance's advice and expose the sinus from the bulb to the torcular. The jugular vein should now be exposed at the level of the cricoid cartilage and ligated below any clot which may exist. This is done to prevent propagation of an infected clot and diffusion of sepsis. Even if a clot does not exist in the jugular, the vein should be tied in two places and divided, because the sinus contains infected clot or putrid material even when the vein as yet does not. According to Ballance, the portion of the jugular vein above the point ligated and divided should be extirpated. Some surgeons after ligating the jugular do not excise it, but if it contains a septic clot, incise the vein up to the base of the skull and pack the wound. After attacking the vein open the sinus, and if a clot is found to exist, cut away the wall of the sinus. Introduce a small spoon into the lumen and carry it toward the torcular Herophili, and scrape away the clot until blood flows. Arrest hemorrhage by forcing a piece of iodoform gauze into the wound and toward the torcular. Jansen opposes removing the entire clot toward the jugular, and does not tie the jugular, believing that to do so increases the danger of thrombosis of the inferior petrosal and cavernous sinuses. He simply removes the soft clot, but does not disturb the solid clot toward the heart. Most surgeons differ with him. Surgeons are of the opinion that it is futile to do any operation if pulmonary metastasis has taken place. In a case of the author's in the Jefferson Medical College Hospital the patient recovered after operation in spite of the fact that endocarditis had developed.

Until recently it was thought that the lateral sinus was the only sinus which should be attacked surgically, but in one case Knapp, of New York, requested Hartley to remove from the cavernous sinus a clot which was causing blindness and was due to sarcoma. The operation was successfully executed by Hartley, the incision being the same as is employed to reach a Gasserian ganglion in the Hartley operation. This patient lived several months. Dwight operated upon another case by incision of the sinus (E. W. Dwight and H. H. Germain, "Boston Med. and Surg. Jour.," May 1, 1902). Some surgeons advise removal of the eyeball and outer orbital wall and curetment of the sinus (Mosher). Some reach the sinus by way of the ethmoid and sphenoid. Bircher did a successful operation in 1893. Operation for infective thrombosis of the cavernous sinus has been futile, but if done early might succeed.

Postoperative Insanity.—Various mental disturbances may follow surgical operation (delirium, obsessions, hysteric excitement, morbid fears, illusions, hallucinations, amnesia, confusion, hypochondria, psychasthenia, melancholy, and genuine insanity). Insanity is no more frequent after abdominal operations than after other

operations if we exclude operations involving the ovaries and testicles. Removal of the testicles and ovaries are peculiarly provocative.

Postoperative insanity is most common in females and in adults. The predisposing elements connected with a surgical operation are: Apprehension, fear, pain, insomnia, and exhaustion before operation, the effects of the anesthetic, shock, and hemorrhage; postoperative pain, insomnia, worry, and perhaps homesickness. There is always predisposition, hereditary or acquired. The patient may have been on the brink of an outbreak when the operation was performed. The insanity may be apparent as the patient awakes from the anesthetic sleep (Savage), and in these very rare cases the anesthetic is blamed. Most acute insanities come on in from three to five days after operation.

If a man has ever had an attack of insanity operation or accident exposes him to distinct danger of another attack. No special mental condition characterizes postoperative insanity. There may be mania, melancholia, stupor, delusional insanity, or acute confusion. Acute confusional insanity is the most usual form. In some cases sepsis is present, in others it is not. We must not mistake insanity for febrile delirium, delirium tremens, delirium from opium deprivation, delirium from morphin or cocain taking or deprivation, delirium of iodoform-poisoning, delirium of the senile, traumatic delirium, hysteric delirium, uremic coma, or bromism.

Many cases of postoperative insanity must be sent to a hospital for the insane. Only cases of brief duration can be properly cared for in a general hospital.

Intracranial Tumors.—An encephalic tumor may originate within the skull. It may have arisen from an external growth invading the cranial cavity, or may be metastatic. A tumor that arises within the cranium may take origin from the periosteum, from one of the membranes of the brain, from the vessels, from the neuroglia, or from the brain substance.

No region of the body is so liable to tumors as the brain. During the course of a number of years the autopsies of the Munich Pathological Institute are stated by Bollinger to have shown 1 tumor of the brain in every 85 autopsies. Hale White's experience is that such tumors are even more common than this, and he estimates them at 1 in every 59 autopsies.

In endeavoring to determine the causes of intracranial tumors we must accredit heredity with considerable influence in tuberculoma, and possibly with some force in sarcoma and carcinoma. Tumors of the brain are decidedly more common in males than in females, probably because of the greater male liability to injury, syphilis, and alcoholism.

The majority of cases of tumor of the brain occur between the ages of twenty-five and fifty. Children are particularly prone to suffer from glioma and from tuberculous growths. In aged persons a tumor of the brain very rarely develops. In 100 cases of brain tumor collected by Hale White only 2 were aged seventy or over. In 100 cases collected by Mills and Lloyd only 1 was over seventy.

Injury may be responsible for the development of sarcoma, of fibroma, and possibly of other forms; in fact, a syphiloma may arise in a syphilitic person at the seat of an injury.

We use the terms "intracranial" and "encephalic tumor" not only to include true neoplasms but also to designate growths of parasitic, syphilitic, or tuberculous origin. It is of importance to attempt to make a diagnosis as to the form of tumor that is present, and this may be possible on account of the fact that in many cases the form affects the symptoms. A useful classification of these growths has been made by Knapp, and is as follows: (1) The infective granulomata, including tuberculous growths, gummata, and actinomycotic areas; (2) connective-tissue growths; (3) epithelial growths; (4) aneurysms. The most common of all these tumors is undoubtedly that due to tubercle. In fact, Gowers estimates that, if we exclude syphiloma, tubercle is responsible for one-half of the cases, and glioma and sarcoma together for one-third.

Tuberculous Tumors (*Tuberculous Gummata; Tuberculomata*).—Tuberculous growths may be primary, but are usually secondary to tuberculosis in some other region of the body. Tuberculous tumors are the most common form met with. They are at least four times as common in children as in adults. They may be single, especially in adults, but are often multiple, especially in children; and multiple growths may be very widespread. According to Allan Starr, these growths are most common in the cerebral axis (especially in the basal ganglia), next in the cerebellum, next in the cerebral cortex, and are least common in the centrum ovale. A tuberculous tumor usually arises in the pia mater, particularly in an arterial distribution, but may begin in a ventricle,

or even in the brain substance. Some of these growths are distinctly subcortical. The tubercle bacilli responsible for the condition are carried by the blood. Some of these growths are small aggregations of miliary tubercles in thickened pia. Others are large masses. A large tuberculous tumor is due to the coalescence of many foci. It undergoes caseation in the center, and is surrounded by a zone of softened or sclerotic brain substance. Tuberculous meningitis is present in two-thirds or three-fourths of the cases of tuberculoma.

Gummatous Tumors (*Syphilomata*).—As gumma seldom arises from inherited syphilis, the condition is very rare in children. There may be a single gumma, but, far more often, syphilitic growths are multiple. A gumma may be round or may be irregular in outline; in fact, the outline is frequently blurred and indistinct. Some of these growths are soft, and some, which contain a quantity of connective tissue, are hard. A syphiloma usually arises from the membranes, and, hence, is generally on the surface of the brain; and the membranes in the region of the growth usually show distinct inflammation. Soft gummata are most common at the base; hard gummata, in the cortex of the cerebrum or cerebellum.

Actinomycosis.—This is a very rare condition, in which the mass may remain solid like a tumor, but is far more apt to break down into an actinomycotic abscess.

Sarcomata.—Injury seems to play a considerable part in the production of intracranial sarcoma. Any variety of sarcoma may arise. Giant-cell sarcoma is very rare, but has been observed. Sarcomata may arise from blood-vessels, meninges, or bone. It may be primary or secondary. As a rule, at least in the beginning, the growth is single; but it may be multiple or may become so. The majority of sarcomata arise from the membranes or from the periosteum, but some cases take origin from beneath the cortex. Early in their progress these growths may be encapsulated, but some of them, from the very start, are infiltrating; and even those that were at first encapsulated later infiltrate. The cortex and the cerebellum are the most common seats for sarcoma. What is called *angioma of the brain* is, in reality, *angiosarcoma.* A *psammoma* is usually sarcomatous.

Endotheliomata may arise from perivascular lymphatics about cerebral vessels. Perithelioma arises from the vessels of the pia. It can arise from the dura and from the brain substance. An endothelioma arising from the arachnoid involves the dura, infiltrates the skull, and causes hemicraniosis. Perhaps for years there may be nothing evident but new bone formation and deformity, usually regarded as exostosis. Later there may be signs of cortical irritation, pressure symptoms, and even perforation of the projecting bone. Mallory calls these growths fibroblastomata. Others have called them sarcomata. (See Cushing and Weed in "Johns Hopkins Hosp. Bull.," 1915; Penfield in "Surg., Gyn., and Obstet.," May, 1923—Fig. 292).

Gliomata.—A glioma is a growth of epiblastic origin, but it resembles in many particulars connective-tissue growths. It grows by infiltration and does not push tissue aside as do tumors which grow by expansion (W. T. Councilman in "Long Island Med. Jour.," 1914, viii). The growth is often so ill defined and so slightly differentiated in appearance from the brain substance that it may easily be overlooked in an exploratory operation. It arises much more frequently from the white than from the gray matter, and develops from the neuroglia of the cerebrum, of the cerebellum, of the pons, or of the medulla oblongata. The growth remains strictly limited to glial tissue and may extend on the surface to a great distance from its point of origin (Councilman, Ibid.). A glioma may be soft or may be hard. A soft glioma is sometimes spoken of as gliosarcoma. Hemorrhage is very apt to occur in these growths. They have a tendency to become cystic. They destroy tissue as they grow, the tumor replacing destroyed tissue; hence pressure signs are late or absent. The growth strangles nerve-cells. Gliomata are the most common of brain tumors.

Fibromata.—Intracranial fibroma is a rare growth. Tumors of the cerebellopontile angle are apt to be of this character. It is of firm consistence, is encapsulated, and may grow to a large size. Such growths can be readily enucleated. Injury seems occasionally to be responsible for their formation.

Osteomata.—Osteophytic growths not uncommonly take origin from the inner surface of the skull, but the osteomata arising in the dura or in the brain substance are rare. Such growths, however, occasionally occur.

Cholesteatomata.—These tumors are fibrous growths covered with endothelium and containing layers of cholesterin. They are particularly apt to arise in the pia mater, but may begin in either of the other membranes or in the brain substance. A cholesteatoma is commonly called a *pearl tumor.*

Enchondromata and *true neuromata* are rare, and *lipomata* are exceedingly uncommon.

Adenomata.—An adenoma occasionally springs from the conarium or the pituitary body.

Carcinomata.—Primary intracerebral carcinoma is rare, but does occur. Secondary carcinoma is more common, and may follow cancer of any part of the body, although it is most apt to follow cancerous growths about the face or neck. A primary growth may begin in the meninges, in the hypophysis cerebri, or in the lining of the ventricle. Intracerebral carcinomata may be single or multiple. They are soft and non-encapsulated growths, infiltrating and very vascular.

Cysts.—Mills says that cysts arise about an old hemorrhage, are small retention-cysts of a vascular plexus, or are porencephalic. Dermoid cysts are extremely rare. Hydatid cysts are very rare in the United States. A cyst may result from the degeneration of a glioma or of a sarcoma.

Symptoms.—They are divided into two sets: (1) *General*, due to increase of pressure, and (2) *local*, *localizing*, or *special*, arising because of the part of the brain involved.

In some cases general symptoms are absent, in some special symptoms are absent, in others even tumors of large size produce no recognizable symptoms, either general or special. A large infiltrating growth, a glioma, for instance, may produce no symptoms at all if situated in a silent region, and if it destroys brain substance as it grows, so that intracerebral pressure is not increased.

General Symptoms.—The chief general symptoms are headache, vomiting, and choked disk. All of these may be present, any one of them may be absent, any two of them may be absent, and in some cases all of them are absent. Other general symptoms that may or may not be present are vertigo, general convulsions, insomnia, mental failure, and somnolence or partial stupor.

Headache.—This is the symptom most commonly present. It occurs sooner or later in a very great majority of cases.

At first it may be noted only at certain times of the day and it is usually complained of most on rising in the morning. The headache of brain tumor when once established is intense in most cases, and as a general thing it is practically continuous, with episodes of increased violence. In rare cases it is paroxysmal. In some cases it is trivial, in some few cases it never arises at all. The headache of brain tumor usually interferes with sleep. It may be general, one sided, frontal, or occipital. The situation of the pain is without localizing value unless there is tenderness on percussion or pressure over the seat of pain, which is sometimes noted in growths of the meninges or cortex.

Headache is less marked in gliomata than in other tumors.

Headache is less common in children than in older persons. In very young children the explanation of this is found in the open fontanels and the expansile cranium. Gliomata are common in children and may not cause intracerebral pressure.

The dura is sensitive, as Cushing says, to "pull or pressure, not to an incision." The headache of brain tumor is due to stretching of the dura.

Vomiting is present at times in many of the cases. It may happen occasionally or it may never occur.

It is usually cerebral, that is, vomiting with a clean tongue without nausea, and without any relation to the taking of food. In some cases it is projectile, quantities of vomitus being suddenly projected from the mouth. It may, however, be associated with nausea, and in some cases there is nausea without vomiting. It is apt to be most severe on getting up, especially on rising in the morning. It is usually most severe when headache is most intense.

The worst attacks of vomiting occur in cases of cerebellar tumor.

The cause of vomiting is uncertain. Some believe it to be due to stimulation of the vagus center; others, to reflex stimulation of a vomiting center in the medulla. If associated with vertigo it may arise from the auditory centers.

Choked Disk (Optic Neuritis, Papillitis, Descending Neuritis, Papillo-edema).—This is a most important symptom. It is disclosed by the ophthalmoscope. When present it is, as Cushing says, one of the "most reliable" signs of tumor. It is present in 80 per cent. of all cases. It may be noted in a few weeks after a tumor begins to grow, in a few months, or longer. It may come on rapidly or gradually.

It is particularly common and severe in growths beneath the tentorium. It is decidedly less common in tumors of the motor cortex. It is nearly always bilateral,

but it is common to find it more marked in one eye than in the other. That it is more advanced on one side *suggests* strongly, but *only suggests*, that the tumor may be on that side. Monocular choked disk is very rare. When it exists it indicates that the growth, in all likelihood, is situated near the back of the orbit on the same side as the choking of the disk. Gowers recorded a case of unilateral choked disk due to a tumor compressing the left optic nerve ("Lancet," July 10, 1909).

Choked disk may exist for some time and attain a high grade without noticeably impairing vision, but ultimately it leads to retinal hemorrhage, optic atrophy, and blindness. When atrophy begins, vision wanes. The presence of choked disk does not *prove* the existence of tumor. The cerebral edema of Bright's disease may cause a condition known as albuminuric retinitis, which practically is not to be distinguished from the choked disk caused by tumor. Cushing believes that the processes are identical in tumor and Bright's disease. Choked disk may be caused by meningitis, brain abscess, cerebral syphilis, infection of the sphenoidal sinus (see Sir Sinclair Thomson's case in "Brit. Med. Jour.," June 2, 1923), chronic otitis media, sinus-thrombosis, myelitis, infectious diseases (typhoid, influenza, diphtheria, and other conditions), toxemias from lead, arsenic, and alcohol, anemia, diabetes, or as an hereditary or family disease in the victims of the cranial deformity known as *oxycephaly*. In this condition there is a high and usually narrow head with a prominence over the site of the anterior fontanel (see Wm. Sharpe in "Amer. Jour. Medical Sciences," June, 1916). Diabetes or diabetes insipidus associated with primary optic atrophy, especially bitemporal hemianopsia, is probably due to hypophyseal disease. Whereas some believe that disease of the ethmoidal and sphenoidal cells may cause choked disk, we must attend to the views of Harvey Cushing who feels in doubt as to the frequent association of accessory sinus infection and retrobulbar neuritis. He says that when 2 or 3 diopters of swelling are found with retrobulbar neuritis we may be sure that we are "dealing with something which a hyperplasia of the mucous membrane lining the accessory sinuses is not capable of producing" ("Jour. Amer. Med. Assoc.," July 24, 1920).

The cause of choked disk has been much disputed. Some believe that the condition is a neuritis due to a toxic condition of the cerebrospinal fluid. Others believe that it is not inflammatory, but is a papillo-edema due purely to mechanical pressure, and is an edema or dropsy. The latter theory is largely held by surgeons because they have become convinced by experience that relief of intracranial pressure relieves or cures choked disk. De Schweinitz and Holloway ("Therapeutic Gazette," July 15, 1909) make the following statement in regard to mechanical pressure causing choked disk: "That this is the *only* etiologic factor may with propriety be disputed; indeed, it seems certain that a combination of factors must be active in the production of this condition, but increased intracranial pressure is the one of which we have most certain knowledge."

Cushing, of Harvard, who has done such notable work on this subject, believes that "almost all, if not all, cases of choked disk are primarily of mechanical origin and do not justify the term 'neuritis'" ("Keen's Surgery," vol. iii). Compression forces the cerebrospinal fluid out of its reservoirs. Some of it is forced into the vaginal sheath of the optic nerve. It reaches the head of the nerve and the swollen disk and large, tortuous veins are seen by aid of the ophthalmoscope. If a tumor has been, from its start, in contact with the nerves, primary atrophy occurs instead of choked disk. In such a case choked disk cannot arise because the fluid cannot be forced down the blocked nerve sheaths. Primary atrophy occurs in hypophyseal tumors.

Convulsions.—Generalized convulsions may occur, and children are especially liable to them. Many cases of supposed general convulsions have an unobserved local beginning which is a focal symptom.

Vertigo.—Mills says it is noted in one-third of all cases and is due to dural, ocular, or labyrinthine irritation.

Insomnia is often due to headache and is apt to be associated with restlessness, lack of emotional control, and irritability. It is most pronounced in cases of syphiloma and some forms of malignant disease, and is worse in adults than in children.

In rare cases there is *somnolence* or partial stupor rather than insomnia. In such cases slow speech is often noted.

Mental Failure.—There is often great lack of emotional control, characterized by irritability and outbreaks of anger. Failure of memory is common and change of character is the rule. There may be great slowness of thought and of mental response to stimuli, with defective power of orientation. Progressive mental deterioration may

occur. There may be mental depression, apathy, or mental excitement. Tumors in certain regions may cause delusions, illusions, or hallucinations.

Hysteria and neurasthenia sometimes arise.

Pulse and Respiration.—Whereas the pulse is often slow, it is very variable, and I agree with Cushing that "pressure-symptoms which characterize acute lesions (namely, rise in blood-pressure; slow, vagus pulse, and Cheyne-Stokes respiration) are conspicuous by their absence" ("Keen's Surgery," vol. iii).

Anemia is a not uncommon symptom of brain tumor. It is usually a result of secondary hydrocephalus.

Special, Focal, or Localizing Symptoms.—These symptoms, when present, indicate the situation of the growth. If the tumor is in a silent region there will be no focal symptoms. General symptoms may exist without focal symptoms and focal symptoms may exist without general symptoms.

Among localizing symptoms we should mention various forms of aphasia, hemianopsia, paralysis, Jacksonian epilepsy, sensory disturbances (to touch, pain, or temperature), a sensory aura, disturbances of taste, hearing, and smell, impairment of muscular sense, alteration or impairment of reflexes, nystagmus, and inco-ordination. Nystagmus is often noted as a general symptom when there is compression.

Exophthalmos unless due to complicating hyperthyroidism or ventricular tumor means direct pressure upon the cavernous sinus or hemorrhage into the orbit. A unilateral exophthalmos is nearly always upon the side of the tumor. In bilateral exophthalmos the protrusion is usually most advanced on the side of the tumor (Weisenberg in "Jour. Amer. Med. Assoc.," vol. lv).

Diagnosis.—In many cases a diagnosis is made at a period so late that irreparable damage has already been inflicted. Early diagnosis is of the first importance. A careful and painstaking study of the patient and of his history will usually enable us to make a diagnosis before, and often long before, the attainment of a degree of pressure which causes papillo-edema, headache, and vomiting. In doubtful cases an exploratory operation should be performed. Exploration is always called for in advancing cerebral palsy and in focal epilepsy.

In *abscess* the symptoms usually develop much more acutely than in tumor. It is true that some cases of encapsuled abscess last for months, but in them intervals of complete remission of symptoms occur, which is not the case in tumor. An abscess follows middle-ear disease or some other pyogenic process or perhaps a head injury. There may be fever and leukocytosis. Choked disk is far less common than in tumor.

Chronic meningitis from syphilis exhibits periods of increase and periods of subsidence of the symptoms, and usually palsy of one or more cranial nerves. The symptoms may pass away under the use of mercury and iodid of potassium. There may be clinical evidences of syphilis. There should be a positive Wassermann reaction.

Chronic tuberculous meningitis causes a headache which is apt to be general and more violent than that of tumor, and there is commonly more cutaneous hyperesthesia and hyperesthesia of the organs of sight and hearing. Choked disk may be absent. When present it is of less intensity than that observed in tumor. In some cases the ophthalmoscope discloses tubercles on the choroid. In meningitis there is a continued, irregular fever. The cerebrospinal fluid obtained by lumbar puncture usually exhibits an excess of lymphocytes. It may contain the bacilli of tubercle. Carbohydrates are absent. The fluid may be sterile. Of course, a tumor might exist with meningitis.

In *Bright's disease* symptoms strongly suggestive of tumor may arise (headache, vomiting, and choked disk) with, perhaps, but little change in the urine. The difficulty in diagnosis becomes evident when we recall that in cases of brain tumor the urine may contain casts and albumin. A sudden onset and brief duration of the symptoms suggest uremia.

Ependymitis with ventricular dropsy may cause symptoms resembling tumor with hydrocephalus. Optic neuritis is not so common as in tumor. Bilateral spastic paralysis may arise.

Severe anemia is capable of producing symptoms which suggest tumor. It can even produce choked disk. A blood examination and the rapid improvement under proper treatment makes the diagnosis evident.

In some cases of brain tumor (especially frontal lobe tumors) there are striking evidences of hysteria and neurasthenia. Always think of this when inclined to make a diagnosis of hysteria or neurasthenia.

The *x*-rays may aid us in diagnosis and many brain tumors can be skiagraphed. Lumbar puncture may aid in the diagnosis, but it must be used with the greatest care,

because in cases of tumor the withdrawal of any considerable quantity of fluid may be followed by sudden death due to the brain stem sinking into the foramen magnum and being squeezed.

Dandy has devised an ingenious and valuable method for determining that a tumor exists and for locating a neoplasm. He injects the ventricles with air and has skiagraphs made (*cerebral pneumography*). Any deviation of the ventricles caused by a tumor is exhibited and any block causing internal hydrocephalus is shown ("Annals of Surgery," July, 1918). The method is not free from danger in all cases. The *x*-ray picture is called a *ventriculogram*. Dandy says ("Surg., Gynec., and Obstet.," May, 1923) that 50 per cent. of tumors can be localized by neurologic study and the *x*-rays. Cerebral pneumography finds the rest. We can find and localize a tumor by this means even if the patient is in coma. Dandy estimates the position and size of the ventricle by aspiration. He perforates the bone in the occipital region on each side of the median line. One can always find an enlarged ventricle by tapping. The needle enters the posterior horn. Marked distention of the ventricles means a tumor block somewhere in the posterior half of the cerebral hemispheres. Dandy also points out the following important facts: Lumbar puncture is dangerous in tumor cases unless antecedent ventricular puncture is performed. The injection of indigocarmin into a ventricle colors the cerebrospinal fluid. If the dye does not pass from one lateral ventricle to the other the tumor is in the anterior or middle fossa. If it does pass it is in the posterior fossa unless it is in the pineal gland or unless there is an old hydrocephalus, new openings having formed.

It has been shown by Temple Fay and Francis C. Grant ("Jour. Amer. Med. Assoc.," Feb. 17, 1923) that the ventricle when internal hydrocephalus exists may be examined by means of an instrument known as the *ventriculoscope*, which is introduced into the ventricle. A photograph may be taken. A small trephine opening is made in the postparietal region and a small incision is made in the dura. The ventricle is tapped to find its depth and a No. 12 cystoscope is then inserted. Important structures are brought into vision and tumor within the ventricle can be seen and the distortion due to a subcortical lesion is definite. Two weeks later the other ventricle can be examined. They prefer to enter the instrument into the posterior horn of the ventricle. The method is only to be used when the ventricles are dilated. The danger is trivial.

Cause, Duration, and Termination.—A brain tumor, unless caused by syphilis, is a certainly fatal lesion if not removed by operation.

Some brain tumors grow for years before they produce symptoms. Some grow with great rapidity. When pressure symptoms appear the patient's life will terminate within a few months unless an operation is performed. It is usually stated that the average duration of life is three years.

Sudden death may occur at any time.

Horsley states that in a very few cases brain tumors have disappeared after mere operative exposure, the tumor not having been removed. Cushing has had the same experience, and regards such an amazing disappearance as due to the cystic degeneration of a glioma.

Localization of a Tumor.—The situation of a tumor is determined not only by localizing symptoms but also from their mode of onset and manner of combination. In some cases the symptoms are not characteristic, in others they are definite. The more marked the signs of compression, the less the value of localizing symptoms. The nature of the tumor, its depth, and whether it is single or if other tumors exist is, if possible, determined. Localizing symptoms may be due to irritation or destruction of functionating power. Irritation causes spasm and destruction induces paralysis. Convulsions which are local or which begin locally are known as *Jacksonian epilepsy*. A local convulsion points to an irritative lesion of, or immediately adjacent to, the center which presides over the muscular movements of the part convulsed. Local paralysis points to a destructive lesion of the center which presides over the movements of the paralyzed part. In some cases a center is damaged and the muscular movements it controls are paralyzed, but the adjacent brain areas are irritated and the muscles they represent are attacked with spasms. In some cases an apparently paralyzed part becomes convulsed, the center not being completely destroyed and sudden hyperemia serving to awaken spasm. Always note the order of invasion of different regions and observe if spasm is followed by muscular weakness or anesthesia.

The Bárány Tests.—These are tests of the vestibular apparatus. We know that failures in certain normal responses indicates impairment of a certain part of the

vestibular apparatus. These failures may enable us to locate a tumor or an abscess. Tumors of the cerebellopontile angle and tumors of the third ventricle can thus be located. The tests must be made and interpreted by an expert. My colleague, Prof. S. MacCuen Smith, described for me the accepted methods of making the Bárány tests. The description follows:

1. *Rotation Tests.*—(*a*) The patient seated erect, in a smoothly revolving chair, with the head at an angle of 30 degrees forward and the eyes closed, is given ten complete revolutions to the right, occupying about ten seconds. On the completion of the tenth turn the chair is locked. The patient is directed to gaze into the distance. There will be a left stimulatory—being to the right, and the quick component—cerebral, inhibitory—being to the left. The average duration of the nystagmus is twenty-four seconds.

(*b*) When rotation is to the right, the left labyrinth is the one receiving the greater stimulus, because on the left side the endolymph in the external semicircular canal is made to flow toward the ampulla, while in the right external semicircular canal the endolymph movement is away from the ampulla.

The Pastpointing Reaction (after Stimulation).—(*c*) The patient is rotated to the right, as in the manner just described, with the exception that the eyes remain closed throughout the test. At the completion of the tenth revolution the patient's extended right index-finger is placed directly on the examiner's index-finger, held stationary. This is done to give him the location of the examiner's finger. The patient is then directed to raise his horizontally extended arm to a vertically extended position and then to return to the examiner's finger. The same is repeated with the left arm. A normal individual will bring his finger down several inches to the right of the examiner's finger, for the reason that when the revolutions cease he experiences vertigo, the subjective sensation being that of rotation in the opposite direction, namely, to the left. This reaction depends upon the pathway of the stimulus over the fibers of the eighth nerve being unobstructed from the external canals to the cerebral cortex. If there is a lesion along the pathways, or if the labyrinth is dead, there will be no pastpointing.

(*d*) All the rotation tests are the same, with the exception that the head is placed at an angle backward of 60 degrees in order to bring the vertical canals in the plane of rotation. Reactions are normally as follows: After rotation to the right there will occur left rotatory nystagmus, the slow movement being to the right and the quick component being to the left. Pastpointing will be to the right. If there is a lesion along this pathway, or if the labyrinth is dead, there will be no nystagmus or pastpointing.

2. *Caloric Tests.*—(*a*) The caloric test is made by irrigating the right external auditory canal with water at 60° F. under the following conditions: The patient is seated erect, with the head at an angle of 30 degrees forward. The water is permitted to flow through a tube in a continuous stream, without undue pressure, from a glass reservoir into the canal until nystagmus is noted, usually within forty seconds, or until the examiner is satisfied that it will not occur. In a normal individual with this chilling of the labyrinth wall there is a flow downward of the endolymph in the vertical canals toward the ampulla, producing left rotatory nystagmus; the slow movement to the right, the quick component to the left, and causing pastpointing to the right.

(*b*) One of the advantages of the caloric test is that only one set of canals and their pathways is stimulated at one time. The reactions depend upon the pathways from the vertical canals on the right side to the cerebral cortex being unobstructed. Should there be a lesion along the pathway, nystagmus and pastpointing, one or both, may not occur. If the labyrinth is entirely dead, neither will occur.

(*c*) To stimulate the external canal it is only necessary to place the patient's head at an angle backward of 60 degrees, because the endolymph is already chilled from the irrigation just performed. The flow of the endolymph is now away from the ampulla, and in a normal individual a left horizontal nystagmus will occur; the slow movement will be to the right, the quick component to the left. Pastpointing will be to the right. The pathway of the stimulus is now that from the external canal to the cerebral cortex and the reactions depend upon its being intact.

(*d*) When the irrigations are performed with hot water at 112° F., the flow of the endolymph is reversed and the reactions are reversed.

Summary.—(*a*) Rotation to the right, horizontal nystagmus to the left for an average of twenty-four seconds, pastpointing to the right with both arms, and continuing so long as the vertigo is experienced; when the rotation is to the left, the same reac-

tions will occur, only in the opposite direction, as when rotated to the right. When the head is extended back during rotation, there will result a rotatory nystagmus; the duration of the nystagmus and pastpointing will be the same in the first stimulation.

(*b*) In rotation to the right two-thirds stimulation is obtained from the left and one-third from the right labyrinth. The stimulation passes over the vestibular fibers of the eighth nerve, from the semicircular canals to the cerebral cortex.

(*c*) The caloric test with water at 67° F. will stimulate one set of semicircular canals at a time; head erect, the vertical canals are stimulated and will produce rotatory nystagmus to the opposite side, with pastpointing to the same side; with the head thrown back 60 degrees there will be horizontal nystagmus to the opposite side, with pastpointing to the same side. The stimulation passes over the vestibular fibers of the eighth nerve from the semicircular canals to the cerebral cortex. Pathologic lesions will interrupt the stimulus and in this way its location may be studied.

Aphasia.—The localizing value of aphasia is a subject of dispute.

Motor aphasia is a condition in which voluntary speech is lost, but the individual can understand words that are spoken to him; can't repeat words on hearing them, but can understand printed and written words. There is no paralysis of the muscles used in enunciation; the man knows what he wants to say, but he can't say it because he cannot start up voluntarily the muscular mechanism necessary for speech. He can't read aloud. He may use certain monosyllables or may repeat one sentence over and over and on all occasions. The lesion of motor aphasia is cortical and is generally supposed to be situated in Broca's convolution, the posterior part of the third frontal, on the left side in right-handed persons, and vice versa. Marie believes that the lesion is of the lenticular nucleus and the island of Reil (Frauent in "Lyon. méd.," 1914, cxxii). The motor aphasic usually has agraphia.

Motor agraphia is a name used to signify that the person cannot write voluntarily, cannot take dictation, and cannot copy. Sensory agraphia is a part of word-blindness. The person cannot write voluntarily, but perhaps can on dictation. The cortical lesion of motor agraphia is thought to be in the posterior part of the left second frontal convolution.

Motor asemia, as sometimes seen in one who is deaf and dumb, is loss of ability to inaugurate the movements necessary for finger language. The cortical center is probably in the center for finger movements. In **word deafness** the sound of the word is lost. The spoken word is devoid of meaning. If the patient is shown a knife he cannot name it. If we speak several names, one of them being knife, he does not recognize it. If he does identify the word the condition is not cortical, but is subcortical and is called partial word deafness or auditory amnesia. The storehouse for memory pictures of words is cortical and in the first and second temporal convolutions of the left side. A word-deaf man can't pick out words, his speech is greatly hampered, but if he is free from word-blindness he can perhaps read and even read aloud. The motor speech centers may be stimulated by usual memories so that when one sees an object or even thinks of an object he may be able to give its name (Starr). It may be that a word-deaf man can be irritated into swearing. Voluntary speech is affected, but emotion and habitual expression remain.

In **word-blindness** a person cannot call up memory pictures of words or letters. These symbols mean nothing to him. He cannot read (*alexia*). He cannot write. He is more apt to remember letters than words. He may have forgotten or may still remember figures. He may copy or may even take down dictation, but he doesn't understand what he writes. The lesion is in the cortex of the angular gyrus and inferior parietal convolution. If the temporal convolutions are also involved there will be word deafness.

In **optical aphasia** the lesion is subcortical and involves the association fibers which join the storehouse for sight memories and the storehouse for sound memories. There is "inability to recall the name of a thing seen and to picture to the mind the appearance of a thing named. Yet the name is recognized when heard and the object is recognized when seen." ("Organic Nervous Diseases," by M. Allen Starr.)

When association fibers which join the various areas wherein are stored memory pictures are involved, the man uses wrong words and, as Starr says, "talks jargon." This is **paraphasia.**

Marie does not believe that motor aphasia is due to lesion of the left third frontal convolution. He maintains that motor aphasia is due to lesion of the lenticular nucleus and island of Reil (Frauent in "Lyon. méd.," 1914, cxxii).

Lesions in the Cortical Motor Area.—A slow-growing tumor which irritates the cortex will cause tonic or clonic convulsions of the opposite side of the body. These convulsions have a local beginning (Jacksonian epilepsy). After a time paralysis may develop (monoplegias and perhaps, ultimately, hemiplegia). An irritative lesion of the lower third of this area causes spasm of the opposite side of the face, angle of mouth, or tongue; and this condition is often associated with tingling. The spasm may remain limited or may extend widely, and may even become general. An irritative lesion of the middle third of the cortical area causes spasm, which is limited to or begins in the fingers, thumb, wrist, or shoulder. An irritative lesion of the upper third of the cortical motor area causes spasm, which is limited to or begins in the toes, ankle, leg, or thigh. If such lesions exist, an aura is occasionally felt in the affected region before the spasm begins, and there is often numbness after the spasm. Destructive lesions of the motor area cause local paralysis, which may be preceded by local spasm of the same parts, and is often associated with local spasm of other parts. If paralysis comes on unpreceded by convulsions the lesion is *subcortical* rather than cortical, that is, it is in the white matter between the motor area and the internal capsule.

Tumors of the anterosuperior portion of the prefrontal region give no definite localizing symptoms, but produce general symptoms. Mental disorders may arise in tumors of any area of the brain, but in tumors of the prefrontal region they are most apt to occur. The intelligence is nearly always impaired, and there is apt to be mental apathy, loss of memory, hysteria, irascibility, and pronounced change of character. As the tumor grows it may subsequently involve the motor region, which in all probability lies entirely in front of the fissure of Rolando.

In tumors of the prefrontal region there may be focal convulsions or local palsy on the opposite side, due either to a spread of irritation from a superficial tumor to the motor cortex or to involvement by a deep tumor of the commissural fibers which join the frontal lobe and the motor cortex.

Tumors of the Antero-inferior Portion of the Prefrontal Region.—In a right-handed man tumor of the second left frontal convolution causes *agraphia*, and of the third left frontal convolution, *motor aphasia*. In a left-handed person these localizations are on the right side of the brain.

Inferior Frontal Areas.—Foster Kennedy ("Jour. Amer. Med. Assoc.," Nov. 14, 1916) describes the following syndrome: On the side of the lesion there is true retrobulbar neuritis with central scotoma and primary atrophy. If pressure is considerable there will be choked disk of the other eye and "ipsolateral anosmia."

Malcolm Gunn pointed out years ago the pupillary reaction characteristic of retrobulbar neuritis. When light is poured upon the pupil rapid contraction occurs, but the contraction is slight and very temporary. The pupil quickly dilates to its former diameter in spite of light continuing to pour upon it.

Tumors of the parietal lobe may occupy a silent region of this lobe. The centers of general sensibility and for the muscular sense are back of the fissure of Rolando in the parietal lobes. Hence a tumor in this region may cause disturbance of muscular sense and general sensibility in the limbs of the opposite side, without spasm or palsy (Durante). There may be word-blindness when the left angular gyrus is affected.

The extension forward of a parietal tumor will involve the motor zone and produce spasm or palsy. Extension backward will involve the occipital lobe and produce hemianopsia.

Tumors of the occipital lobe are apt to produce *lateral homonymous hemianopsia* (blindness of the nasal half of one retina and the temporal half of the other retina. If the right side of the brain contains the lesion the right side of each retina is blind, and vice versa). Wernicke's pupillary sign is absent. By this sign we mean loss of pupillary light reflex when light is cast upon the blind part of the retina. This sign only occurs in a lesion in or in front of the centers for pupillary reflex. Lesions of the cuneus and of the calcarine fissure are especially apt to produce hemianopsia. A lesion of the occipital cortex may produce it. Lesions of both occipital lobes cause blindness. In tumor of an occipital lobe color vision only may be affected (Cushing). Tumor of the optic radiation may produce hemianopsia (that is, growths of the chiasm, optic nerve, or pulvinar may, but it is not certain that a growth of the quadrigeminal bodies or of the external geniculate body can).

In a tumor of the occipital lobe (the left lobe in right-handed persons and vice versa) there may be *mind-blindness*, that is, an inability to know what is seen. The patient may fail to understand written or printed words (*word-blindness*), the nature of things (*apraxia*), or signs (*asemia*).

Tumors of the temporosphenoidal lobe frequently produce no symptoms. In the temporal lobes the cortical centers for hearing are placed, and each center is connected with both auditory nerves, but the crossed auditory bundle is larger and more active than the direct (Francesco Durante, "Brit. Med. Jour.," Dec. 13, 1902). Tumors in the left lobe are particularly apt to cause deafness and may cause *word-deafness*. Tumors at the apex of the lobe may cause perversion or impairment of taste and smell. Tumors of the temporosphenoidal lobe may make pressure on the motor tract and cause paralysis of the opposite side.

Tumors of the Corpus Callosum.—These growths affect mentality as do tumors of the frontal lobes and frequently cause hemiplegia of each side.

Tumors of the Crus.—These tumors cause hemiplegia of the opposite side and paralysis of the third nerve on the side of the lesion. If the optic tract is pressed upon there will be hemianopsia. If the tegmentum is involved there will be hemianesthesia.

Tumors In or About the Optic Thalamus.—On the side of the lesion there are nystagmus and impairment in the movements of the eyeball. There are muscular weakness and impairment of sensation in the limbs of the opposite side. There may be sudden and uncontrollable movements, astereognosis, mental dulness, emotional outbreaks, and impairment of emotional control of the facial muscles. A lesion of the posterior part of the thalamus causes hemianopsia and the pupillary reaction of Wernicke.

Tumors of any size in or about the **corpus striatum** cause hemiplegia of the opposite side by pressure upon the internal capsule. Pressure upon the *optic thalamus* produces homonymous hemianopsia and hemianesthesia. Growths near the basal ganglia produce intense choking of the disk and early pressure because of distention of the ventricles.

Tumors of the Corpora Quadrigemina.—These tumors produce cerebellar ataxia, palsy of the eye muscles, and sometimes, perhaps, hemianopsia. Hearing may be impaired in the ear opposite to the lesion. Tumors of the corpora quadrigemina are apt to involve the crura, and later the third nerve. Ocular symptoms are always present (loss of pupillary reflex and nystagmus). If the third nerve is involved there are paralysis of the motor oculi area on the side of the lesion (external strabismus, dilated pupil, and drop-lid) and hemiplegia of the opposite side of the body from pressure upon the crus. This condition is a form of *crossed paralysis*.

Tumors of the Third Ventricle.—Symptoms are due in part to pressure on nearby structures and in part to secondary hydrocephalus. Weisenburg, on the strength of 30 reported cases, each case with an autopsy, pointed out a syndrome, viz., exophthalmos, dilated pupils, impaired pupillary reactions, cerebellar ataxia, and paralysis of upward associated eye movements ("Brain," 1910, xxxiii). Bassol ("Jour. Amer. Med. Assoc.," Nov. 11, 1916) reports a case of soft glioma filling the third ventricle. There was secondary hydrocephalus. The symptoms were headache, mental dulness, drowsiness, papillitis and blindness, ataxia, and limitation of ocular movements. The patient was fourteen years of age and there was precocious development of hair and also of the genitals.

Tumors of the Fourth Ventricle.—The symptoms result from internal hydrocephalus and pressure upon the cerebellum, pons, and medulla. So far diagnosis from cerebellar tumors has not been possible.

Tumors of the Pons.—Pontine lesions produce symptoms by pressure upon the particular nerves which come from this region, with or without the evidences of pressure upon the motor path. Forms of crossed paralysis may exist. Lesions in the lower half of the pons may affect the fifth, sixth, and seventh nerves on the side of the lesion and the limbs on the opposite side. The auditory nerve may be involved in the lesion. In crossed paralysis the face on the side of the limb paralyzed is usually not affected, but in extensive tumors it may be paralyzed. *Conjugate deviation* of the eyes may occur *away* from the *facial paralysis*. In tumors of the upper part of the pons the pupils may be first contracted because of irritation of the third nerve nuclei, and later dilated by destruction of these nuclei. Anesthesia as a result of pontine tumors is not nearly so common as motor paralysis, and convulsions are rare. There may be hemiplegia with crossed hemianesthesia. A tumor on the side of the pons which involves the peduncles causes ataxia and sudden, uncontrollable movements. Knee-jerk may be absent in a case of pontine tumor.

Tumors of the Medulla.—An extensive lesion inevitably causes death. Cranial nerves only may be involved, but crossed paralysis may take place. There may be hemiplegia with crossed paralysis of the hypoglossal nerve. Vomiting is common, retraction of the head is not unusual; respiratory and circulatory disturbances and

dysphagia are usually noted; sometimes there is numbness and occasionally there are convulsions; usually there is inco-ordination because of pressure upon the cerebellum.

Tumors of the Cerebellum.—The main function of the cerebellum is to synergize body movements and the symptoms of cerebellar disease are due to impairment of this power.

As a rule tumors are gliomatous, they grow slowly and affect particularly the middle regions of the cerebellum. Tumors often cause internal hydrocephalus. In general it may be said that tumors of the cerebellum cause headache, vomiting, vertigo, choked disk, and early blindness. *Tumors of the middle peduncle* cause sudden uncontrollable movements of the trunk, either toward the side of the tumor or away from it. Vertigo and nystagmus are common. Symptoms are frequently complicated by evidences of pontine disease proper.

Tumors of the middle lobe of the cerebellum cause a sense of lost equilibrium and obvious unsteadiness in attempting to walk or even to stand. The knee-jerks vary. The Babinski reflex is absent in an uncomplicated case. The patient has a tendency to fall backward; there are giddiness and vomiting, early and violent choked disk and occipital headache, nystagmus, inability to stand steady when the feet are together and the eyes shut, and perhaps temporary palsies of the eye muscles. Nystagmus which is brought into being by voluntary movement is probably due to a lesion outside of the cerebellum which lesion affects vestibular fibers. Cranial nerve symptoms usually mean extracerebellar lesions. The same may be said of dizziness with ear symptoms. Motor involvement points to a pontine lesion (Weisenburg, "Jour. Amer. Med. Assoc.," 1915, lxv).

Cerebellar symptoms are common in cases of internal hydrocephalus.

Tumors of the cerebellar hemisphere produce no localizing symptoms. The usual unsteadiness of gait is due to pressure upon the middle lobe (Nothnagel).

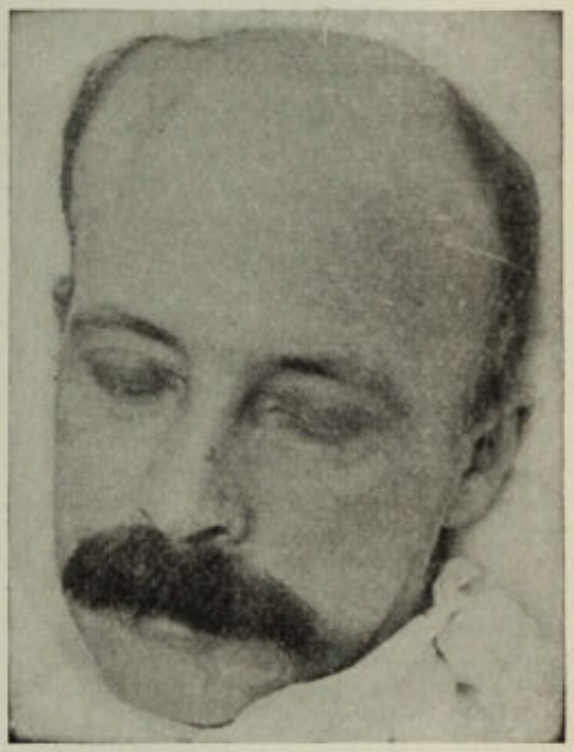


FIG. 633.—Case of cerebellar tumor. Bulging of flap after osteoplastic exploratory operation.

Tumors of the Cerebellopontile Angle.—Tumors of this region are usually attached to the acoustic nerve, sometimes to the seventh, sixth, or fifth nerve. They are usually fibromatous and are occasionally cystic. They produce general pressure symptoms and may cause cerebellar or pontine symptoms by making direct pressure on those parts. In these cases localizing symptoms may be late in appearing. The Bárány tests are valuable. If the tumor arises from the cerebellum the first symptoms will be cerebellar. If the tumor springs from a cranial nerve the first symptoms will point to that nerve. If the tumor involves the acoustic nerve there will be tinnitus, objective vertigo (sometimes with, sometimes without, forced movements), a liability to sudden attacks of falling to the ground, failure of hearing or actual deafness, perhaps sudden blindness or sudden unconsciousness, and sometimes tonic extensor spasms. If the tumor involves the trigeminal nerve there will be violent neuralgia in the course of the nerve and anesthesia of the face on the same side as the tumor, the anesthesia involving the cornea. If the seventh nerve is involved there will be peripheral facial palsy of the same side. If the sixth nerve is involved internal strabismus will arise because of palsy of the external rectus muscle.

Tumors of the Hypophysis Cerebri.—The hypophysis cerebri is a ductless gland of immense importance to the economy. It is present in all vertebrates. If the anterior lobe is removed death follows. If the anterior lobe is damaged or partially removed developmental disturbances occur. The pars intermedia of the posterior lobe furnishes a very active substance which is called pituitrin which acts upon the kidney, uterus, urinary bladder, intestine, the secretory cells of the mammary gland,

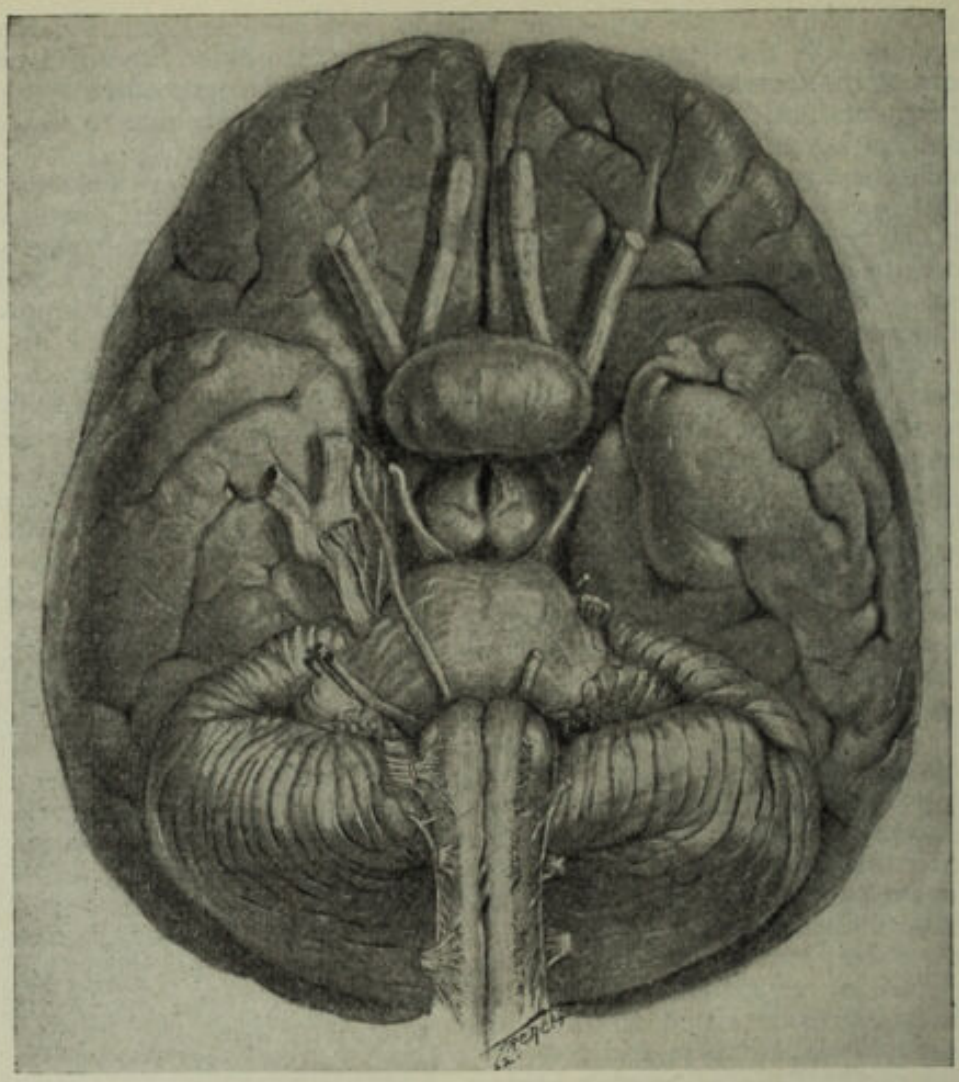


FIG. 634.—Suprasellar tumor.



FIG. 635.—Suprasellar cyst with calcification in the wall (U. S. Naval Hospital, League Island, Pa. Skiagraphed by Lieut. George U. Pillmore, Medical Corps, U. S. Navy).

the heart, and the blood-vessels. Overaction of the anterior lobe, however induced, is the cause of acromegaly. Underaction produces *Frohlich's syndrome*. This syn-

drome is composed of adiposity, retarded development of the genital organs, scanty body hair, a feminine figure, a high pitched voice, fingers which taper, a tendency to drowsiness, a great appetite for sweets, perhaps epileptiform seizures, and generally delayed development. There is a very high tolerance to carbohydrates. The posterior lobe can be removed without dangerous results. Diabetes insipidus is probably due to irritation of the posterior lobe. In this disease subcutaneous injection of extract of the posterior lobe will diminish the amount of urine one-half or more (J. L. Miller, "Jour. Amer. Med. Assoc.," 1916, clii).

Pituitrin arrests hemorrhage by its power in causing coagulation. It is used in intestinal stasis and peritonitis following operation to cause peristalsis. It stimulates uterine and vesical contractions, raises blood-pressure, and lessens the rapidity of the heart.

In pituitary tumor the *x*-rays show enlargement of the pituitary fossa.

A. D. Dunn ("Amer. Jour. Med. Sciences," 1914, cxlvii) has drawn up the following useful schedule of classification of disorders of the function of the pituitary body.



FIG. 636.—Enlargement of sella turcica from new growth (U. S. Naval Hospital, League Island, Pa. Skiagraphed by Lieut. George U. Pillmore, Medical Corps, U. S. Navy).

I quote it in the words of the abstract in "Surgery, Gynecology, and Obstetrics," Dec., 1914:

1. Affections of the pars anterior:

(*a*) Hyperfunction—acromegaly, gigantism.

(*b*) Hypofunction—true or pituitary dwarfism—not chondrodystrophic, rachitic, or cretinic dwarfs.

2. Affections of the pars posterior:

(*a*) Hyperfunction—diabetes insipidus.

(*b*) Hypofunction—hypophysial obesity—dystrophia adiposogenitalis.

3. Mixed affections:

(*a*) Hyperfunction of the pars anterior with hypofunction of the pars posterior—acromegaly with hypophysial obesity.

(*b*) Hypofunction of both lobes—drawfism with hypophysial obesity.

4. Hypophysial disturbance, in conjunction with perverted activity of other glands.

(*a*) Ovarian or testicular hypofunction with:

1. Hyperfunction of the pars anterior—acromegaly with sexual impotence—eunuchoid giants.

2. Hypofunction of the pars anterior—pituitary dwarfism with sexual impotence.

3. Hypofunction of the pars posterior—dystrophia adiposogenitalis.

(*b*) Associated with disturbances of the functions of other ductless glands, *i. e.*, adrenals, pancreas, thyroid, pineal gland, thymus (status thymolymphaticus), etc.

The size of the pituitary fossa is determined by the *x*-rays (Fig. 636).

When the gland is imperfectly developed and hypopituitarism exists as a result, the fossa is small.

The fossa may be deformed by tumors enlarging from within or by tumors pressing down from above. Enlarged sella may be due to adenoma of the anterior lobe, to malignant growth of the fossa, perhaps to repeated physiologic enlargement, sometimes to general or local hydrocephalus, to local meningitis, or to distant brain tumors (V. Z. Cope in "Lancet," 1916, cxc).

Cope says that if the dorsum sellæ or anterior or posterior clinoid process are obliterated or definitely absorbed there is decided intracranial extension of the tumor (Ibid.). The pituitary body may be subjected to pressure from, or become involved in, tumors of the region about it (Fig. 634), or tumors or cysts may spring from it directly. Tumors of or tumors making pressure upon the hypophysis may in some cases cause acromegaly, and in others impotence, genital infantilism, a tendency to fat deposit and stunted stature, and amenorrhea in women. There is intense headache, amblyopia due to primary atrophy (no preceding choked disk), appearing often as a bitemporal hemianopsia (Cushing, "Jour. Amer. Med. Assoc.," July 24, 1909). In some cases extreme drowsiness has been noted, and in some cases there has been binasal hemianopsia. When there is stimulation of the pituitary (hyperpituitarism) acromegaly develops; when there is lessened secretion (hypopituitarism) there are obesity and genital atrophy. In hyperpituitarism dextrose may be found in the urine. In hypopituitarism there may be polyuria and polydipsia and immense increase in carbohydrate tolerance.

Any brain tumor which causes internal hydrocephalus may thus cause pressure on the hypophysis and lead to the development of hypophyseal symptoms. (For full information regarding the hypophysis see the classic monograph by Harvey Cushing, called "The Pituitary Body and Its Disorders."[1])

Treatment.—If there is any doubt as to the existence of brain syphilis, and if the Wassermann reaction is positive, give the patient a dose of salvarsan (intravenously) and a course of iodid of potassium. Give the iodid at first in small amounts, but rapidly increase it until heroic doses are taken (100 or more grains a day). Mercury should also be given hypodermically or by inunction. If salvarsan, iodid of potassium, and mercury really relieve the symptoms, and if the improvement is not merely temporary, operation is unnecessary, although it may be demanded later in order to remove an irritant scar. If antisyphilitic treatment fails, the question of operation must be considered. The test of success is improvement in the choked disk. If this improves, the treatment is succeeding; if it does not, the treatment is a failure. It should not be persisted in over six weeks if there is no improvement in the eye-grounds. To delay operation further may mean blindness. We must always bear in mind that in certain cases of glioma the symptoms *temporarily* improve under antisyphilitic treatment. The term *operable case* does not of necessity mean a tumor which can be entirely removed by operation. Some tumors which can be only partially removed should be operated upon. An operable case is one in which an attempt may be made to remove the tumor and in which the tumor can be entirely removed or in which a part can be removed, the removal of this part promising relief. We are justified in being radical, because without operation a brain tumor is a certainly fatal malady. In many cases of undoubted tumor excision for cure is not attempted because of the absence of localizing symptoms or because of the inaccessible situation of the growth. In all cases operation is, first of all, exploratory. Tumors of the dura which have not infiltrated the brain, many cortical and some subcortical growths, are operable. Dural tumors give a particularly good prospect for operative cure. So do endotheliomata of the arachnoid with hemicraniosis. Cerebral and cerebellar cysts may be opened and drained in hope that benefit will result. Tumors of the lateral lobe of the cerebellum and tumors of the cerebellopontile angle should be removed. Byron Bramwell maintains that tumors at the base, tumors of the pons and medulla, of the corpus callosum, of the basal ganglia, and of the deeper parts of the centrum ovale are irremovable. Surgeons now regard many tumors of the cerebellopontile angle as operable, but agree with Bramwell's views as to growths in the other situations he mentions. Frazier has concluded that "if the tumor is found to be very vascular and of the infiltrating type, it is very questionable . . . as to whether any attempt whatsoever should be made to extirpate" ("University of Penna. Med. Bull.," April–May, 1906), and with this opinion I certainly agree. In tumors which are very extensive complete

[1] For full consideration of localizing symptoms see particularly the writings of Gowers, Mills, Allan Starr, Potts, Lloyd, Burr, Dana, Dercum, Osler, Spiller, Frazier, and Cushing, which have been freely used in the above section.

removal is usually out of the question. There is no use in removing secondary malignant tumors. It often happens that the brain itself (as in syphilis) is so extensively diseased, or that other organs (as in tuberculosis) are so involved, as to render attempts at removal of the tumor futile or actual removal useless. Mills thinks that 50 per cent. of cerebellar tumors can be attacked surgically ("New York and Phila. Med. Jour.," Feb. 11–18, 1905). He classifies operable tumors of the cerebellum as follows: 1. Tumors situated entirely or chiefly in the lateral lobe. 2. Tumors upon or even invading a part of the vermis or middle lobe. 3. Tumors of the cerebello-oblongato-pontile angle. The most favorable tumors for removal are fibromata and encapsulated sarcomata. Gliomata and gliosarcomata have been removed, but are very apt to return. A hard syphiloma requires removal as truly as a real tumor. The cases are commonly unfavorable, as there is often wide-spread brain disease. The same is true of tuberculoma. Among inoperable tumors are most gliomata and all infiltrating sarcomata, metastatic tumors, and multiple tumors. Bramwell[1] tells us that he has studied 82 cases of intracranial tumor, and he considers that in only 5 of them could the tumor have been entirely removed. In 157 reported cases the tumor was either not found or not removed; in 104 reported cases the tumor was found, and in some of them it was removed (Ransohoff in "Jour. Amer. Med. Assoc.," Oct. 11, 1902). The conclusion is that though some tumors of the brain may be successfully removed, extirpation is feasible in only a small minority of cases and is to be decided on only after careful study of all the indications and contraindications offered by the case. When about to operate apply an apparatus to the arm and take the blood-pressure just before the operation and at frequent intervals during it. Thus by noting a great fall in blood-pressure the surgeon gets early warning of dangerous shock, learns when to hasten, and whether or not the operation should be temporarily abandoned and be completed at another time (**two-stage operation**). We may be driven to abandon operation after cutting the bone and dural flaps, and if we are forced to stop, we restore the bone and dura to position, and complete the operation after a day or two. I agree with Frazier that the lessening of hemorrhage by temporarily clamping the common carotids in the neck is not free from danger, and it is not proper to do more than apply Crile's clamp to the vessel on the side operated upon. In a brain tumor when the dura is first opened there is usually at once marked bulging of the brain, which is called *initial bulging;* after working for a time on a brain, even when there is no tumor, bulging occurs from traumatic edema, which is called *consecutive bulging*. That consecutive bulging may occur is a sound reason for operating rapidly (Frazier). The mortality from tumor operations is large, death being due to shock and hemorrhage. Haas collected 122 cases in which the tumor was removed; the mortality was 60 per cent. Operations completed at one séance give a larger mortality than two-stage operations. During the operation an erect posture causes the brain to recede and permits of extensive exploration under the dura (Ransohoff-Cushing). The same thing is accomplished by lumbar puncture (Cushing). The fibromata constitute the best cases for operation. In operating on a cerebral tumor make a large osteoplastic flap. If on opening the dura the tumor is not visible, and if the localizing symptoms have been reasonably positive, the surgeon is justified in making an exploratory incision through the cortex to see if there is a subcortical growth. Operations for cerebellar tumors are peculiarly difficult because of the large blood sinuses, because of the limited space through which one must work, because of the great bulging after the dura has been opened, because of the impossibility of reaching the anterior, mesial, or upper surfaces through the incision, because of the liability to injure the pons and medulla, and because of the difficulty of retracting the parts (Frazier, "New York and Philadelphia Med. Jour.," Feb. 11–18, 1905). In approaching tumors which are not within a cerebellar hemisphere by a one-sided exposure of the cerebellum, it may be best to remove a considerable portion of the hemisphere in order to obtain free access to the growth. I prefer Cushing's "cross-bow" incision and bilateral exposure (see Fig. 650). This enables the surgeon to dislocate the sound lobe outward and so obtain room to work upon the lobe containing the tumor. The diagnosis of cerebellar tumor is usually doubtful, hence practically all operations are at first exploratory and are then made palliative or radical as the case demands. Operation must be early because cerebellar growths quickly cause blindness. If we operate for cerebellar tumor and find nothing, puncture the corpus callosum and then explore the fourth ventricle (Bassol, "Arch. f. Psychiat.," 1911, xlviii). Cerebellar operations are very dangerous particularly because of the sudden relief of pressure.

[1] "Edinburgh Med. Jour.," June, 1894.

In tumor of the cerebellopontile angle the usual method is to retract a lobe of the cerebellum to gain access to the growth. Some hold that the mortality of the operation is 70 per cent. or over. This high mortality is due to the sudden relief of pressure, to hemorrhage, to contusion of the brain, and disturbances of circulation caused by retraction of the lobe. In tumors involving the acoustic nerve not involving the cerebellopontile angle Zange reaches the growth by a translabyrinthine operation ("Berlin. klin. Wochen.," 1915, lii). It would seem possible to remove a tumor of the fourth ventricle if it arises from the roof and many do arise from the roof. Sir Victor Horsley, McArthur, Hochenegg, von Eiselsberg, Cushing, Frazier, DaCosta, and others have operated for tumor of the hypophysis. Entire removal of a healthy pituitary body from dogs is sure to be fatal, as the gland is necessary to the life of the dog. Entire removal of a healthy pituitary from a man would in all probability prove fatal. The entire anterior lobe should not be removed. If the tumor is associated with acromegaly, removal of the tumor may arrest the acromegaly. One route of approach to the hypophysis is from the side, just as we reach the Gasserian ganglion (Carton, Paul, Horsley). Another route is by way of an osteoplastic frontal resection, the longitudinal sinus being ligated and the frontal lobes lifted (Krause, Hartley, Borchardt). Another method involves osteoplastic resection of the anterior wall of the frontal sinus and nose. The transsphenoidal route has been variously modified. Cushing's plan of approach through a sublabial incision is described on page 797. Though thorough extirpation of a brain tumor is feasible in only a minority of cases, operation should often be performed for palliative purposes when the tumor cannot be located, when it is in a region from which it cannot be removed, or when its nature forbids removal. Grainger Stewart, Annandale, Horsley, Macewen, Cushing, and Keen have advocated *palliative trephining* in certain cases. Simple trephining is of little value. In order to really relieve pressure the dura must be opened and left unsutured, so that hernia cerebri may follow. Cushing insisted on this years ago. Cushing has had some cases of extraordinary improvement in cases of cerebral tumor after trephining in the right temporal region and removing a piece of the dura. The operation is called by Cushing a *decompression operation*. The brain bulges through the dural opening, but the dense temporal fascia stitched together over it prevents fungation. It is the temporosphenoidal lobe that bulges, and the right side is selected on a right-handed person because word-deafness might ensue if the operation were done on the left side. I have seen several of Cushing's cases. One of them, a colored man, had been almost blind for some time, and was unconscious and had rapidly failing respiration when the operation was performed. He was so much benefited that he returned to work, obtained useful vision, and had no pain. I have had several very gratifying results in my own practice. A decompression may, in rare cases, cause a glioma to degenerate and pass away. Horsley saw such a case. In cases of cerebral tumor subtemporal decompression, and in cases of cerebellar tumor suboccipital decompression, may be performed. Sir Victor Horsley believes that the opening for decompression should be near the tumor and not always in the subtemporal region. He believes an opening near the tumor possesses the advantage of aiding us later if the tumor should become operable. He maintains that subtemporal decompression may later confuse the localizing symptoms should such symptoms develop.

Decompression may relieve choked disk and thus retard or prevent optic atrophy and blindness. Cushing demonstrates that intracerebral pressure is the chief element in choked disk.

Decompression is of value in diminishing excessive intracranial pressure, and thus relieving headache and choked disk, and decreasing the tendency to sudden death from inhibition of the heart or from respiratory failure. The usual method of decompression will not relieve the headache caused by tumor of the hypophysis. This headache is due to distention of the dural box in which the gland is placed, and can be relieved only by incision into the dural box (Harvey Cushing, "Jour. Amer. Med. Assoc.," July 24, 1909).

We conclude that in most cases of brain tumor operation should be performed for exploration; in some cases extirpation may be performed; in most cases extirpation is impossible, and the surgeon must be content with the palliative influence of Cushing's decompression operation. A tumor of the brain if not cured by antisyphilitic treatment is of necessity fatal if unoperated upon, and exploratory operation is not very dangerous.

Thorburn ("Med. Chronicle," 1914, lix) tabulated 490 cases of operation for brain tumor. In nearly 40 per cent. of the cases the operation was useless and in some of

them it hastened death. In nearly 24 per cent. of cases it cured the patient or at least prolonged life greatly. In over 38 per cent. the value of the operation was uncertain. Thorburn takes the ground that most brain tumors are malignant and that the surgeon seldom aims at cure, but in most cases simply seeks to prolong life, prevent blindness, and abolish headache. Operations which expose the surface have little danger. Operations involving brain substance are very dangerous. Heuer and Dandy ("Bull. Johns Hopkins Hospital," 1916, xxvii) report upon 62 cases of brain tumor operated upon in Prof. Halsted's clinic. On these 62 cases, 71 operations were performed. Six deaths occurred within twenty-four hours to five days of the operation, an operative mortality of 8.6 per cent. Two cases died later. Including these the total operative mortality was 11 per cent. No patient died upon the table.

In a case of brain tumor if operation is refused, if extirpation is impossible, or if decompression fails, it may be necessary to use the bromids for convulsions and morphin for headache. The headache is often benefited by purgatives, courses of potassium iodid, and the ice-bag to the head.

Operative Treatment of Epilepsy.—The shock of an accident or a cerebral concussion may establish epilepsy, especially in those predisposed by heredity or other causes. Traumatic epilepsy, Le Dentu[1] tells us, may be due to: (1) Bone fragments from skull fracture; (2) outgrowths of bone due to tumor; (3) cicatrices of the meninges resulting from laceration of membranes by bone fragments; (4) chronic meningitis which ends in sclerosis of the membranes; (5) cysts resulting from intracranial hemorrhage at the point of fracture; (6) arteriovenous aneurysm. We would add: (7) tumors of the brain; (8) sclerosis of the cortex. We refer here, in speaking of traumatic epilepsy, purely to the condition when it follows a head injury, and this is the common meaning of the term. Remember that epilepsy, as shown by Sachs, may follow a long-forgotten injury. Before undertaking a brain operation for epilepsy it is a sound rule to remove all sources of definite peripheral irritation. I have seen apparent cure follow the removal of a tender cicatrix and follow circumcision of a patient with phimosis. Briggs reported a case of epilepsy in which there was a distinct depression of a portion of the skull. There was also necrosis of the tibia, and after the cure of the necrosis the convulsions ceased. The removal of supposed peripheral irritation, however, is only occasionally beneficial. Are operations upon the skull and brain curative? Surgeons are much less enthusiastic than they were a few years ago. I believe operation can cure less than 5 per cent. of cases, but it is important to remember that in some cases in which operation seems to have failed medical treatment becomes much more efficient than it was before the operation. The high rate of cure (70 per cent.) once claimed for operations was due to failing to follow up the patient sufficiently long. A patient should not be reported as cured until at least three years or, better, five years have passed without any evidence of the disease. Another source of error was a failure to understand that any traumatism may improve epilepsy *for a time*. "The administering of an anesthetic, the shock of an injury, the traumatism of an operation, just like a febrile seizure, may interrupt an epileptic habit and cause a patient to go for weeks or months without an attack" (the author in "Medicine," Feb., 1904).

Operation must never be indiscriminately applied. In some cases it gives hope of relief, in others it is obvious that it would be utterly futile. In order to determine if a case is or is not suitable for operation it must be studied with great care. The history must be carefully obtained, particularly as to hereditary predisposition, the record of the first convulsion, and its *supposed* cause. The question of injury, recent or old, should be thoroughly investigated, and it is a sound rule to have the head shaved and then examine for a scar and for a depression. Convulsive seizures must be studied by an expert, hence the patient should be in a hospital, constantly watched by a trained nurse, until one or two fits have occurred. The nurse watches the convulsion and describes it in writing, noting particularly if it had a local beginning. The general health must be investigated. An *x*-ray should be taken.

I am accustomed, for surgical purposes, to make the following classification of epilepsy. It is a modification of Sir Victor Horsley's classification (the author in "Medicine," Feb., 1904):

1. Reflex epilepsy, the surgical treatment of which I shall not discuss in detail.
2. The common non-traumatic, idiopathic, or essential epilepsy, in which the attacks are general and are without a local onset.
3. Idiopathic epilepsy with a local onset of attacks (focal or Jacksonian epilepsy).

[1] "La Presse médicale," June 9, 1894.

4. Traumatic epilepsy. This may be subdivided into two forms: (*a*) attacks without a local onset, and (*b*) attacks with a local onset (focal or Jacksonian epilepsy).
5. Jacksonian epilepsy due to gross brain disease (tumor, aneurysm, etc.).
6. Epilepsy following infantile cerebral palsy.
7. The posthemiplegic epilepsy of adults.

1. **Reflex Epilepsy.**—Remove the supposed cause of irritation. When epilepsy follows traumatism and a scar is found on the scalp, excise the scar. This is an imperative duty if the scar is tender or the seat of an aura.

2. **Essential or Idiopathic Epilepsy.**—Operation upon the brain is useless. If persistent headache exists, it may be proper to trephine and open the dura for exploration. Such an operation is done to relieve headache. Some claim remarkable results from bilateral excision of the cervical ganglia of the sympathetic (see page 716). The operation is a theoretic one and of doubtful utility. It was founded upon a misconception as to the cause of epilepsy, and favorable reports are no more favorable than have been set forth regarding various other now abandoned procedures.

3. **Idiopathic Epilepsy with Local Onset of Attacks** (*Focal or Jacksonian Epilepsy*).—Many of these cases begin in young children who have had infantile palsy, the traces of the palsy having disappeared. In such cases the convulsions may begin on one side, and, in fact, may be nearly limited to one side. If, from the very beginning, the attacks began in one group of muscles or in one extremity, whether or not they spread to the rest of the body, and if the case is seen within two years of the first attack, the surgeon is justified in exposing the brain and excising the irritated portion of cortex. This operation, it is true, cures very few cases, but it benefits many for a considerable time and seems to make most of them more amenable to medical treatment. In the vast majority of cases fits recur, but rarely as severely as before. After fits have been going on for two years operation offers no prospect of cure, as the association fibers have surely degenerated. But, even in very old cases, if the attacks are frequently repeated and thus threaten life, the excited center should be removed to save life.

In cortical excision more of the cortex than the excited center is of necessity removed, because, in order to get the entire center, we must go wide of it. Paralysis of the parts controlled by the extirpated cortical area follows. The paralysis is seldom permanent except to the finer movements. The operation gives the best prognosis in young persons, and when done early in the case. The return of fits after apparent cure is thought to be due, at least in some cases, to the formation of *adhesions* between the brain and its membranes. Various unsatisfactory attempts have been made to prevent adhesion by the insertion of silver-foil, gold-foil, rubber tissue, egg-shell membrane, and Cargile membrane. In operating for cortical epilepsy a large osteoplastic flap is required. In the previous remarks we dealt with partial epilepsy and with generalized epilepsy in which, from the first, the attacks had a local beginning. If cases of apparent idiopathic epilepsy develop Jacksonian attacks (attacks with a local beginning), it is useless to excise the cortex. In these cases the entire cortex is diseased, though one region is particularly unstable.

4. **Traumatic Epilepsy.**—Always remember that the origin of epilepsy subsequent to a traumatism may be a mere coincidence; the condition may be essential epilepsy and the traumatism may have had nothing to do with it. Epilepsy ensuing upon traumatism may not begin until months or even several years after the injury. In the earliest attacks consciousness may or may not be lost. The causative injury may have been slight or severe. "An injury may cause a hemorrhage or a depressed fracture; may be followed by a scar upon the membranes; may occasionally lead to the development of an innocent or malignant tumor or a cyst, or may merely induce some trivial change in the subtle chemistry of the nerve-cells" (the author in "Medicine," Feb., 1904). Injury may excite general epilepsy or cause Jacksonian epilepsy. If an identified traumatism exists, the surgeon should operate even after years. When the traumatism has not left definite evidence, the surgeon is justified in making an exploration any time up to the termination of the third year after the accident. The earlier the operation, the better the prognosis. The best prognosis of any form of epilepsy is given by Jacksonian epilepsy of traumatic origin.

"In focal epilepsy with evidences of skull injury or depression, trephining is imperative and somewhat promising. The dura should invariably be opened, even if it seems in good condition. A dural scar should be extirpated. The brain should be examined by sight and by touch, and should be explored with the little finger and with the dural separator to well beyond the limits of the opening in the dura. If a tumor is found, it should, if suitable, be removed; if a scar upon the brain exists, it should be

extirpated; if a cyst is discovered, it should be drained; and if there is any obviously damaged area in the brain tissue, it should be unhesitatingly cleared away. If nothing obvious is found on exploration, and if the attacks have been distinctly local in origin, it is justifiable to extirpate the motor center from which the discharge seems to originate.

"When Jacksonian epilepsy has followed an injury in the motor region, the chances of effecting a cure are much better than they are when the epilepsy has followed an injury in the sensory region. When it has followed an injury in the frontal region, operation affords very little hope of cure.

"When the condition is not focal but essential epilepsy, the surgeon will remove a scalp scar; and if there is any evidence of bone injury, he will trephine the bone, open the dura, and explore the brain. It is needless to say, however, that in such a case he will not extirpate any of the cortex.

"In cases of focal epilepsy I use the osteoplastic method of operating. In cases of generalized epilepsy I use the simple trephine and leave the button of bone out, as a means of effecting a prolonged modification in the intracerebral pressure" (the author in "Medicine," Feb., 1904).

Bramwell maintains that when traumatism is followed by epilepsy and the epileptic discharge starts from a cortical center which is not beneath the scar, the surgeon should trephine first at the seat of injury, and if this fails, he should trephine over the excited center.

5. **Jacksonian Epilepsy Due to Gross Brain Disease.**—The treatment of this condition is the treatment of the brain disease.

6. **Epilepsy Following Infantile Cerebral Palsy.**—In this group of cases the palsy is manifest. It is justifiable to operate upon a child, but not later in life. The prospect of benefit is poor even in a child.

7. **The Posthemiplegic Epilepsy of Adults.**—Operation is useless.

Our conclusions are that these operations sometimes seem to cure epilepsy, but so, occasionally, does any operation. White[1] records 90 trephinings in which, though no cause was found for the epilepsy, great relief followed, and 2 cases were apparently cured; he mentions benefit or apparent cure following tracheotomy, ligation of the carotid artery, incision of the scalp, etc. The same effect may be obtained by a great shock, high fever, the administration of an anesthetic, or an accident. The fact seems to be that any operation, by means of nervous shock, may interrupt the epileptic habit; but in ordinary operations the fits tend after a time to recur and soon reach their old standard of frequency. In the special brain operations with removal of obvious lesions or extirpation of discharging centers the fits usually recur, but they will rarely reach the old standard of frequency, and will be more amenable to medical treatment.

In non-traumatic chronic epilepsy without localizing symptoms trephining is not justifiable unless persistent headache calls for it as a means of relief from intracranial pressure. Genuine essential epilepsy is probably due to relaxation of cortical control and as a consequence discharge from the centers of the midbrain occurs (Rosett. Quoted editorially in "Jour. Amer. Med. Assoc.," June 30, 1923). Some regard epileptic fits as expressive of sensitiveness to foreign proteins. Annandale advised us to consider experimental operation in essential epilepsy when the drug treatment has failed and when the patient's condition seems hopeless. He says there is no chance of improvement without operation, and operation may possibly disclose a removable lesion.[2] After trephining for epilepsy five years should elapse without a convulsion before cure is reasonably assured; and if convulsions arise, they must at once be met by medical treatment. A man having once had a convulsion may at any time have others; hence he should always be watched. It is not unusual for a few convulsions to occur soon after an operation for epilepsy, and then to cease for a considerable time. These early fits result from habit (*habit fits*). Among the operative procedures suggested for the treatment of epilepsy may be mentioned circumcision, clitoridectomy, ocular tenotomy, ligation of the vertebral arteries, removal of the cervical ganglia of the sympathetic (see page 716) (Alexander, Jonnesco, Jaboulay), the actual cautery to the head (Féré), puncture of the corpus callosum, drainage of a lateral ventricle, and appendicostomy. Dr. Charles L. Reed is convinced that epilepsy is a chronic convulsive toxemia and bears a constant relation to constipation due to mechanical causes and associated with acidosis. In severe cases or cases of long standing he finds conservative treatment of little avail and operates. "The local conditions may require

[1] "The Supposed Curative Effects of Operations *per se*." "Annals of Surgery," Aug. and Sept., 1891.

[2] "Edinburgh Med. Jour.," April, 1894.

parietal implantation of the colon with or without either appendicostomy or cecostomy; an ileosigmoidostomy supplemented by either an anatomic or a physiologic colectomy; or a resection may be required" ("Medical Herald," Feb., 1917).

Operative Treatment of Insanity.—(See the author in "Journal of Nervous and Mental Diseases," June, 1904.)

1. **Epileptic Insanity.**—The conditions which call for operation on a non-insane epileptic (see page 783) call for it on an insane epileptic. It is sometimes justifiable to operate if there has been a head injury, and operation may lessen the number and diminish the violence of the attacks. If focal seizures exist, we may proceed as for focal seizures in the sane. In status epilepticus we may operate to relieve pressure. It will be observed that operation is for the convulsions and not for the insanity.

2. **Paresis.**—I do not advocate operation in paresis. If we believe in traumatic paresis, we may be inclined to advise operation. Personally I do not believe that genuine paresis is ever traumatic or is ever cured; the lesions of the disease are the results of syphilis, and are widely disseminated; the pons, medulla, and even the cord may be diseased and the lesions cannot be removed.

3. **Non-traumatic Insanity and Paranoia.**—Operation cannot cure the insanity and is not to be advised.

4. **Hypochondriacal Delusions.**—Operation is useless. Some practice it with the idea of getting rid of a delusion by removing a part to which the attention is directed. Such attempts always fail, because it is the insanity which causes the delusion, not the delusion which causes the insanity.

5. **Operations for Traumatic Insanity.**—A psychosis constructed on the basis of a traumatic neurosis never calls for operation. The only cases in which operation is ever justifiable are those in which traumatism is the direct cause. Insanity may begin at once or soon after an injury, but is often unrecognized for weeks or even months. Nearly all of these cases are predisposed to insanity and the injury has been only an exciting cause. Traumatism is the direct cause in about 2 per cent. of cases of insanity.

"An antecedent injury may have directly induced the alienation; it may have had no bearing at all upon the latter; or it may have produced an insanity by fear and shock, and not by creating a direct brain lesion. Again, the head injury, by increasing the individual's susceptibility to alcohol and to the effects of the sun, may, if this person drinks alcohol or exposes himself to the rays of the sun, be indirectly responsible for lunacy.

"In insanity following an injury to the head there may be various supposed causative lesions: A fracture of the skull, with or without depression; the development of an exostosis; sclerosis or softening of the cortex; edema of the membranes or of the brain itself; cerebral hyperemia or congestion; thickening of the membranes; adhesion of the membranes to the skull, to each other, or to the brain; new growth; inflammation of the membranes; or minute, slowly developing, wide-spread nutritive changes. The injury may be assumed to be the cause of the insanity if the insane condition becomes manifest almost at once or soon after the accident; but if the symptoms do not appear until long after the accident the traumatism may be considered to be the directly exciting cause in some cases, and not in others. It may be blamed if, between the time of the accident and the appearance of the insanity, there has been a marked change in the patient's disposition, temperament, or character; if he has developed headache, insomnia, irritability, passionate outbreaks of temper, moodiness, or lapses of memory; if he has plunged into immorality or excess in alcohol; if he has displayed a tendency to neglect business or family obligations, and if he has shown increased susceptibility to alcohol and to the sun. Persons of such perverted disposition are apt to commit crimes of violence because of loss of self-control. In such cases there is grave question as to criminal responsibility. Sometimes epilepsy may develop during this period (Richardson, "American Journal of Insanity," July, 1903. The author's "Address on Surgery," delivered before the meeting of the Medical Society of the State of Pennsylvania, May 18, 1897). If there was none of these intermediate changes in the normal mode of thinking and way of acting, one cannot count the traumatism as causative. Many persons that have received severe head injuries have shown these changes, but have never gone insane. I have been studying this point for a number of years, and have decided that quite a few patients that have had concussion or that have been trephined for fracture or for meningeal hemorrhage have subsequently shown pronounced and permanent changes in character and disposition. Of the number that show such changes, many never go insane, but some do. Such an insanity is distinctly traumatic in origin" (the author in "Journal of Nervous and

Mental Diseases," June, 1904). The prognosis is very unfavorable; some recover sanity after operation, many do not. Some recover sanity without operation. Sometimes operation cures by removing a lesion; sometimes by shock, etc. Some cures following operation did not result from the operation.

On what cases should we operate?

We should operate on cases "in which insanity has soon followed a head injury. If the site of the trauma is indicated by a scar, a depression of bone, local tenderness, fixed headache, or some localizing symptom—motor or sensory—operation should positively be undertaken. In a case in which the insanity has developed later, in which the intermediate period between the injury and the development of the insanity has shown the change from the normal mode of thinking and way of acting previously alluded to, and in which the site of trauma is indicated by any of the evidences mentioned above—operation should positively be performed. One should not operate upon a case simply because there is a dubious record of an antecedent fall or blow, which merely suggests the possibility of a traumatic origin for the insanity. In any case in which there are positive signs of increased pressure it may be considered proper to trephine as a palliative measure" (the author, Ibid.).

Abdominal, Gynecologic, and Genito-urinary Operations.—If an insane person has a disease which is dangerous to life or which is productive of pain, discomfort, or ill health, he or she is entitled to be cured, if possible, by a surgical operation. The removal of pain and other depressing influences may result in great improvement in the general health and in notable mental improvement. The operation may thus indirectly exercise a beneficial influence on the insanity, but the influence is not direct and it is never justifiable to do such an operation as oöphorectomy upon an insane woman unless the condition of the ovaries would call for it in one not insane.

Operations on the Skull and Brain.—As a preliminary it is well to note that urotropin (hexamethylenamin) given by the mouth quickly appears in the cerebrospinal fluid, and that the fluid contains the maximum amount in from one-half hour to an hour after ingestion. The presence of this drug decidedly inhibits the growth of bacteria in the fluid. This is Crowe's discovery. We believe it wise to give this drug in all cases in which meningitis is threatened or exists (S. J. Crowe in "Johns Hopkins Hospital Bulletin," April, 1909). It should be given for twenty-four hours preceding and for several days after an operation upon the brain or spinal cord. From 40 to 60 gr. a day are given by mouth. Cushing has subjected this drug to the severest test in his operations to reach the pituitary body. He gave 60 gr. a day of this drug "on the day preceding and for some days after the operation" ("The Pituitary Body and Its Disorders," by Harvey Cushing). After 33 transphenoidal operations there were 2 cases of meningitis. One of these cases (which was inaugurated by violent sneezing) was fatal. Cushing now does much work upon the skull and brain with the aid of local anesthesia. He believes that any watery solution damages brain tissue, and in cases requiring the direct application of an antiseptic employs dichloramin-T.

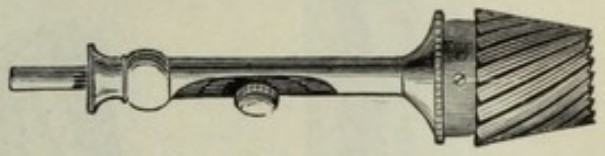


FIG. 637.—Galt's conical trephine.

Simple Trephining for a Fracture of the Skull.—The patient should be anesthetized unless he is unconscious, and should be placed upon the back with the shoulders a little raised. A sand-pillow is placed under the neck, and his head is turned away from the side to be operated upon. The position of the surgeon is such that the patient's head is a little to his left. A large semilunar incision is made with the base down, which incision goes through the periosteum, and the flap is lifted. The bleeding vessels of the flap are caught by forceps. The fracture is sought for and found. The pin of the trephine is projected beyond the crown and is set upon sound bone, the crown overhanging the line or edge of the fracture. The surgeon tries to avoid the region of a sinus or large artery. A gutter is cut in the bone, the pin of the instrument is withdrawn, and the trephining is completed. In going through the diploë bleeding is copious. In a young child the diploë may be absent. The inner table feels very dense. Stop from time to time, clean out the gutter in the bone with gauze, and try the bone with an elevator to see if it is loose. In an old person the skull may be much thinned by absorption. Bear in mind Holden's valuable admonition: "Think that you are operating on the thinnest skull ever seen, and thinner in one portion of the circle than the other." When the fragment is loose enough, pry it out. If the surgeon desires

to replace the button, hand it to an assistant, who places it at once in a bowl of warm normal salt solution, kept warm by standing in a basin of water at 105° F., or in warm carbolized towels. The edges of the opening should be rounded by a rongeur, and the bone, if depressed, must be elevated. Sometimes it may be necessary to remove splinters and fragments of bone. The dura should be examined to see if injury exists, and hemorrhage must be arrested. Bleeding from the dura is arrested by passing a ligature of silk or catgut threaded in a small curved needle under the vessel on each side of the wound, and tying the ligatures (*suture ligatures*). Bleeding from the pia is arrested by direct ligation, by suture ligature, or by gauze packing. Bleeding from the diploë is arrested by the use of Horsley's wax. The wound is cleansed, the edges of the dura are sutured by catgut or fine silk; in some cases the button of bone is reintroduced; in other cases some chips are cut from the bone and scattered upon the dura, but in most cases no attempt is made to fill up the gap in the bone. The scalp is sutured by silkworm-gut, and horsehair or gauze drainage is employed for a day or two. Sterilized gauze dressings are applied, and a gauze bandage is used. In a young person the opening may close partly or entirely by thin bone. In most youths and in practically all older persons the closure will be by fibrous tissue or fibrocartilage and a soft area remains on the cranial vault. In many cases a raised ring of bone forms around the opening. In some cases the bone thins and the opening is slightly lessened in size by a ring of new bone. A soft spot is, of course, vulnerable to traumatism and to that extent a danger. The older surgeons were accustomed to protect the region by wearing a plate of silver upon the scalp. This custom gave rise



Fig. 638.



Fig. 639.

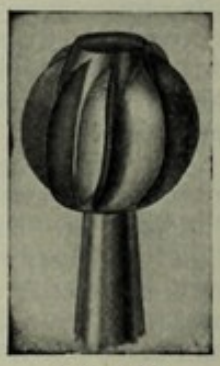


Fig. 640.

Figs. 638–640.—Hudson's burrs.

to the popular belief that the opening in the bone was closed by the insertion of a silver plate. If the bone defect is very large it may be closed by bone transplantation. In some cases the transplant becomes absorbed. In others the operation is successful. Some surgeons have used plates of cow's horn, cut to the required shape and sterilized by keeping for three days in alcohol. Estor has closed defects in a number of cases by gold plates, inserted about two months after trephining. He slips the edges of the plate between the two tables of the skull. The operation is indicated when coughing or straining causes the brain to bulge at the opening. Gold undergoes no change ("Bull. et mém. Soc. de Chir. de Paris," 1915, xli).

Instead of the trephine some surgeons use the chisel or gouge and hammer to remove a portion of the bone. Other operators, believing that this procedure may cause concussion, employ the surgical engine.

I now seldom use the old trephine, preferring instead the instruments of Hudson (Figs. 638–641).

Osteoplastic Resection of the Skull.—Wolff suggested this operation, and in 1889 Wagner performed it. It is employed for the removal of tumors and the Gasserian ganglion, for focal epilepsy, and for exploration. It is the operation of choice when a large opening is needed, as when the operation is, first of all, for diagnosis. The incision shown in Fig. 642 is made through the scalp and periosteum, and the flap is tacked to the bone, ordinary long tacks being used. Otherwise our manipulations

may separate the flap from the bone (Fig. 642). A groove corresponding to this incision may be cut in the bone by special gouges or chisels. I do not use chisels. I am convinced that the blows of the mallet add to shock, may cause hemorrhage or add to existing hemorrhage, may extend a line of fracture or cause a fracture, may diffuse a purulent collection, or produce concussion of the brain. Some surgeons use the surgical engine. It is difficult to keep it sterile, it runs at too high a speed to be readily controlled, and it is troublesome to cut a bevel with it. The instrument is dangerous except when in very skilful and highly trained hands. Some surgeons make

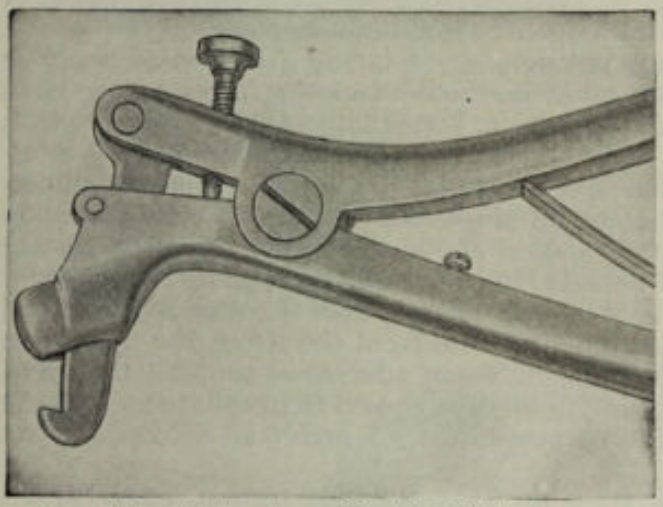


FIG. 641.—Hudson's modified DeVilbiss forceps.

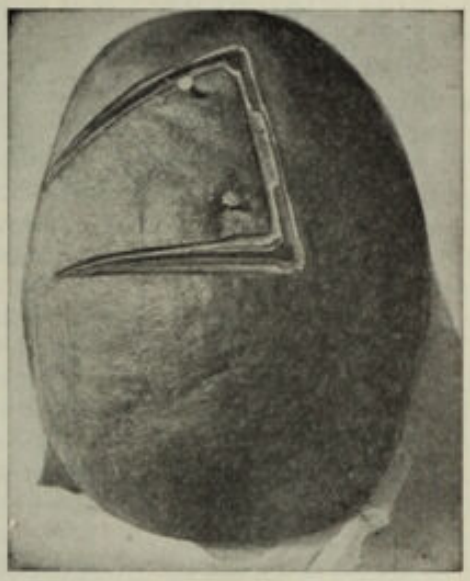


FIG. 642.—Combined osteoplastic operation. First step: Incision through superficial tissues and bone. Flap held in place on the bone by tacks.

trephine openings and then cut from within outward by the Gigli wire saw (Obalinski). Cushing, of Harvard, does what is called the *combined* method. I prefer this to any other plan. It is rapid and free from all danger of wounding the dura. I make two or several openings with Hudson's burr. This excellent instrument divides bone with great rapidity, but does not divide the dura. In fact, one cannot divide the dura with

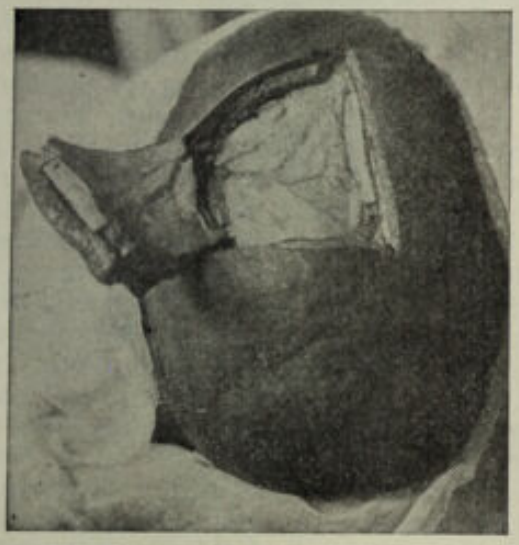


FIG. 643.—Combined osteoplastic operation. Second step: Bone-flap turned down.



FIG. 644.—Combined osteoplastic operation. Third step: Showing exposure of brain by removal of dural flap.

it, if he uses ordinary care, for the burr binds as soon as it is through the bone. Figures 638–640 show Hudson's burrs. The sides of this bone-flap are rapidly cut by Hudson's improvement of the DeVilbiss forceps (Fig. 641). An inch or so of the upper margin is cut on a bevel with the Gigli saw. Because of this bevel when the flap is restored to place the upper edge of the flap rests on a shelf of bone and does not press on the brain. By whatever method performed, three sides of the bone-flap are

cut through, but the bone is left attached to the scalp. It is a good plan to save the scalp from detachment by temporarily nailing it in place (Fig. 642). The bone is then forced outward by means of levers, the fracture taking place at the base of the bone-flap, the dura is opened a little distance from the edge (sufficient space being retained for sutures), and the exploration is made and the operation is performed (Figs. 643, 644). When we are ready to suture the dura we note if the brain bulges greatly. If it does, manipulation will surely injure it, and we should cause the brain to recede before suturing by placing the patient nearly erect, by the intravenous use of salt, or by performing lumbar or ventricular puncture. After suturing the dura the bone, which is still adherent to the pericranium and scalp, is restored to its proper place, and the scalp is sutured. In cases of injury or tumor in which a considerable portion of dura requires removal the defect is filled by a flap of aponeurosis or a piece of transplanted fascia which is sutured in place.

Besides restoring a flap of bone into position, or replacing a button of bone, or strewing the dura with bone fragments, other methods of closing the opening have been practised—for instance, heteroplasty with a bone-plate of cow's horn, with a decalcified bone-plate, with a celluloid plate, or other foreign material.[1]

Trephining the Frontal Sinus.—This operation may be employed for inflammation of the lining membrane of the sinus or for empyema. Make a vertical incision in the middle of the forehead, starting 1½ inches above the nasion and terminating at the root of the nose. The button of bone is removed and the opening is enlarged if necessary. The mucous membrane is incised, the opening into the nose is found and is dilated, and a drainage-tube is passed into the nose from the sinus, the upper end being left in the sinus. In some severe cases Jacobson advises us to curet the sinus, to disinfect it by the use of silver nitrate or chlorid of zinc, and to insufflate an "aseptic powder." In some cases resect the mucous membrane. I prefer an osteoplastic resection to trephining the frontal sinus.

Trephining the Mastoid.—(See Operation for Mastoid Suppuration, page 792.)

Technic of Brain Operations.—In focal epilepsy a faradic battery is required. Always shave the scalp and always antisepticize it. In localizations, mark out the fissure of Rolando upon the scalp with an anilin pencil, with iodin, or with silver nitrate. Have the patient semirecumbent. Mark three points upon the bone with the center-pin of the trephine before incising the scalp (both ends of the Rolandic fissure and the point at which the trephine is to be applied). Make a semilunar flap 3 inches in diameter, with the base below. Control bleeding in the flap by forceps pressure. If the operation is by trephining the 1½-inch trephine should be employed, but if a smaller trephine or the Hudson burr is used the opening must be enlarged with a rongeur. Before enlarging the opening separate the dura from the bone by a dural separator. In most cases an osteoplastic flap is preferable to trephining. It is always employed in explorations for tumor. As a rule, open the dura and examine the brain. The dura is lifted by a mouse-toothed forceps and is opened by scissors along a line ¼ inch from the bone edge, a broad pedicle of dura being left uncut. Hemorrhage is arrested by pressure and hot water or by passing suture ligatures of silk or catgut around any bleeding vessel by means of a curved needle. In some cases packing must be retained or forceps must be kept on. In packing, endeavor to use but one piece of gauze, so as to avoid leaving in a forgotten piece. Upon opening the dura cerebrospinal fluid sweats out, the amount being increased at each expiration. Absence of pulsation of the brain points to abscess or tumor, and a livid color indicates subcortical growth. An old laceration is brownish. If the brain bulges through the opening, it means increased pressure (tumor, abscess, effusion into the ventricles, etc.). After opening the dura employ no antiseptics, especially when the surgeon intends using electricity to locate a center. Irrigate by warm salt solution only. In operating for tumor the dura is opened and in some cases the brain is incised. A removable tumor is turned out by the finger or, if this is impossible, by the dry dissector, the scissors, the dull knife, or the sharp spoon. If the entire tumor cannot be removed, it is sometimes proper to take away as much as possible. The removal of a portion may retard the growth of the remainder, and the trephining, by lessening cerebral pressure, may relieve the symptoms and prolong life. After removing a tumor arrest distinct points of bleeding by ligatures or by suture ligatures. Pack the tumor cavity with gauze and bring the end of the strand out of the wound. Stitch the dura with silk and suture the scalp with silkworm-gut. In electrifying the brain faradism is employed of a strength about sufficient to move the fibers of the exposed temporal muscle. The best electrode is that of

[1] See Bretano in "Deutsche med. Woch.," May 17, 1894.

Cushing (Fig. 645). It is a "glass unipolar electrode carrying a fine platinum wire core, coiled into a spiral at the end" (Cushing in "Keen's Surgery," vol. iii). The other pole is attached to an extremity, "preferably on the homolateral side." During the electric test the patient must not be deeply anesthetized, and the arachnoid must be punctured. A careful observer watches the muscular movements. If, for instance, the surgeon wishes to remove the thumb center, he moves the electrode from point to

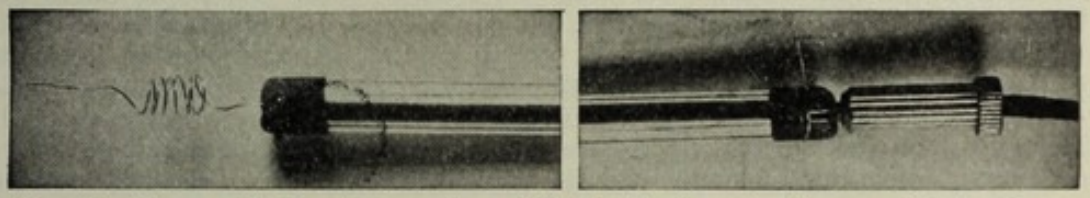


FIG. 645.—Showing terminal and connection of Cushing's electrode (¾ natural size). Instrument should be 16 inches or more in length.

point until he obtains thumb movements. The region is sliced away bit by bit until the center which is responsible for the convulsive movements is removed. It will be found impossible to remove only the thumb center. Adjacent centers are sure to be more or less damaged, and a certain amount of paralysis follows the operation. If we wish to *tap the ventricles*, Keen directs the trephine opening to be 1¼ inches behind the external auditory meatus and the same distance above the base-line of Reid (Fig. 646, *a*).

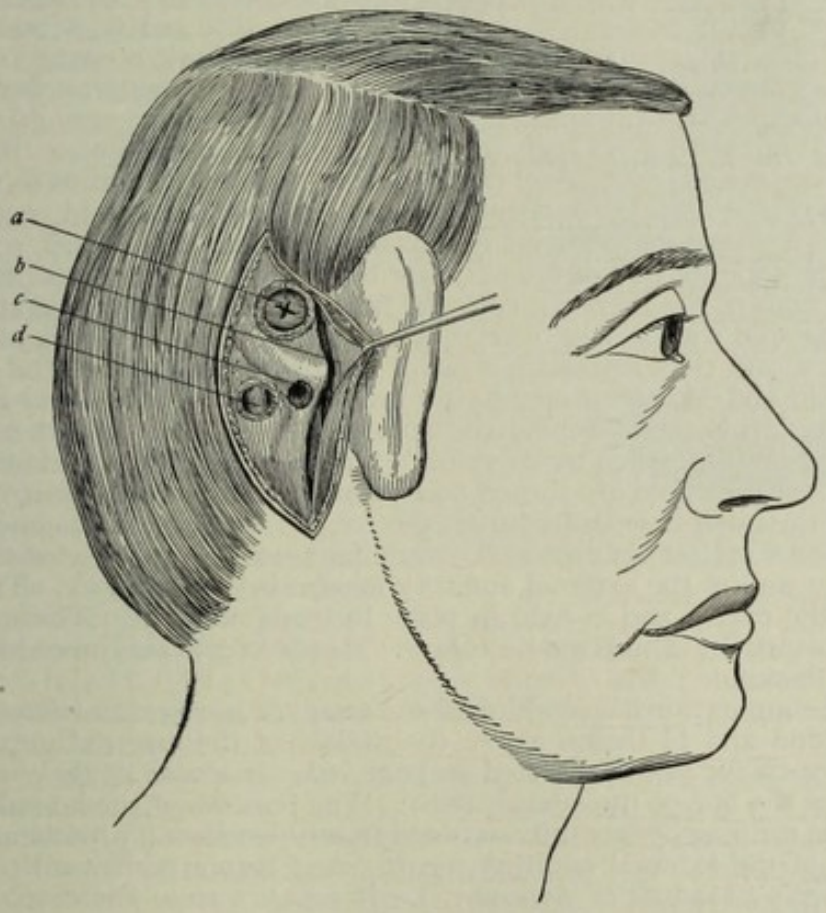


FIG. 646.—Opening the mastoid antrum and the lateral sinus; exposure of the temporosphenoidal lobe and puncture of the descending horn of the lateral ventricle: *a*, Temporosphenoidal lobe (descending cornu of lateral ventricle is 1 cm. deeper); *b*, inner surface of periosteum; *c*, mastoid antrum; *d*, lateral sinus (Kocher).

A grooved director or metal tube is passed into the brain in the direction of a point "2½ to 3 inches above the opposite meatus." The normal ventricle will be entered at a depth of 5 cm., but the dilated ventricle will be entered at a lesser depth. The moment of entry is marked by lessened resistance and a flow of cerebrospinal fluid. Drainage can be maintained by introducing a rubber tube. This operation has been employed in hydrocephalus. Kochler punctures the ventricle 2½ cm. from the midline

and 3 cm. in front of the fissure of Rolando. After an aseptic cerebral operation, as a rule, do not drain unless hemorrhage has been considerable. In many cases after trephining replace the bone, but not when the bone is diseased, is infected, is very compact, or if we desire to alter pressure.

Control of Hemorrhage in Brain Operations.—Elevation of the patient's head decidedly lessens hemorrhage. A table should be used which permits elevation. If the blood-pressure falls rapidly the head must be lowered. A rubber band around the head usually controls scalp bleeding, but will actually increase it if there is a large cortical growth with greatly enlarged vessels joining intracranial and extracranial veins (Landon in "Surgery, Gynecology, and Obstetrics," 1914, xviii). I seldom use the band and depend upon clamp forceps for the temporary arrest of scalp hemorrhage and upon the sutures which close the wound for permanent arrest. Bleeding from diploë is controlled by Horsley's wax or by bits of muscle. Bleeding on the dura can usually be arrested by hot water and pressure or by the application of a bit of muscle. If this fails, a suture ligature is used. Bleeding from a pial vessel is arrested by suture ligatures if a bit of muscle fails. When the patient comes out of ether he should be placed semi-erect in bed.

Operation for Mastoid Suppuration.—Place a sand-bag under the neck. An incision is made $\frac{1}{4}$ inch posterior to the auricle and down to the bone, and in the direction of the long axis of the mastoid. The bone is bared and examined, especially at a point in the line of the incison, which is on a level with the roof of the meatus (Fig. 646, *c*). The bone will usually be found softened. Gouge it away and thus open the mastoid antrum. The bone opening is within the limits of *Macewen's suprameatal triangle*, a space bounded by the posterior root of the zygoma, the posterior bony wall of the meatus, and an imaginary line joining the two. If the mastoid is opened in this triangle the antrum is entered directly and there is no chance of wounding the lateral sinus. If, in the adult, pus is not found on opening the mastoid antrum, gouge downward and backward, but with great care, so as to avoid the lateral sinus. If there be any possibility of the existence of pus in the groove of the sinus, the sinus should be unhesitatingly exposed. After evacuating the pus from the mastoid, cut away bony septa, enlarge the opening between the mastoid and the middle ear with the gouge and remove the superior half of the posterior bony wall of the meatus (avoid the facial nerve on the floor of the meatus), turn the head toward the side operated upon, and irrigate the mastoid with salt solution, dust with iodoform, pack with iodoform gauze for a few days, and then introduce a silver drainage-tube. Treat the causative ear disease. Sheild and Macewen operate on inveterate cases of mastoid disease as follows: A thick flap is raised behind the auricle, the flap including the orifice of any sinus and being "left attached by its stalk." The auricle is "detached forward and the soft parts over the mastoid are turned backward by horizontal incision." The "lining membrane of the canal is separated from the bone." The mastoid is opened and dead bone and caseous matter are removed, overhanging edges are chiseled down, and the posterior bony wall of the external auditory meatus is gouged away. The skin-flap is pushed into the cavity and is held in place by pads of gauze. The margins of the flap may be sutured, but this is not necessary. Macewen calls this procedure "papering" the cavity with skin.[1]

If mastoid suppuration has established *abscess in the temporosphenoidal lobe*, trephine $1\frac{1}{4}$ inches behind and $1\frac{1}{4}$ inches above the middle of the external meatus (Barker's point), and search for pus as directed on page 763. If *abscess of the cerebellum* exists, trephine below the line of the lateral sinus. "The position of the lateral sinus is indicated by a line running horizontally outward from the occipital protuberance to within about 1 inch of the external auditory meatus, and thence downward to the mastoid process" (Owen's "Manual of Anatomy"). If *infective sinus-thrombosis* exists, break into the lateral sinus (Fig. 646, *d*) from the mastoid opening and proceed as directed on page 766.

Linear Craniotomy.—Make a large flap. Trephine the skull a fingerbreadth from the sagittal suture, and the same distance back of the coronal suture. Rongeur the bone away in a line parallel with the sagittal suture and a safe distance from the longitudinal sinus, up to a point in front of the lambdoidal suture. Remove the pericranium which covered the bone excised. Insert the dural separator or pass it along the margins. In some cases an additional portion of the bone is removed over the fissure of Rolando. Various suggestions have been made as to the direction and situation of bone sections. Bleeding is arrested and the flap is closed without drainage.

[1] "Lancet," Feb. 8, 1896.

Removal of Gasserian Ganglion.—(See page 720.)

Operation for Infective Sinus-thrombosis.—(See page 766.)

The Decompression Operation (*Decompressive Trephining*).—This operation is employed particularly in cases of inoperable brain tumor. It differs from palliative trephining in the fact that the dura is incised and an opening left to permit of bulging of the brain. The bulging relieves pressure. By Cushing's method we get a hernia of the brain, but not a fungus cerebri. I have followed Cushing's recommendation in a number of tumors, and have used it on both sides in fractures of the base of the skull, and I believe it often saves vision and life.

Cushing and Bordley have performed it in cases of uremia and improvement has followed ("Amer. Jour. Med. Sciences," Oct., 1908). They suggest that the operation be used in certain cases of renal disease when medical treatment and lumbar puncture have failed to abate uremic symptoms, or when blindness is impending. It has been used in apoplexy and in pneumonia with cerebral symptoms.

The effect of the operation in cases of brain tumor is sometimes extraordinarily beneficial. In other cases it does no good at all. I believe at least half the cases are improved. I have seen paralysis practically disappear after a few months. As a rule it does little good when a tumor has caused coma unless the operation is associated with tapping the ventricles. Its most prominent benefit is in abolishing choked disk. It must not be done over a tumor, because the bulging tumor might become the seat of hemorrhage. It may, however, be done near the tumor (see page 782).

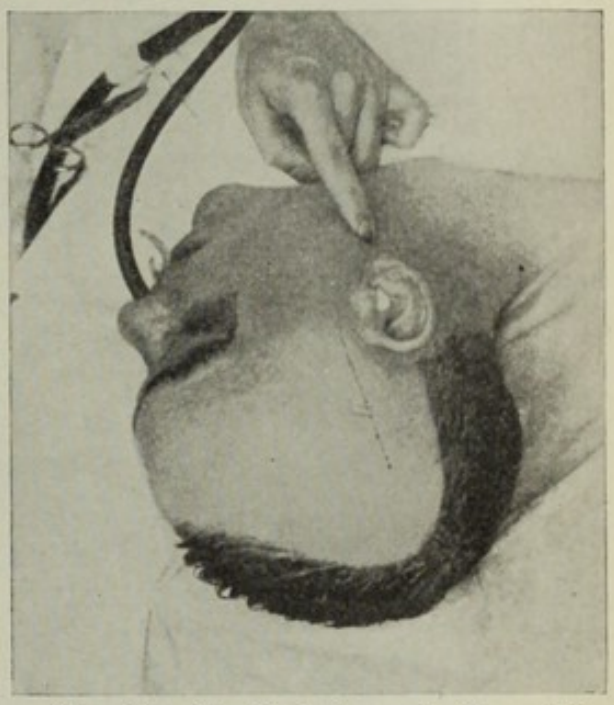


FIG. 647.—Showing intranasal ether administration; area of shaving; primary epidermal incision (from Harvey Cushing, Ochsner's "Surgical Diagnosis and Treatment," vol. i, Lea & Febiger, Publishers).

It is, of course, useless in relieving blindness, for blindness means atrophy, but it is often very valuable in *preventing* blindness. Blindness of even a day's duration is not recovered from by relieving pressure. Choked disk should be regarded as a late symptom of brain tumor. When choked disk exists operation should be done early if there be good vision. If in advanced cases any sight remains, it should be performed. Now and then there is an unfavorable result, for instance, the development of retinal hemorrhages or even the loss of vision, which may have been good previous to operation. (See deSchweinitz and Holloway on "Operative Treatment of Papillo-edema Dependent Upon Increased Intracranial Tension," "Therapeutic Gazette," July 15, 1909.) Decompression will probably be fatal if there is a tumor of the third or of the fourth ventricle. The patient may die upon the table or a few hours later. Elsberg ("Surgery, Gynecology, and Obstetrics," Aug., 1916) points out that if a subtemporal decompression is made for subtentorial tumor and the ventricle is dilated, the ventricle may be dragged upon and nerve tracts damaged. He further says that in a (1) left or right midbrain tumor a subtemporal decompression on the right side usually aggravates motor symptoms. So it does in a tumor to the (2) inner side of the internal capsule. In these two classes of cases, (1) and (2), bilateral decompression is advisable, the right side being done first and the ventricle punctured, so as to avoid too great a prolapse of the left temporal lobe and a resulting aphasia. The duration of the relief to the choked disk is variable. Relief may not be permanent. The operation may be done for an unlocated tumor and later the tumor may perhaps be located and removed. It may be done for an inoperable tumor and later, the decompression having made the danger less, operation may perhaps be performed.

Cushing's subtemporal decompression is done upon the right side, as a rule, but in some cases on the left side. An objection to doing it on the left side is that the bulging of the left temporosphenoidal lobe may cause word-deafness. A straight incision



FIG. 648.—Cushing's method of decompression when exploration has been made by means of an osteoplastic flap (Professor Harvey Cushing).

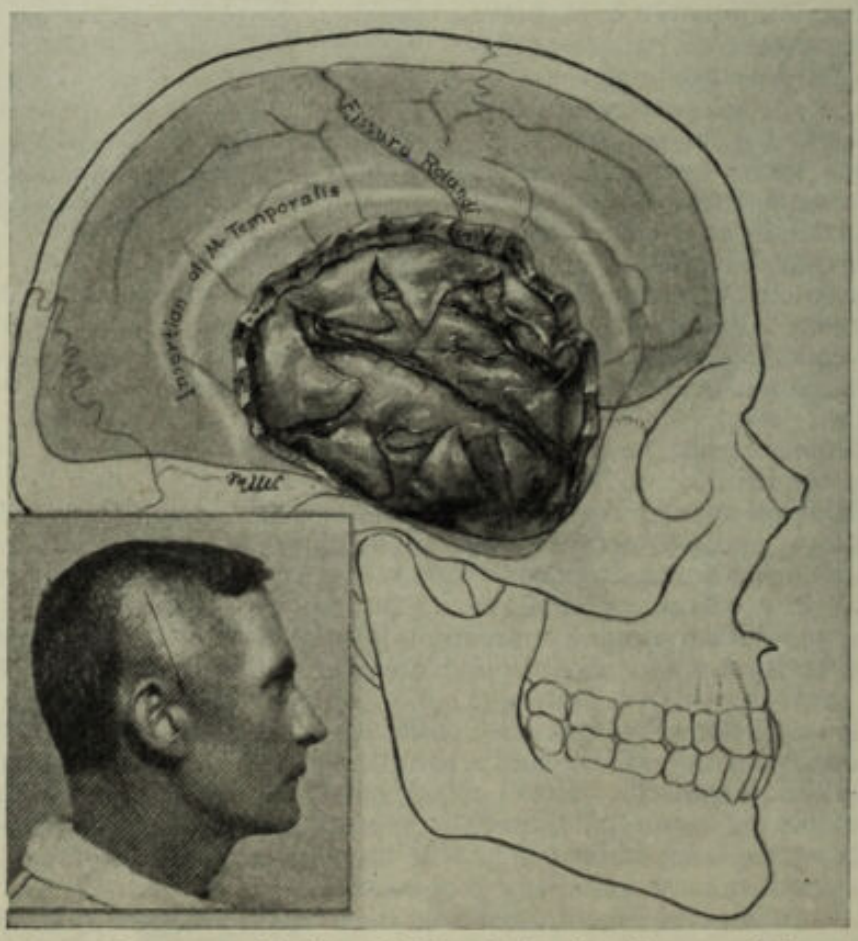


FIG. 649.—Diagram to show area of subcortical denudation in subtemporal decompression. The small cut shows the healed incision (Professor Harvey Cushing).

is made through the skin and subcutaneous tissue (Figs. 647, 649), the flap edges are retracted, the temporal fascia is incised in the direction of the muscle-fibers beneath it, the temporal muscle is split and not cut, the periosteum is separated from the bone, the soft parts are retracted, the bone is opened as the surgeon prefers, and the opening is enlarged by a rongeur. The dura is opened and radiating incisions are made through it toward the edges of the bone gap. The extra-osseous wound is closed by four layers of fine silk sutures (Fig. 649).

Figure 650 exhibits the exposure for suboccipital depression as done for subtentorial tumors. The same exposure is obtained in order to remove a cerebellar tumor. "In subtentorial decompressions a puncture of the corpus callosum or at least a ventricular puncture should always precede the opening of the dura" (Elsberg, Ibid.).

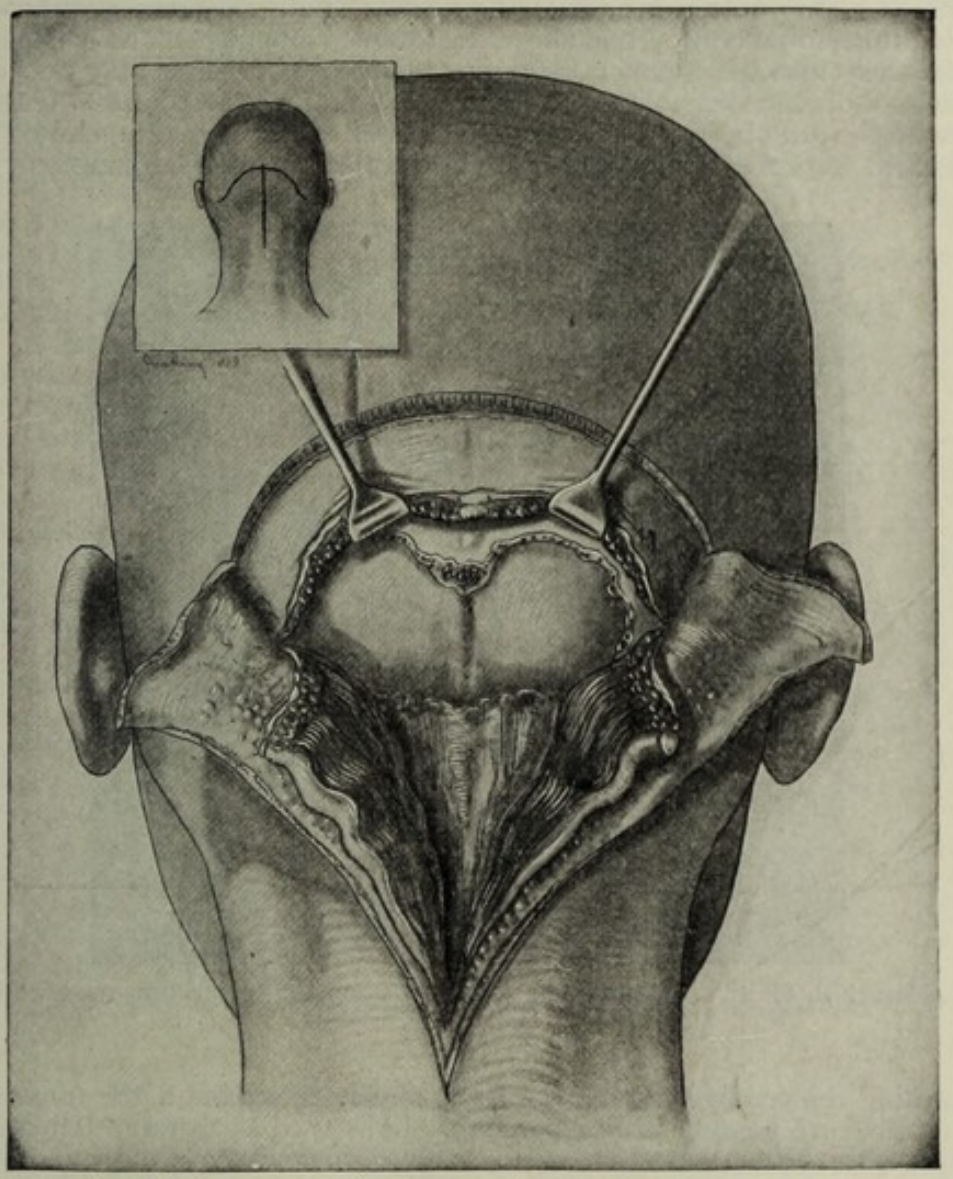


FIG. 650.—The suboccipital exposure, showing opening partly made and Cushing's "cross-bow" incision (Cushing in "Keen's Surgery").

Eagleton points out that in acute suppurating meningitis arising from the ear we have first an initial or primary stage in which the infection is restricted to the adjacent subarachnoid space, and second, the terminal stage, in which the whole cerebrospinal system is involved. Surgical treatment is of use only in the first stage (Wells P. Eagleton, Paper before the Medical Society of the State of Pennsylvania, the Scranton Session, Oct. 5, 1922). The same author shows that spinal drainage is bound to fail, that subarachnoid irrigation is only effective in an early stage, and can only be applied to those specially trained to use it. The primary focus of infection must be opened and drained.

Eagleton's Operation for Acute Purulent Meningitis.—Drill the frontal region, making two holes on the side to be used. Tap the cisterna. On finding fluid, replace

the stilet at once. Make a lumbar puncture. On finding fluid, at once replace the stilet. Perform the mastoid or labyrinth operation. Puncture the dura and let out the fluid. If the brain protrudes, remove the stilet from the occipito-atloid needle. When tension is lessened incise the dura and introduce a small spatula into the subdural space "adjacent to the infected area." Insert inlet cannula and irrigate, and have the drops of outflow counted from the occipito-atloid and from the lumbar needles. For full description see Eagleton's paper read before the Medical Society of the State of Pennsylvania, Oct. 5, 1922.

Drainage of the Cisterna Magna (*Haynes's Operation*).—This operation was suggested by Cunningham and the technic was developed by Haynes (see Deuch in "Laryngoscope," 1913, xxiii). An incision is made in the middle line from the occipital protuberance to the posterior arch of the atlas. The periosteum is stripped from a portion of the occipital bone at and above the foramen magnum. The bone is trephined and is cut away into the foramen magnum. The occipital sinus may not be present. If present as a double sinus, incise the dura between the two sinuses. If there is one sinus, divide the dura between two ligatures. Open the dura and arachnoid by a very small incision. As soon as excess of fluid has escaped, enlarge the incision. By lifting

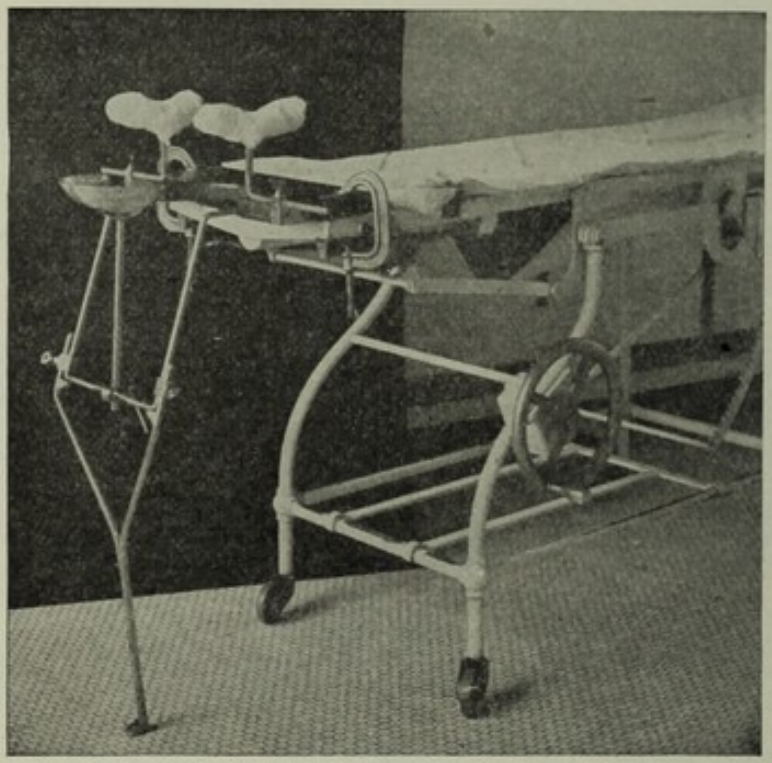


FIG. 651.—Horner B. Smith's head-rest for operations upon the cerebellum (modified by William J. Taylor).

and separating the cerebellar lobes the surgeon can determine if the foramina of the fourth ventricle are patent. Gutta percha tissue is used as a drain. The muscles are sutured together by catgut. The skin is closed below the drain by silkworm-gut (abbreviated from Haynes's description in "The Laryngoscope," June, 1912). So far the results of Haynes's operation in meningitis have not been encouraging. It is said to have succeeded in hydrocephalus. I had one gratifying case. Probably a better procedure for meningitis is Eagleton's operation.

Methods of Reaching the Pituitary Body.—The subtemporal route was suggested by Carton and Paul. Horsley has operated in this way. The bone is removed from the subtemporal region, the dura is opened, the brain is lifted, and the dural box of the hypophysis is incised. It may be necessary to remove bone from each subtemporal region and raise the brain from both sides. Borchardt performed osteoplastic frontal resection, ligated the superior longitudinal sinus, and lifted the brain.

Giordano suggested a transphenoidal operation, and Schloffer improved his method. Schloffer freed the nose so as to turn it toward the right side and then excised the turbinates, orbital wall, maxillary sinus, the middle septum, the left nasal process of the superior maxillary, and the ethmoid cells (Cushing, "The Pituitary

Body and Its Disorders"). In the inferior route of Kanavel most of these structures are preserved and the incision is within the mouth.

McArthur ("Jour. Amer. Med. Assoc.," June 29, 1912) trephines the frontal eminence of one side 4 cm. above the supra-orbital notch and preserves the button in warm salt solution. By means of the DeVilbiss forceps and the chisel he cuts away a bone fragment, which brings with it a considerable part of the roof of the orbit. This fragment, too, is placed in warm salt solution. The rest of the orbital roof is cut away by a rongeur. The dura covering the inferior surface of the frontal lobe is separated from the bone, while the lobe is raised and the orbital contents are held out of the way. Between the clinoid processes the dura is divided by Krause's hook-shaped knife. An enlarged hypophysis will now be accessible. At the conclusion of the operation on the hypophysis the bone fragments are replaced. Frazier has modified McArthur's operation ("Annals of Surgery," Feb., 1913). I have performed the operation once for a cyst of the hypophysis. Cushing has had wonderful success with his nasal method which involves resection of the septum (1 death in 32 cases). To perform this one must be highly skilful in working in a very small area. To most surgeons the fronto-orbital method will be easier. The operation can be done aseptically and by aid of sight and the brain needs to be retracted far less than in the temporal approach. A solid tumor can be removed more satisfactorily than by the nasal route. After the operation there may be edema of the eye and the eyeball may not be quite on a level with the other eyeball.

The Combined Method of Harvey Cushing (From Cushing's "The Pituitary Body and Its Disorders").—This surgeon, whose experience is very large, operates as follows: Intratracheal anesthesia. Place the patient with the shoulders slightly raised so that the head drops back. Pack the posterior nares with a sea-sponge. Insert cotton wet with adrenalin in each nostril. Lift the upper lip. Make a transverse incision across the frenum, and carry it down to the anterior nasal spine. By blunt dissection raise the soft parts on each side from the inferior margin of the osseous nasal opening until the cartilaginous septum is exposed. From now on the operation is submucous. Separate the membrane on each side from the bony and cartilaginous septum. Introduce a retractor on each side between the separated mucous membrane and the septum. Separate the blades of the instrument. Remove "most of the vomer, the lower edge of the median plate of the ethmoid, and a small strip of cartilage." It may be necessary to remove by means of a rongeur the anterior maxillary spine. With the retractors retained, a series of dilating plugs are introduced. These "flatten the turbinates." The largest dilator has a diameter of 1.8 cm. The retractors are removed and a bivalve speculum is inserted. An electric head-light must now be used. It may now be found necessary to remove "the prow of the vomer."

The body of the sphenoid is identified and the "anterior and lower walls of the sinuses are chipped away with long-handled nasal rongeurs." The lining of mucous membrane is removed, when the protrusion of the sella can be identified. The floor of the pituitary fossa is then clipped away. The dural case of the gland (or tumor) is divided by a hook-shaped knife.

Removal of the entire anterior lobe must never be done, as this lobe is necessary to life.

XXIII. SURGERY OF THE SPINE

Congenital Deformities.—Myelocele or Rachischisis.—This condition is due to deficiency in the formation of the vertebral arches, the cord being rudimentary, the medullary plates having failed to coalesce, the central canal not having formed, and the endothelium which should line it being exposed. If the entire cord is involved, the condition is called *amyelia* or *total rachischisis*. If only a part of the cord is involved, the condition is called *partial rachischisis*. In partial rachischisis a portion of skin is absent in the midline. At this area is a circular, dark red focus surrounded by a very thin and glistening membrane which becomes continuous with the skin. A dimple at the upper part and a dimple at the lower part of the dark area indicates the situation of the central canal above and below. Victims of rachischisis are usually stillborn or, at most, live but a few days.

Spina Bifida.—This is a deformity similar to the one just discussed, but in it the cord is much more developed. The first accurate description of it was given by Tulpius in 1685. It is a congenital sac of fluid due to vertebral deficiency, permitting protrusion of the contents of the spinal canal in the median line. In this condition the

cutaneous epiblast is adherent to the spinal exiblast, because structures from the mesoblast have failed to grow between. The laminæ and spines of one vertebra or of several vertebræ or of many vertebræ may be deficient, most frequently in the lumbosacral region. In very rare cases there is division of the vertebral bodies and the projection is forward and to the side. A case in which there are ununited arches but no protrusion is called *spina bifida occulta*. Sometimes there are two protrusions in one person. In spina bifida the dura does not cover the sac because it is cleft as well as the arches. There are three distinct varieties of spina bifida: 1. *Meningocele:* In this condition the dura is cleft (Hildebrand), there is a protrusion of the arachnoid, fluid gathers in the arachnoid meshes and "distends this so as to form one continuous cavity which is traversed by nerve-roots" (Henle in "A System of Practical Surgery," by von Bergmann, Bruns, and von Mikulicz. Translated and edited by Wm. T. Bull and Carlton P. Flint). The cord is not in the sac. 2. *Meningomyelocele* (the commonest form) is a protrusion of arachnoid and cord substance, the sac containing cerebrospinal fluid, nerves, and cord substance. The cord may spread upon the sac wall or it may pass through the sac and re-enter the canal. A cutaneous dimple or furrow indicates that the cord is attached and hence is within the sac. 3. *Syringomyelocele* is a protrusion of cord. There is great distention of the central canal, the sac wall being formed of the thinned cord and the spinal membranes. A spina bifida varies in size from that of a walnut to that of an infant's head; it grows rapidly during the early weeks of life; it is usually sessile, but may present, where it joins the body, a definite constriction or even a pedicle, the base of the sac is covered by healthy skin, and the fundus is covered by thin epidermis only or by the spinal membranes themselves. Pressure upon the tumor may diminish its size and increase the tension of the anterior fontanel, and possibly cause convulsions or stupor. The cyst in meningocele is translucent, does not pulsate, may enlarge from crying, and the margins of the bony aperture are distinct. Meningomyelocele and syringomyelocele are not translucent, but usually pulsate. Crying, coughing, or pressure upon the anterior fontanel makes a spina bifida more tense. Spina bifida is apt to be associated with club-foot, with hydrocephalus, and with rectal or vesical paralysis. Spina bifida usually causes death (90 per cent. of cases die during the first year of life). A few meningoceles and a very few meningomyeloceles undergo spontaneous cure by growth of the vertebral arches constricting the neck of the sac. The sac may remain distended with fluid or may shrink. Syringomyelocele is invariably fatal. The cause of death may be rupture of the sac or marasmus. The *x*-rays show the bony gap. *Spina bifida occulta* is a cleft in a vertebral arch without any protrusion of the cord or of the membranes. In this condition there is usually a profuse growth of hair in the skin over the bony gap and the hairy condition may be much more wide-spread. In some cases the hair is present at birth; in others it appears at puberty. Trophic changes and deformities may exist in the lower extremities.

Treatment.—Very small protrusions which grow slowly and are covered with sound skin may be treated by the use of a compress and bandage, by an elastic bandage, or by applications of contractile collodion. It was formerly regarded as proper to tap and drain the sac. Injection was used by many. The skin having been cleansed, the child was placed on its side and a little chloroform was given. A fine trocar was plunged obliquely in at the side of the sac through sound skin, little or no fluid being drawn off, and 1 dram of Morton's fluid injected (iodin, 10 gr.; iodid of potassium, 30 gr.; glycerin, 1 oz.). The trocar was withdrawn and the puncture was sealed with a bit of gauze and iodoform collodion. The child was put to bed. If injection proved successful, the sac was found to shrink; if the injection failed, it was the custom to repeat it at intervals of from seven to ten days (Jacobson, White). Surgeons now prefer excision of the sac in suitable cases. Whenever possible the incision should be through healthy skin. If the sac contains nerves they should be separated from the wall and placed within the canal. Bayer treats it as he would a hernia. Robson in some cases excises the entire sac. Operations upon children much under the age of five have an enormous mortality. Operations are comparatively safe after the child reaches the age of five. Operations for spina bifida have been done successfully immediately after birth (Lovett in "Amer. Jour. Orthop. Surg.," Oct., 1907). We should not operate if there is hydrocephalus or extensive paralysis, if the mass is very large and growing rapidly, or if there are other marked deformities. A ruptured sac or a sac about to rupture should be operated on at once; otherwise death is practically certain.

Tumors of the Vertebræ.—Secondary tumors (sarcoma, carcinoma) of the vertebral bodies are not very uncommon.

Primary tumors, except osteomata, are very seldom found. Only 9 or 10 cases are on record as having been operated upon. Enchondroma is the most common growth. Sarcoma (spindle-cell or giant-cell) may arise. Chondrosarcoma and myxosarcoma have been met with.

Sacrococcygeal Tumors.—Dermoids dorsal to the sacrum are occasionally seen in this region. In the lower sacral or coccygeal region the cutaneous structures sometimes fail of complete coalescence and a *postanal dimple* or *sinus* is the result. Such a sinus is lined with skin and its wall contains numerous glands and often hairs. It may inflame or suppurate. If it blocks up at the outlet, a form of dermoid develops. Lipomata and hydatid cysts may be found in front of the sacrum. The term "sacrococcygeal tumor" should mean a tumor ventral to the sacrum and arising from misplaced anlages. Early in embryonic development the neurenteric canal joins the central canal of the spinal cord with the primitive alimentary canal. The neurenteric canal later undergoes obliteration. At a certain point the ectoderm and entoderm grow together, pushing aside the mesoderm and forming the anal plate. The plate becomes depressed, forming the anal pit or proctoderm. The proctoderm invaginates more and more in front of a portion of the gut and reaches the gut above the neurenteric canal. There is a section of gut behind the anus known as the *postanal gut* which is obliterated during development. This is a region of tissue vestiges, remains, and misplacement; in it developmental defects are not unusual and new growths may arise. Tissue misplacement may give rise to dermoid formation. Teratomata and curious mixed tumors may arise which are apt to show growth from all three embryonic layers (Law in "Surgery, Gynecology, and Obstetrics," 1913, xvii). Mammary tissue, testicular tissue, an eye, a limb may be found. In fact, some observers regard such a tumor as in reality a suppressed fetus.

Law (Ibid.) says sacrococcygeal tumors vary so much and show such diverse tissue elements that they have been called "histologic potpourri."

As a rule they originate in the connective tissue of the pelvis and are encapsuled. They are on the verge of malignancy.

Treatment.—Dermoids require extirpation. If a postanal dimple or sinus causes no trouble, it is let alone; otherwise it should be dissected out. It may or may not be possible to remove teratomata. Lipomata and hydatid cysts are extirpated.

Tumors of the Spine and of the Spinal Cord.—Tumors may arise from the cellular tissue, fatty tissue, the nerve-roots, the membranes of the cord, or from the vertebra (*extramedullary tumors*). They may arise within the cord (cord tumors proper or *intramedullary tumors*).

Extramedullary Tumors.—Syphilomata, hydatid cysts, tuberculomata, and inflammatory masses or adhesions may compress the cord and produce symptoms indistinguishable from genuine tumor. Among extramedullary tumors are secondary carcinoma, sarcoma (primary or secondary), fibroma, myxoma, lipoma, chondroma, and neuroma. Dermoid sacral cysts may exist. Lipoma, fibroma, and certain cysts may be congenital. Injury of the back sometimes seems to bear a causal relation to extramedullary tumors.

The *symptoms* are due to pressure upon nerve-roots and the cord. The most prominent symptoms are pain in the back and evidences of nerve-root irritation.

The early or irritative symptoms are pain and stiffness of the back, usually very severe and interfering with sleep, shooting pains in the area of the implicated nerve-roots, and sensory abnormalities in the same area. Tenderness may occur below the level of the growth. Tenderness of bone disease corresponds to the level of the disease. There may be hyperesthesia of a limited area. The area of distribution from one or two roots is involved in pain, sensory disturbance, and slight motor impairment. In some cases the nerve-roots of one side only exhibit irritation and the symptoms are strictly unilateral. In other cases the symptoms are bilateral, but are most marked on one side. In some cases the symptoms are symmetrically bilateral and indicate pressure upon the cord rather than upon nerve-roots. Muscular spasms may occur. There may be lateral curvature of the back, the concavity of the curve being on the side of the tumor. Sooner or later paralytic symptoms come on (motor and sensory paralysis). They may be due to pressure upon or destruction of nerve-roots or to compression of the cord. When anesthesia exists there may be a zone of hyperesthesia above its upper limit. As motor palsy develops from root compression the pain usually abates. The muscles undergo atrophy and show the reactions of degeneration. If motor or sensory disturbances become more marked after lumbar puncture the growth is probably dural (Elsberg and Stookey in "Archiv. of Neurol. and Psych.," Nov., 1922).

A tumor may, by cord pressure, produce the symptoms of compression myelitis, locomotor ataxia, or myelitis. Contractures or paraplegia may arise from tumor. The location of the growth can be inferred by a study of the territory of paralysis and the zone of sensory disturbance. The tumor is always situated somewhat above the upper limit of anesthesia. In many cases the diagnosis is impossible. Gradually increasing painful paraplegia, with pain in the back and with hyperesthesia or anesthesia appearing after a time and ascending from the feet toward the trunk, points to tumor as a cause. The paralysis is usually spastic, but may be flaccid, or it may be spastic at first and become flaccid. In spastic paraplegia the reflexes are increased. In flaccid paraplegia they are decreased. In spastic paraplegia there are ankle-clonus, the Babinski sign (extension of the great toe or all the toes when the sole of the foot is irritated), Gordon's paradoxic reflex (extension of the great toe or all the toes when pressure is made upon the deep calf muscles), and Oppenheim's reflex (extension of the great toe or all the toes when the handle of the percussion hammer is drawn along the inner edge of the tibia so as to make pressure from above downward). Trophic lesions are apt to arise in the trajectory of nerve involvement. The sphincters are usually involved. Growths outside the membranes produce particularly pain and spasm; growths within the membranes produce especially motor paralysis and anesthesia. Symptoms that are unilateral, were at first unilateral, or which are most, marked on one side, are very significant.

Intramedullary Tumors.—These tumors develop in the substance of the cord. They are far less common than extramedullary growths and are more often benign. These growths are, as a rule, primary and solitary and do not produce symptoms of pressure until they attain the size of a hazelnut. The most common tumors are glioma, sarcoma, and tuberculoma. Syphiloma occasionally arises. Most tumors in cord substance are small, but a glioma may involve practically the entire cord. A tumor is often for a time limited to one side of the cord, but later it presses upon and finally involves the opposite side. When the cord is pressed upon, degeneration occurs. In some cases a wrench or bruise of the back is supposed to be causal. Glioma may be congenital.

Symptoms.—They are at first, in most cases, very uncertain. In some cases, however, paralysis develops early.

There is often pain in the back, but it is not nearly so common or severe as in extramedullary tumor. The most prominent symptom is a slow-developing motor palsy. In some cases the palsy is at first unilateral, but later becomes bilateral. The Brown-Séquard syndrome is impairment of motion, of tactile sense, and of muscular sense on the side of the lesion and loss of pain and temperature sense on the opposite side. Although sensibility to pain, heat, and cold are lost, sensibility to touch is preserved (sensory dissociation). Irritative root symptoms are absent (spasm and darting pain). Anesthesia or hyperesthesia develops. The sphincters are involved and trophic disturbances arise. There may be spastic paraplegia or flaccid paraplegia. If the tumor is in or presses upon the anterior cornu, there will be limited muscular atrophy. Tuberculoma produces the symptoms of transverse myelitis.

In glioma there are paresis and muscular atrophy.

Diagnosis.—Fixed and localized pain lasting for months or longer leads one to suspect tumor. Pain alone does not make the diagnosis, as it might be due to root inflammation or meningomyelitis. The diagnosis is established by the advent of hyperesthesia, anesthesia, motor impairment, and reflex disturbance (Frazier and Spiller in "Archiv. of Neurol. and Psych.," Nov., 1922). Exaggerated tendon reflexes with a Babinski reflex of the lower limb of one side with a diminution of pain and temperature sensations in the lower limb of the other side is suggestive. In every suspected case an *x*-ray examination is to be made and a spinal tap is necessary. Sooner or later a spinal tumor causes a subarachnoid block. Even early the fluid below the block shows diminished pressure and protein increase. In later cases it shows xanthochromia and massive coagulation (the *Froin syndrome*) (Ayer in "Archiv. of Neurol. and Psych.," Oct., 1923). Ayer taps the cisterna and the lumbar theca and compares the pressure and the composition of the fluids. For supposed caudal tumor double lumbar puncture is used. If the fluid distal to the obstruction shows lowered pressure and if the pressure remains low even though the pressure above remains high there is a complete block. In a complete block pressure upon the jugular veins will increase pressure of the fluid above the obstruction, but not below it. If an iodized material is injected the *x*-rays shows the exact situation of the block. Wegeforth, Ayer, and Esick ("Amer. Jour. Med. Sciences," July, 1919) describe cisterna puncture.

Cisterna puncture is made between the occipital bone and the first cervical vertebra right through the occipito-atlantoid ligament. Close to the anterior surface of the ligament is the dura mater. Under this is the arachnoid membrane forming part of the posterior wall of the cerebellopontine cisterna. The anterior wall of the cisterna is formed by the posterior surface of the upper cervical cord and the lower part of the medulla. The distance between the arachnoid and the posterior surface of the cord and medulla at the level of the ligament is about 1.5 cm. The needle is introduced in the midline just above the spine of the axis.

In thin persons we can distinctly feel the depression between the occipital protuberance and the spine of the axis.

The average distance to which we should insert the needle is 4 cm., though it varies with the individual from 3 to 5 cm.; hence the operator must perceive when the resistance from the ligament and the dura ceases, which it does when the needle enters the cisterna. Movements of the head may alter the relations of the point of the needle and the nervous structures.

When there has been a complete subarachnoid block (no fluid coming from the lumbar tap) one observer has tapped in the eighth dorsal space (Chartier). Some other operators have tapped between the sixth and the seventh cervical vertebræ.

Treatment of Tumors of the Cord.—If syphilis is suspected, give the patient a course of heroic doses of iodid of potassium, and administer mercury hypodermically or by inunction. Intravenous injection of salvarsan is advisable. In a focal lesion not due to dissemination of a known malignant growth perform the operation of laminectomy to permit of exploration and possibly of removal. The laminæ of at least three vertebræ should be removed and the tumor looked for distinctly above the upper level of the zone of anesthesia. It is not necessary for the patient to wear a spinal support after the performance of laminectomy. Extramedullary tumors are usually removable. Localized intramedullary tumors should be removed if they can be located and if removal can be accomplished without serious injury to the cord. After exposing the cord and discovering an intramedullary tumor, follow the advice of Elsberg and Beer ("Amer. Jour. Med. Sciences," Nov., 1911) and make a short incision in the posterior median column a little external to the posterior median fissure. The cut reaches the tumor, which bulges through it. Do not attempt removal now. Suture the skin and muscles and wait one week. On opening the wound the tumor will be found almost completely extruded from the cord. In order to remove it, it is only necessary to divide a few strands of tissue. Extrusion by this method probably inflicts little injury upon nerve-fibers. This method is called *delivery by extrusion*. I had one very promising case after this plan. The patient improved greatly and was apparently on the high road to recovery, when he developed empyema from pneumonia and died. McCosh truly says that operation for spinal cord tumor is decidedly more hopeful than for brain tumor, because localization is much more accurate and removal can be effected with less permanent damage. The mortality from laminectomy is certainly not over 10 per cent., and is probably less. Lloyd collected 51 operations: 10 per cent. died and 31 per cent. were actually cured or improved. A tumor is found in three-fourths of the cases explored. Joseph Collins ("Med. Record," Dec. 6, 1902) collected 70 cases of spinal tumor, 30 of which were operated upon. In 12 the operation was a success, that is, the pain disappeared and motor power returned; in 8 the operation was partly successful, that is, the pain disappeared and the motor power improved; in 10 the operation failed and death occurred within a few weeks. Complete recoveries have been obtained. Elsberg cites a number of cases ("Internat. Abstract of Surgery," June, 1914). If the tumor is found to be irremovable, McCosh suggests division of several nerve-roots to relieve the pain.

Acute osteomyelitis of the vertebræ is a rare disease; it may be associated with osteomyelitis of other bones, may be secondary to some distant suppurative focus, or may occur alone. It may begin in the periosteum or in the marrow. Infection of the viscera not unusually accompanies it. In many cases there is a history of trauma. Any part of the spine and any part of a vertebra may suffer from it. The vertebral arch is most apt to be attacked, whereas in tuberculosis the body is usually diseased. This condition may follow cold, overexertion, distant suppuration, any focal infection or traumatism, and is more common in the first two decades of life than in elderly people. The process may be superficial or it may involve the bone deeply and widely. Suppuration always occurs, sequestra generally form, and phlebitis is a dangerous complication. Any region of the spine may be attacked, but the lumbar region is

particularly liable to invasion, next the dorsal, next the cervical. The sacral region is least often affected. The situation of the abscess varies with the situation of the disease. If the vertebral bodies are diseased the pus passes forward (retropharyngeal, mediastinal, psoas, or pelvic abscess). If the vertebral arches suffer the pus passes backward (cervical lumbar or dorsal abscess). Rupture into the spinal canal may occur. The membranes of the cord, the cord itself, the nerves, and the vertebral articulations are frequently involved in the process. Motor palsy and anesthesia may arise. Paraplegia is not uncommon from pressure or myelitis. Staphylococci, streptococci, or other pyogenic bacteria may be cultivated from the pus.

Symptoms.—The general symptoms are those of osteomyelitis. The local symptoms depend on the seat of disease. If the posterior portion of the column is diseased there is a hard swelling which, in the neck, is in the middle line; in the dorsal and lumbar regions, in the middle or to the side; and in the sacral region, invariably to one side.

Rigidity of the spine always exists. If the vertebral bodies are affected, rigidity is noted, the spine is tender, and special symptoms appear, their nature dependent on the region affected (retropharyngeal abscess, etc.). Occasionally symptoms of meningomyelitis are noted. The constitutional symptoms of sepsis are marked. The condition is sudden in onset, the general symptoms are violent, and purulent collections diffuse widely and rapidly. Mentality is frequently markedly dulled. These points enable the surgeon to make a diagnosis between acute osteomyelitis and Pott's disease. In osteomyelitis angular deformity rarely arises because the patient is obliged to be recumbent and because hyperostosis is taking place. The mortality is from 40 to 60 per cent. Metastatic abscesses are apt to arise. Death may be due to pachymeningitis, pneumonia, empyema, retropharyngeal abscess, invasion of the cord, or amyloid disease (H. S. Warren, "Boston Med. and Surg. Jour.," May 7, 1903).

Treatment.—The patient is kept recumbent. His constitutional treatment is such as will combat sepsis (food, stimulants, etc.). The treatment is early operation. A purulent area must be incised and disinfected. If bone denuded of periosteum is found, it is touched with a solution of chlorid of zinc or with the actual cautery. If a sequestrum exists, it is removed. A drainage-tube is inserted and dressings are applied (Müller, Makins, Abbot, Tscherniak, Hahn, Volkmann, and Chipault).

Typhoid Spine.—It was pointed out by Gibney in 1889 that typhoid fever may leave as a legacy a painful, stiff, and weak back; 74 cases of the condition have been reported (F. W. White in "Jour. Amer. Med. Assoc.," Feb. 13, 1908). The muscles of the back are found to be rigid and there is tenderness of one or more vertebræ. The pain may only be appreciated on motion, but in some cases there is aching even when the patient is at rest. The pain may be localized, may run into one or both thighs, or may be felt in the abdomen. The symptoms arise at an uncertain period after the fever, develop rapidly, and are occasionally associated with transient episodes of elevated temperature. Either kyphosis or lateral curvature may develop. (See L. W. Ely, "Medical Record," Dec. 20, 1902.) Many of the patients are hysteric. The condition is due to osteitis and periosteitis, or chronic osteomyelitis. The prognosis is excellent.

Treatment.—The use of a plaster or leather jacket; counterirritation by the hot iron; later, massage and electricity.

Cervical Rib.—This condition was first described as an anatomic anomaly by Hunwauld in 1742. It is due to atavism. Henderson points out that in certain low limbless vertebrates there are rib attachments to every vertebra, but that in the limbed vertebrates there are rib attachments only on certain vertebræ ("Collected Papers by the Staff of St. Mary's Hospital," Mayo Clinic, 1913). Cervical ribs were seldom recognized during life before the days of the *x*-rays. We are now aware that the condition may be clinically significant. There may be one cervical rib on one side or the condition may be bilateral. Out of Henderson's 31 cases, 24 were bilateral. When bilateral, ribs are seldom quite symmetric. The rib may be fully developed, may be rudimentary or may be nothing more than a projection of the costal process of the seventh cervical vertebra. A rib may spring from the sixth cervical vertebra. A rudimentary rib or a projecting costal process may be fixed to the first rib by a fibrous band. Two-thirds of the cases are in women. The condition does not seem to be hereditary. The subclavian artery passes over a long cervical rib and in front of a short cervical rib, but never under it. The anterior scalene muscle is front of the artery and the pleura may be attached to the cervical rib. A complete cervical rib may fuse anteriorly with the costal cartilage, the sternum, or a cervical rib of the

opposite side. Of late *x*-ray findings indicate that the condition is much more common than was formerly supposed. I have seen 7 cases and have operated successfully on 2 cases.

Symptoms.—If symptoms arise, they are due to pressure or friction and may arise suddenly or gradually. The condition may never produce any uneasiness and hence may escape detection, and seldom does produce trouble in youth. It raises up the brachial plexus and subclavian vessels, if the rib is large. It may lead to interference with the blood-supply and even to aneurysm of the subclavian artery (Keen's case developed aneurysm), or gangrene of the hand may result from bending or blocking of the vessel. There may be no radial pulse when the arm hangs down by the side or the pulse may perhaps be made to disappear by pulling the arm strongly downward. Neuritis of the brachial plexus may arise from pressure. Pain is common. Anesthesia, palsy, or both may develop. When sufficiently large to produce venous or vascular trouble, a cervical rib can be felt, and the pulsating artery over it is very distinct and higher than natural in the neck. Sooner or later the artery dilates distal to the rib.

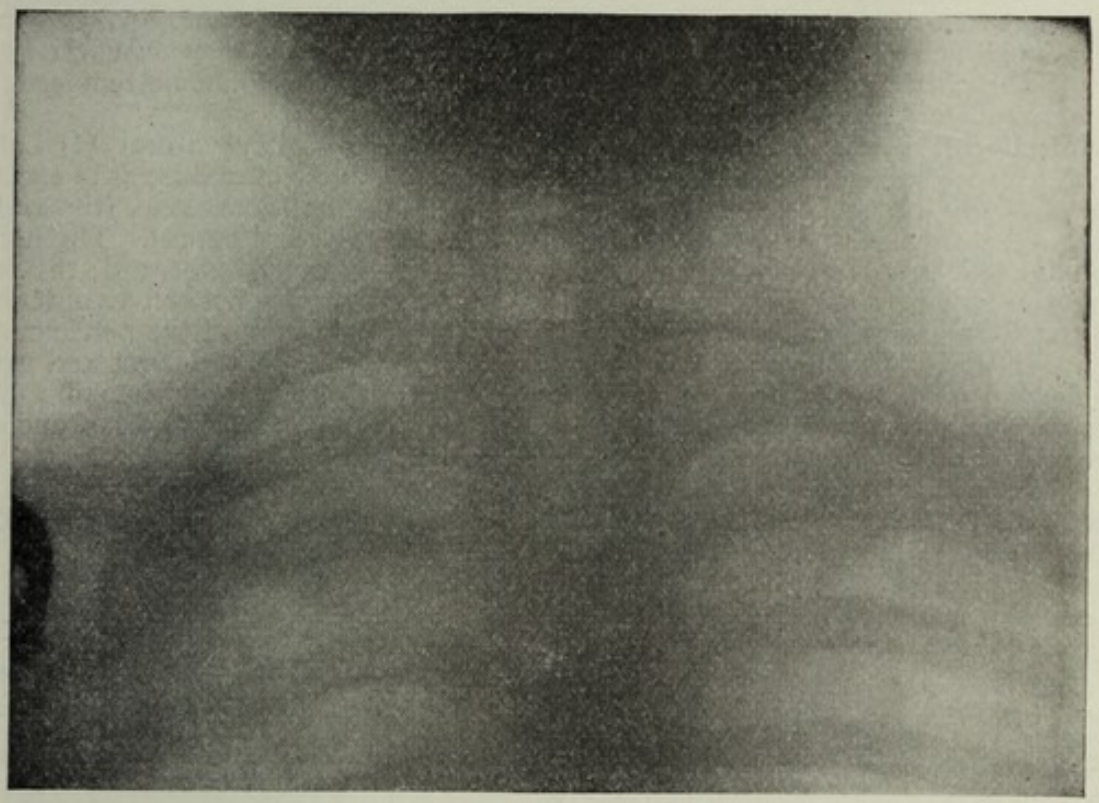


FIG. 652.—Cervical ribs.

The patient is seldom a child, may be an adolescent, but is usually an adult or old. As a person gets older the shoulders droop and symptoms develop because of the droop. There is frequently pain in the neck and extremity, and atrophy of shoulder and arm. Some are supposed to have aneurysm, others ordinary neuritis. The shoulder droops, the neck is full, the artery is felt to be pulsating strongly and there may be circulatory impairment (see above). Percy Sargent thus sums up the usual symptoms: "Pain, paresthesiæ, disorders of circulation, affection of cutaneous and other forms of sensation, weakness, wasting, and alteration of electric reactions." There may be coldness, edema, tingling, or numbness. Wilson pointed out that the abductor brevis, the opponens pollicis, and other thenar muscles do not waste. The *x*-rays confirm the diagnosis.

Treatment.—The treatment, when the rib is causing trouble, is excision of the rib with its periosteum. In a case of cervical rib the operation is by no means easy. (See Kammerer in "Annals of Surgery," Nov., 1901, on "The Diagnostic Difficulties.") The operation should be done by the plan of A. A. Law (Abstract in "Surgery, Gynecology, and Obstetrics," 1914). He makes a vertical incision parallel to the border of the scalenus medius muscle, divides the scalenus anticus across (being careful to avoid the phrenic nerve), frees the subclavian artery and plexus by dissection, sep-

arates the pleura from the inner surface of the rib and divides the rib by means of cutting forceps. Percy Sargent operated upon 65 cases. Operation usually relieves pain, but is not so efficient in correcting vasomotor phenomena.

Variations in the Lateral Process of the Fifth Lumbar Vertebra.—If this process is sufficiently long it impinges on the anterior portion of the iliac brim when the patient is in an upright position. The pain may develop suddenly after a twist or contusion. It may develop gradually. It may only be felt when the patient is in certain positions, or it may be more or less constant, being aggravated by certain postures. Overextension is particularly prone to develop it. Pain may radiate on the fifth lumbar nerve which emerges between the sacrum and fifth lumbar vertebra. The sciatic nerve may be the seat of the pain. Radiating pain and paralysis may develop in one or both lower extremities. In making the *x*-ray diagnosis a picture must be taken from several directions. The treatment usually suggested is operative removal of the process. The operation may fail because of damage done to the fifth lumbar nerve. Paralysis may follow operation. H. A. Wilson maintains that in less than 30 per cent. of reported operations was the result perfectly satisfactory (Paper, delivered before the "West Virginia Medical Association," Oct., 1917). This operation is now performed frequently with excellent results. If carefully and cautiously performed there should be no ill effects. It has been suggested that instead of excising the lateral process the portion of the ilium against which it impinges should be removed. In the latter operation the nerve certainly escapes damage.

Spinal Curvature.—There are four chief forms of spinal curvature: (1) Lateral curvature (the scoliosis of the older surgeons); (2) posterior curvature (the excurvation, gibbosity, or kyphosis of the older surgeons); (3) anterior curvature (the lordosis of the older surgeons), and (4) angular curvature (from spinal caries). The normal spine has four curves: the *cervical* curve, the convexity of which is forward; the *dorsal* curve, the convexity of which is backward; the *lumbar* curve, which is convex anteriorly, and the *pelvic* curve, which is concave anteriorly. The dorsal and the pelvic curves, which are primary, are due to the formation of the cavities of the chest and pelvis, and depend upon the shape of the bones (Treves). The cervical and lumbar curves, which are compensatory, depend upon the shape of the intervertebral disks, and only appear after birth when the erect position is assumed.

CONDENSED DIFFERENTIAL DIAGNOSIS TABLE OF SPINAL DISEASES AND CONDITIONS WITH WHICH THEY MAY BE CONFOUNDED

(After Professor H. Augustus Wilson)

	Scoliosis.	Rachitic spine.	Pott's disease.	Hyperesthetic spine.	Arthritis deformans.	Torticollis, congenital.	Hip disease.
Age.	8 to 16.	4 to 6.	4 to 6.	16 to 20.	After 30.	Any age.	4 to 6.
Onset.	Insidious.	Insidious.	Insidious.	Sudden.	Insidious.	From birth.	Insidious.
Pain.	In back.	None.	Referred to anterior abdomen.	Severe in spine.	In spine.	None.	In knee.
History.	None.	Rachitic.	Tuberculous.	Trauma.	None.	From birth.	Tuberculous.
Posture.	Free.	Excessively free.	Guarded spine.	Guarded.	Guarded spine.	Typical.	Guarded hip.
Muscular rigidity.	None.	Free.	In spine.	In spine.	In spine.	In one direction only.	In hip in all directions.
Temperature.	Normal.	Normal.	1 degree rise.	Varies.	Normal.	Normal.	1 degree rise.
Local tenderness.	None.	None.	In spine.	Painful all over.	All over spine.	None.	In hip.
Night cries.	Absent.	Absent.	Present.	Absent.	Absent.	None.	Present.
Tendency to abscess.	None.	None.	Probable.	None.	None.	None.	Probable.
x-Ray.	Characteristic deformity.	Normal.	Focus in spine.	Normal.	Late bridges of bone. No necrosis.	Distortion of cervical spine.	Spine normal.
Hot-water test.	No tenderness.	None.	Localized in spine.	Sensitive all over spine.	Sensitiveness.	No tenderness.	No tenderness in spine.
General symptoms.	Constant.	Constant.	Intermittent.	Constant.	Constant.	Constant.	Intermittent.

Scoliosis is a non-pathologic distortion of the spine characterized by rotation and lateral bending, hence the name, rotary lateral curvature (Fig. 653). It is either functional or organic.

Functional scoliosis is caused by any prolonged alteration in the relationship normally existing between the axis of the shoulders and the axis of the hips. The etiologic factors depend upon the maintenance of faulty postures in occupations, es-

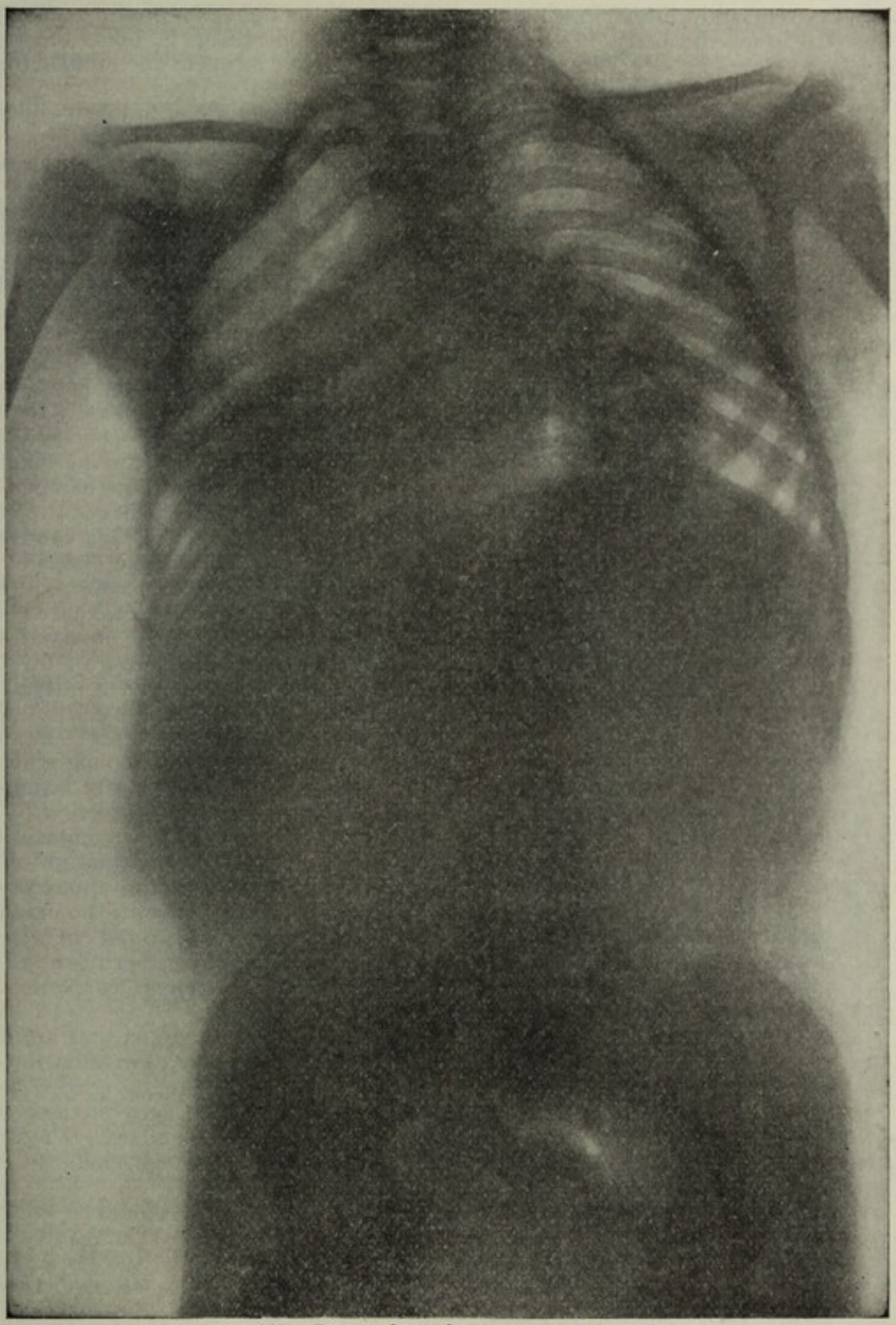


FIG. 653.—Rotary lateral curvature of the spine.

pecially during the period of growth. School life is especially influential in producing the condition because school furniture is adapted to the average requirements of a given class, and therefore a proportion of pupils are able to find desks and benches that are unsuitable. Properly furnished modern schools are supplied with desks and

seats that are adjustable to each occupant. Gould ("The Ocular Factors in the Etiology of Spinal Curvature," H. Augustus Wilson, "New York Medical Journal," July 12, 1906) has directed attention to the errors of refraction that produce head tilting and thereby induce scoliosis. In adults, scoliosis is observable in blacksmiths, fencing masters, and waiters, in whom excessive use of the right arm produces an asymmetric posture of the body. If a child has chronic appendicitis it holds the trunk bent toward the right side. A spinal convexity to the left forms in the lumbar region and to the right in the dorsal region.

When functional scoliosis is not corrected or occurs in rachitic or indolent children, it results in organic or permanent changes in the contour of the bones composing the spinal column. Organic scoliosis may be congenital, caused by prenatal deficiencies or augmentations of the spinal column.

Postmortem examinations reveal a confirmation of Wolfe's law that prolonged alteration of the normal functions always results in changes of anatomic structures. In extreme cases the bones of the spinal column become extensively altered in shape, the ribs are altered in contour, and the thoracic and abdominal viscera are forced into unnatural positions and assume abnormal shapes, their functions often being materially altered.

Diagnosis.—The patient is usually taken to the physician because of apparent elevation of one shoulder, or because one hip is thought to be larger than its mate, or one mamma higher than the other. Dressmakers and corset makers are generally the first ones to direct attention to the faulty posture (as scoliosis occurs in 8 girls to 1 boy). A patient suspected of having scoliosis should be nude at the time of inspection, as clothing hampers the normal action and tends to conceal the movements of the body. The accompanying diagnostic table (see page 804) is a condensed comparative statement of the important features in diseases and conditions that may resemble scoliosis in some respects. It is only by carefully studying the symptom-complex that a definite decision can be reached. It is frequently observed that patients with mild types of functional scoliosis can sit or stand erect for a few minutes and thereby deceive even a critical observer. The habitual posture, and also the rapidity with which the patient returns to the distorted position after temporary voluntary correction, demand careful attention. Young children, when chided by parents or teachers, often temporarily assume an approach to a normal posture without actual correction. The ease with which their surrounding joints yield in compensatory action is often overlooked. A patient with contracture of the pectoral muscles will elevate the shoulders into an apparent correction of stoop or round shoulders instead of throwing the shoulders well back, a posture that is to them impossible. In the same way, a patient who has preternatural contracture of the hamstring tendons, either unilateral or bilateral, will often conceal that condition by bending the knee or knees enough to permit the pelvis and trunk to bend forward.

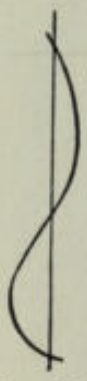


FIG. 654.

Lateral dorsal curvature to the right, and compensatory lumbar curve to the left.

Goldthwait has directed attention to forward curves of the scapula that are often present in patients who are stoop shouldered and has devised an operation for correction.

Treatment consists especially in removing the cause. If the eyes produce head tilting, proper refraction will be necessary. Adenoids should be removed. The clothing should be regulated to avoid constriction and the shoulder straps should fit close to the neck and not be allowed to slip on to the shoulder-joint.

Contractures of the pectoral muscles and hamstring contractures should be stretched by corrective manipulations. Hoke ("A Study of a Case of Lateral Curvature of the Spine: A Report on an Operation for the Deformity," "Amer. Jour. Orthop. Surg.," vol. i, Nov., 1903, p. 169) has devised an operation of rib resection for cosmetic purposes. Every effort should be made to prevent the *occurrence* of scoliosis. The successful treatment of scoliosis depends on preventing its progress. Each individual patient requires careful study to determine the special characteristics that may be present.

Remedial measures should be employed that meet the peculiar individual requirements of each case.

School gymnastics are generally more harmful than beneficial in cases of scoliosis.

No one but a physician should prescribe the gymnastic work. The soft bones may be still further distorted by injudicious exercises.

The first requirement in the application of applied physical culture is to secure the hearty co-operation of the patient. Without such co-operation progress cannot be expected.

No gymnastic apparatus of any kind is required when the patient can be instructed in the proper methods of autoresistance. There are over four thousand movements of the body that may be employed in remedial physical culture. From this vast assortment those may be selected that are suitable to the peculiar conditions of the patient. At first the least tiresome forms are to be employed, and gradually and progressively others are resorted to until the patient presents a strong robust development. Usually about a year is required for the purpose, as the progress must be essentially educational. Training in developing muscle action goes hand in hand with instruction in walking, in sitting, and in all the postures assumed by the human body in the various occupations of the patient.

In organic scoliosis, in which the distortion is more or less of a permanent character, much can be accomplished in preventing the progress of the condition as well as in aiding correction by removing any rigidity that may be present. By increasing the flexibility we facilitate muscular development in much the same manner as in functional scoliosis.

When rigidity is present it must be considered in the same light as rigidity of any other joints. Its presence prevents muscular development. Manipulative measures are similar in effect to those employed in fibrous ankylosis of any joint, and are peculiar to the parts involved. In the majority of cases the force for manipulative correction must be applied through the interposition of the ribs, and the great danger of producing fractures of these structures should be realized.



A B

FIG. 655.—Kyphosis (A) and lordosis (B).

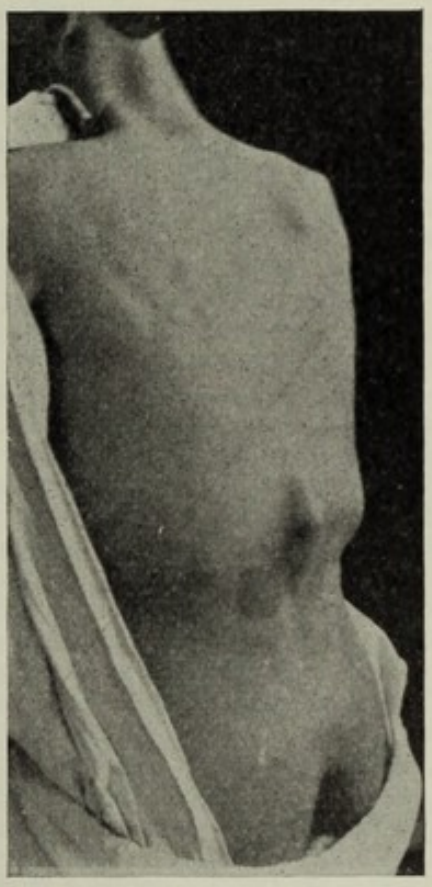


FIG. 656.—Dr. Arthur J. Davidson's case of tuberculosis of the spine.

If, however, there is any tendency to increase of the deformity, a suitable brace or removable jacket of plaster or celluloid should be applied to maintain correction until the musculature has been strengthened and trained to perform its full functions.

Organic or structural scoliosis has been shown by Abbott, of Portland, to be capable of correction by several types of fixed jackets (E. G. Abbott, "New York Med. Jour.," 1912, and A. M. Forbes, Ibid., July 6, 1912). The keynote of the treatment in each method is flexion of the spine, as in that position the vertebræ are unlocked. Partial correction is secured by means of bandages pulling in various directions and, after proper padding, a plaster jacket is applied. Further progress to overcorrection is continued by means of pads of felt slipped under the jacket to increase the pressure in certain directions. After overcorrection has been obtained, a celluloid jacket is worn to maintain this and exercises are assiduously employed to restore muscle function. These methods of treatment constitute the greatest advances in this work in many

years, but to secure the best results they must be followed out most carefully by a skilled physician. Special forms of apparatus are essential in the application of these jackets. The combination of the gymnastic and mechanical treatment in severe functional and in organic scoliosis proves the most satisfactory in that it not only restores muscle balance, but also corrects deformity, and secures as great correction of the deformity as possible before ankylosis occurs. Any appliance used in these cases should be made to order to fit the peculiarities of the patient and should never be one of the shop-kinds that are so extensively advertised. Much valuable time is often lost while unmechanical and unsuitable apparatus is being used, during which time the bony changes may become permanent and beyond repair.

Anteroposterior curvature (not from spinal caries or from hip-joint disease) is an increase of the normal anteroposterior curves. Increase of the dorsal curve is *posterior curvature, kyphosis*, or *excurvation* (Fig. 655, A); increase of the lumbar curve is *anterior curvature, lordosis*, or *saddle-back* (Fig. 655, B). Both lordosis and kyphosis are apt to be present. Scoliosis has nearly always some anteroposterior curvature associated with it. Lordosis is apt to be compensatory to prevent the center of gravity going too far forward. Lordosis is always found in pregnant women and in very fat men. In an old man kyphosis arises because of flattening out of the vertebral disks from pressure. Rheumatic gout may cause anteroposterior curvature. Anteroposterior curvature is often due to paralysis of the erector spinæ mass (from infantile paralysis). Pseudohypertrophic paralysis causes lordosis.

Symptoms and Treatment.—The *symptoms* of anteroposterior curvature are as follows: the thorax is flattened, or *pigeon-breasted;* the shoulder-blades are widely separated and the scapular angles project; the abdomen is protuberant; the patient complains of backache and soon tires. A recent kyphosis disappears when the patient lies upon his stomach. The facts that the erector spinæ muscles are soft and that pain is absent on concussion transmitted to the back separate kyphosis from caries. Lordosis is unmistakable. When the spine is movable, employ the same plan of *treatment* as in lateral curvature, suiting the gymnastics to the deformity. In painful kyphosis with partial ankylosis endeavor to make the ankylosis complete in order to prevent pain, obtaining this result by applying a plaster jacket which laces up and letting the patient wear it for several years.

Angular curvature (*spinal caries; spondylitis; Pott's disease*—Fig. 656) is usually due to tuberculous caries of the vertebral bodies, and occurs particularly in children who are the victims of tuberculosis, but it may arise at any age. Any portion of the spinal column may be attacked. The dorsolumbar region is most prone to suffer. The chief *cause* is tuberculosis, but syphilis and secondary cancer of the vertebræ are occasional causes, and acute osteomyelitis is a very rare cause (see page 801). Blows or sprains appear to have a causal influence in some cases (see Trauma in Tuberculosis, page 156). Angular curvature may develop after an exanthematous fever.

The cancellous tissue of the anterior portion of the vertebral body becomes primarily carious, or the inflammation begins in an intervertebral disk. The changes of tuberculous osteitis have previously been set forth (see pages 179, 452, and 582). The body of the vertebra and the vertebral disk are destroyed gradually, and the process extends to adjacent vertebræ. The weight which rests upon the spinal column causes softened bone to crumble, compresses the diseased vertebræ and disks, and produces angular deformity (the anterior part of the column formed by the vertebral bodies is shortened, the posterior part is not, and hence the spines project). In some cases the disease is spontaneously arrested by organization of inflammatory products, and ankylosis (fibrous or bony) in deformity is Nature's cure. In most cases, however, the disease spreads and caseous pus is formed, which, according to the point of formation and the route it takes, causes lumbar abscess, dorsal abscess, psoas abscess, or postpharyngeal abscess (see pages 171, 172). In some cases the spinal cord is compressed, but in most cases it is not, and even when it is compressed paraplegia is rare and is usually temporary. Compression of the cord may be caused by the displaced vertebræ, by inflammatory material or caseous matter between the bone and dura mater, but is most often due to pachymeningitis. Caries of the cervical region constitutes a more dangerous disease than caries of either the dorsal or the lumbar region (*dangerous* pressure may occur there). Death may be caused by exhaustion, sepsis, hemorrhage, amyloid disease, pneumonia, peritonitis, pleuritis, tuberculous dissemination, pressure upon the cord, or inflammation of the cord or its membranes.

Symptoms.—The sufferer from Pott's disease, if a child, grows tired easily. The disposition alters. The victim becomes weak, sickly, moody and irritable, and com-

plains of vague pains in many places, and is disposed to lean, rest, or lie down, suffers on movement, but is easy when at rest. The child walks with the back rigid, which produces a peculiar gait. Examination may disclose evidences of pulmonary or glandular tuberculosis. A painful spot may be found by pressing upon the spines. Faradism to the back causes pain. Spasm of the erector spinæ mass is detected (Hilton, Golding-Bird). It is not proper to seek to develop pain by jarring the back or by pressing the head downward. The posture of the child and the muscular rigidity prove the existence of inflammation, and to seek to develop pain by the methods referred to may do harm, and at best can only call attention to what is already known. Pain in the back, which is increased by motion, by pressure, and by vertebral jars, may be absent until late in the case. Distinct pain and tenderness in the back often mean abscess formation. Neuralgic pains pass into distant parts (sciatica, intercostal neuralgia) and are often linked with muscular spasm. A chronic bilateral pain in the trunk or extremities is suggestive of Pott's disease. "Chronic bilateral bellyaches in children are almost diagnostic" (Jordan Lloyd). The pain of dorsal caries can be relieved by lifting the shoulders; the pain of cervical caries, by traction on the head. Cramp in the legs occurs in dorsal and in lumbar caries. The presence of the knuckle due to bending the spine at an acute angle is a very important sign of the disease. In many cases angular deformity appears late; in some cases it does not appear at all. An angular deformity is detected sooner in those regions where the normal curves are posterior than where the normal curves are anterior. The deformity appears early in the dorsal region, but late in the cervical and lumbar regions. In many cases lateral deformity occurs. Rigidity is an early sign of great importance. It is always present. Rigidity is manifest very early in cervical caries, tolerably early in lumbar caries, late in dorsal caries. Jordan Lloyd gives the following practical rules to enable us to detect rigidity.[1] In the cervical region: seat the patient in a chair and tell him to nod the head affirmatively. Stiffness in nodding points to occipito-atloid disease. Tell him to look far to the right and then far to the left. Stiffness of these motions suggests atlo-axoid disease. Tell him to place his shoulders against the back of the chair and carry his eyes back along the ceiling. Stiffness in this movement indicates disease below the second cervical vertebra. It is practically useless to examine the dorsal region of an adult for rigidity, but such an examination can be made in a child. Place the patient prone on an adult's lap, mark the tip of each spinous process with an anilin pencil, then make the child stand up straight on the floor, and observe if any of the pencil marks fail to come nearer together. If it is seen that two or more marks do not approach each other, there is rigidity which prevents approximation. To test for rigidity in the lumbar region lay the naked patient prone upon a couch. Grasp the patient's ankles and raise the pelvis from the couch. If the lumbar spine is flexible, the pelvis can be lifted without raising the chest from the bed, and the maneuver deepens the hollow of the loin. If the lumbar spine is stiff, the movement lifts the trunk and produces no alteration in the vertical outline of the lumbar spines. If a child with Pott's disease is asked to pick up something from the ground, because of rigidity or pain on movement he will not bend the back, but will bend the knees or get upon the knees. Paralysis may exist, and it is due to pachymeningitis more often than to pressure from bone. Cervical caries causes dyspnea and torticollis, the head requiring support with the hands. Dysphagia indicates cervical abscess. In adults the first signs of Pott's disease to attract attention are headache, backache, neuralgia, girdle pain, cramp, or even paralysis. In abscess due to caries of the dorsolumbar vertebræ the pus usually enters the psoas muscle and passes out of the pelvis below the junction of the middle and outer thirds of Poupart's ligament. It may point here or may pass to the inner aspect of the thigh and point a little below the spot where a femoral hernia is met with if it exists. In a psoas abscess a mass is always felt in the iliac fossa above Poupart's ligament; in a hernia no such mass exists (J. T. Rugh). In sacral caries there is no deformity and frequently no pain. The diagnosis becomes apparent when bilateral abscess is detected in the buttocks or groins (Jordan Lloyd). If an abscess due to spinal caries opens spontaneously, sinuses form and persist, there will be free discharge of tuberculous pus containing tubercle bacilli, and healing will not occur. The *x*-rays will usually show some large sequestra. If mixed infection takes place death may follow.

Treatment of Caries of the Spine.—When recent caries of the spine is active and affects a child; when it is accompanied by pain and fever, and when paralysis threatens, insist upon perfect rest. Place the child supine on a hard mattress, and, if possible, take it, while in a portable bed, out of doors daily. Leeches, blisters, or the hot iron

[1] "Birmingham Med. Review," April, 1897.

over the area of pain may do good. When the activity of the process abates, apply a fixation apparatus. In diseases at or near the vertebro-occipital articulation, as long as dyspnea persists, keep the patient supine with a small hard pillow under the nape of the neck (Hilton) and a sand-bag on each side of the head and neck. After several months mechanical support can be given by Furneaux Jordan's method. Jordan applies his support as follows: The patient lies on a flat, hard table, his arms are raised above his head, and traction is made upon the head by means of a pulley and a weight. Cotton pads are placed over the ears, the back of the neck and the clavicles, and are held in place by a broad flannel bandage applied as a figure-of-8 on the head, neck, and chest. The flannel bandage is overlaid with plaster-of-Paris bandages.[1] In disease of the cervical region below the axis, or of the dorsal region above the seventh vertebra, use Sayre's jury-mast (Fig. 658) or some other form of head support. Instead of the jury-mast a steel upright may be used to hold the head rigid. Sayre's appliance relieves the spine from the weight of the head and acts admirably. In most cases of dorsal and lumbar caries a steel, leather, or plaster jacket as a fixation apparatus must be employed. The best of all fixation apparatus is Sayre's plaster-of-Paris jacket applied while the patient is suspended (Fig. 657) or, better, while the column is in hyperextension. The Sayre apparatus applied in this manner is used for the treatment of caries of the lumbar region and the lower half of the dorsal region, or a plaster jacket may be applied while the patient is lying prone in a hammock or stretched between two tables.



FIG. 657.—Plaster-of-Paris jacket (Sayre).



FIG. 658.—Plaster-of-Paris jacket and jury-mast applied (Sayre).

Greater corrective pressure over the deformity is secured by thess methods than by suspension. When all subjective signs cease, substitute for the plaster-of-Paris jacket a felt or sole-leather jacket which laces down the front. Caries of the upper half of the dorsal region is often treated by a Sayre jury-mast (Fig. 658); but if the jury-mast fails, it may be necessary to place the patient horizontally in "an open cuirass, fitted to the back from occiput to sacrum, and combined with pulley extension to the head and pelvis."[2]

During the course of caries of the spine have the patient eat fat-forming and nutritious food, insist on a plentiful supply of fresh air day and night, and administer tonics. Full antituberculous treatment is imperative (see page 162). Sea-air and heliotherapy are very beneficial. When all active disease ceases and only angular curvature remains, use an apparatus to combine extension with mechanical support, the plaster jacket being generally employed.

Albee's Bone Transplantation Method of Treatment.—The ordinary ambulatory treatment of Pott's disease is seldom satisfactory. It is particularly unsatisfactory in the upper dorsal region. Ridlon and Robert Jones emphasize this fact and declare that when the disease is situated in that region only prolonged recumbency prevents increase of the deformity. Albee reached the conclusion that the treatment should be

[1] See "Children's Deformities," by Walter Pye.

[2] Jordan Lloyd in "Birmingham Med. Review," April, 1897.

one which secures bony union and hence complete immobility. Perfect bony fixation means cure.

Albee was accustomed to see perfect cure in hip tuberculosis after ankylosing the joint, and in knee tuberculosis after erasion. He has secured a like result in vertebral caries by grafting into the spinous processes a large piece of bone cut from the patient's tibia. This graft usually becomes fixed to the spinous processes. It at least unites with the surrounding ligamentous structures and gives unyielding support which produces cure, see page 828 (Albee in "New York Med. Jour.," March 9, 1912; in "Post-Graduate," Nov., 1912).

Beyond question this is a very valuable method. The mortality is extremely low. The fixation is secured within a year (other methods require several or a number of years). The diseased area undergoes cure. An abscess usually disappears without being opened, and in most cases all manipulations are carried out on healthy tissue (J. T. Rugh in "Amer. Jour. Orth. Surg.," 1916, xiv).

Spinal abscesses are treated as indicated on pages 171 and 174.

Paralysis in Pott's Disease.—Partial or complete motor and sensory paralysis may develop in the course of vertebral caries. It may be due to the pressure of tuberculous material or to pachymeningitis with thickening of the membrane. In only 2 per cent. of cases is the paralysis due to the pressure of angled bone (Willard). The paralysis may come on gradually. There are weakness in walking or actual inability to walk, exaggerated reflexes, muscular rigidity, impaired sensation in the legs, and loss of control of the bladder and rectum. Caries in the high dorsal region is more apt to result in paralysis than in any other region because of the small size of the spinal canal. Pressure in the cervical region is highly dangerous.

Treatment.—We must remember that angulation is the rare cause, tuberculous masses the common cause. Treatment for paralysis due to tuberculous masses is the full open-air and sunlight treatment of tuberculosis, with rest, fixation, and progressive straightening of the spine. The patient is kept in bed (see Treatment of Tuberculosis, page 162) on a Bradford frame and with his head overextended. If after one year the condition is not notably improved, do laminectomy and clear away tuberculous masses. If angulation is the cause of the paralysis, consider gradual correction, laminectomy, and Albee's bone transplantation. In several of the cases reported by Albee recovery from paralysis occurred soon after bone-grafting.

Gradual Correction of Angular Deformity.—Pressure is made upon the hump with the hand, and while the hand is thus held the weight of the body is allowed to bear upon it above and below. Something is perhaps gained after a time, and then plaster-of-Paris is applied, somewhat later a little more gain is obtained, and so on. This method is safer and more satisfactory than forcible correction.

Forcible correction of angular deformity was advocated by Chipault and Calot in cases of Pott's disease without abscess. It was only used in angular deformity of the middle and lower part of the dorsal region and was not advised in the cervical, upper dorsal, or lumbar regions. The operation is not safe, and a number of deaths have been reported. Gabaert[1] pointed out certain disasters which might follow forcible correction; they are: death during anesthesia; rupture of an abscess; subsequent paralysis of the legs and bladder; disseminated tuberculosis and shock, with convulsions and death. I do not believe in forcible correction, and I do believe that the alleged dangers are real dangers, that the operation is unsafe, and that it should never be done.

Laminectomy is warmly advocated by some surgeons for paraplegia from spinal caries. This operation is rarely necessary, but in some few cases it is imperatively demanded. Many cases recover from paraplegia without operation. Operation for paraplegia has a very heavy mortality (25 per cent.), and many are not benefited at all by it. If degeneration of tracts in the cord has occurred, operation cannot help the paralysis. Nevertheless, in some cases laminectomy has certainly cured palsy and saved life. Menne has collected 132 cases of laminectomy. Of these, 56 per cent. were cured or permanently improved and 18 per cent. were temporarily improved.

Laminectomy should not be undertaken until treatment by rest, fixation, and extension has been applied for at least one year. Laminectomy may become necessary in cervical caries to prevent asphyxia. The operation enables the surgeon to remove masses of inflammatory material which make pressure on the cord, and also lets him free the cord from pressure due to angulation. The dura should not be opened unless there is evidently trouble beneath it, in which case it is incised and any tuberculous area removed, the dura being subsequently sutured. Ménard removes the transverse

[1] "Ann. de la Soc. Belge," July 15, 1898.

process of the diseased vertebræ and the heads and necks of the associated ribs in order to give the surgeon access to diseased vertebral bodies.

Spondylitis Deformans (*Bechterew's Disease*).—This is the name usually applied to osteo-arthritis of the spine (see page 603). In this disease osteophytic formation takes place at the vertebral borders, and the vertebræ become ankylosed. The vertebral bodies, as a rule, are most affected by the disease, but any portion of a vertebra may be attacked, and often the heads of the ribs are anchored to the spine by bone.

The disease may begin in infancy, childhood, youth, adult life, or old age.

Symptoms.—There are decided and persistent pain and tenderness of the spine, and occasionally evidence of pressure on the nerve-roots. Early in the case deformity is apt to occur, because at this period there is inflammatory softening.[1] The deformity is not angular, but is usually a total kyphosis, the column being bent forward from above and forming a single curve. Lateral curvature may occur. In many advanced cases and in some comparatively recent cases the spine becomes rigid and ankylosed, and when it does, there may be evidences of irritation of the posterior nerve-roots. In this condition there is rigidity of part or of the entire spine, other joints escaping. If the entire spine is involved, there is rigid cervicodorsal kyphosis, a condition which causes the neck to stick forward and the head to appear as if forcibly driven down between the shoulders. If the entire spine is involved, the lumbar spine is rigid and the normal lumbar curve disappears. As a consequence the patient stands in an unnatural attitude, the hips and knees being partly flexed, and the legs and feet being in a condition of external rotation. In Bechterew's disease there are compression of the posterior nerve-roots, severe pain, muscular atrophy, and ascending degeneration of the cord. What Marie calls *spondylitis rhizomelique* is said by Osler to be a form of arthritis deformans. There is rigidity of the spine, shoulders, and hips, but no nervous lesions, as in Bechterew's disease.

Treatment.—Cure is impossible, but amelioration can be obtained.

The local and constitutional treatment is as for osteo-arthritis in any region (see page 601). If spinal curvature begins, a mechanical support must be applied or Albee's bone-grafting operation should be performed. Rugh operated on such a case with gratifying results ("Internat. Clinics," vol. i, Twenty-third Series). So did Finkelstein ("Annals of Surgery," 1916, lxiv).

Injuries of spinal ligaments and **muscles,** which may complicate more serious injuries or may exist alone, are caused by wrenches, twists, and violent muscular efforts (as in lifting). Railway accidents may be responsible for these sprains and strains. The injury is called *railway spine* when it is caused by a railway accident.

Symptoms.—Injuries of the back, even without cord injury, are frequently linked with very deceptive nervous symptoms, hysteria, and neurasthenia (see below). Symptoms are often severe, but are usually temporary. In some few cases the symptoms are persistent. Secondary disease of the cord is extremely rare. Any region may be affected, but the lumbar is most usually injured, and the entire spine may suffer. The three marked symptoms are pain, tenderness, and stiffness of the back. At the time of injury and for a while after there is often marked shock, and hysteric excitement is occasionally observed. The cardinal symptoms may arise very soon, but may not become severe for a day or two. The pain is not acute when at rest, but becomes acute on movement.[2] The pain is felt in the back and sometimes darts into the extremities. The muscles of the back are rigid, the spasm being due to pain. The patient is very careful not to twist or bend the spine, because to do so increases pain. In a one-sided injury the rigidity is unilateral, and this symptom cannot be simulated. Often, but by no means always, the region of the back is swollen and the skin is discolored. The tenderness is not of the skin, but of the muscles. Firm pressure on a spot of real tenderness causes rapid pulse (*Mannkopf's sign*). The vertebral spines are regular and are not mobile. There is no distant paralysis or hyperesthesia unless the cord is damaged (though in some rare cases the bladder and the rectum are paralyzed when no cord lesion can be detected, and hyperesthesia may exist over the spines). Moullin tells us that the extremities feel weak because they are deprived of proper support on account of the immobility of the muscles of the back. For the same reason the action of the abdominal muscles is interfered with, and the power of micturition and of defecation is impaired (there are constipation and difficulty in emptying the bladder).

The **treatment** of recent injuries comprises rest, the application of an ice-bag,

[1] J. Jackson Clarke's book on "Orthopedic Surgery."

[2] Moullin on "Sprains."

and leeching over the painful area. After a day hot fomentations, tincture of iodin, compression by adhesive strips, and inunctions of ichthyol and lanolin are used; and, later still, massage, douches, and frictions with a stimulating liniment are employed. Phenacetin helps to relieve pain, though in some cases opium is temporarily necessary.

Traumatic Spondylitis (*Kümmell's Disease*).—Many doubt if this condition is a clinical entity. It was described as such by Kümmell, of Hamburg, in 1895. An injury of the spinal column by direct or indirect force is supposed to cause rarefying osteitis of the bodies of one or two vertebræ. After a time the vertebral body collapses as it does in Pott's disease, and the intervertebral disks may become compressed. The force may be slight or so violent as to contuse or crack the body of the vertebra. For a brief time after the accident the patient is laid up. He then returns to his work. After he has been at work for from two months to two years or more he begins to suffer from pains in the extremities, intercostal neuralgia, weakness of the legs, uncertainty of gait, and spinal tenderness and rigidity. Examination discloses kyphosis. An *x*-ray picture makes the vertebral collapse evident. The condition is not to be confused with Pott's disease, ankylosing spondylitis, hypertrophic osteo-arthritis, traumatic neurasthenia, or hysteria. I have seen 2 supposed cases involving the neck. Both turned out to be tuberculosis.

Treatment.—A brace or a plaster-of-Paris support. In severe cases insert a bone-graft to secure ankylosis. Fosdyck Jones has recently written on Kümmell's disease ("Jour. Amer. Med. Assoc.," Jan. 1, 1923).

Traumatic neurasthenia, a not very uncommon condition, arises after the *immediate* effects of the accident subside. There is not any organic lesion which is causal. It is not due to organic disease, but results from fear, worry, apprehension, anger at a corporation or person supposed to be responsible for the condition, and perhaps the suspense of litigation. It may occur after a railroad accident, even when the person was not injured physically. Shell shock (or war neurosis) may exhibit it. The severity of an injury is not a gage of the degree of neurasthenia. There may be no neurasthenia after an amputation of a leg and deep neurasthenia after a mere twist of the back. The condition is most apt to arise after a blow upon the head or a twist of the back, but it may follow an injury in any region, or may arise without any injury at all. It is one of the possible consequences of cerebral concussion. It is most apt to arise in those of neurotic heredity. The victim suffers from the "*anxiety neurosis.*" There is more or less headache in the form of a band about the head or pressure upon the vertex. The patient grows tired very easily and complains of inability to concentrate the mind, vertigo, pain, and usually tenderness at the alleged seat of injury, weak and hesitating voluntary movements, and pains and aches in the back and loins, interfering with or preventing work. Paresthesia and numbness may exist in the extremities, and in many cases sexual intercourse is impossible because of premature ejaculation or of incapacity for erection. There are dyspepsia, eye-strain, vertigo, tremor, insomnia, impairment of memory, rapid and irregular pulse, elevated blood-pressure, flushes of the face, cardiac palpitation, and mental depression or confusion. The reflexes are usually exaggerated, but they can be exhausted more easily than can the exaggerated reflexes of organic cord disease (because of irritable weakness). Some rigidity and tenderness exist in the back, and the skin over this region is often hyperesthetic. Attacks of retention of urine may occur. Hypochondriasis is not unusual. Buzzard ("Lancet," Dec. 15, 1923) points out that the spinal form of neurasthenia is usually linked with the anxiety neurosis, arises after injury of the back, or effort lumbago, is accompanied by tenderness over most of the spine, and that the patient has a characteristic attitude when walking. In Buzzard's words: "The patient invariably walks into your room leaning on a stick in one hand, with the dorsum of the other placed over the lower part of his back." There are no evidences of organic disease. Arteriosclerosis predisposes to neurasthenia and neurasthenia aggravates sclerosis. It is probable that the ductless glands play a part in neurasthenic states. The prognosis is much better in the young than in the elderly, as the former are free from arteriosclerosis (Doré in "N. Y. Med. Jour.," Sept. 9, 1916).

Treatment of Traumatic Neurasthenia.—Employ rest, tonics, suggestion, massage, douches, and frictions to the back. Secure sleep, and endeavor to bring about a gain in weight. If sexual incapacity or seminal emissions worry the patient, dilate the urethra with steel sounds. Some cases get well with marvellous rapidity on the termination of a litigation, even when the verdict went against them. Symptoms which thus disappear have been called *litigation symptoms.* Such a person is not of necessity a

fraud. The fear of the court room, the apprehension of a severe cross examination, the common antipathy to the law and lawyers may have served to aggravate the condition. When the suit ends grave worries pass away. Certain it is that persons who do not sue or who have no claim to press recover sooner and more easily than do those caught in the litigation trap.

Traumatic hysteria develops chiefly in those predisposed by a neuropathic hereditary tendency; traumatic neurasthenia may arise in any one. In the first named disease the accident is only the *exciting* cause; in the second disorder it is the cause. Youths and adults, women, Jews, Celts, and Latins are most liable to hysteria. Many cases of so-called "railway spine" are really examples of traumatic hysteria. Traumatic hysteria and neurasthenia may be associated. Neurasthenia is a condition of exhaustion associated with a number of chronic disorders; it forms a foundation on which hysteria is apt to build its structure. The structure of hysteria is made up of morbid impressionability to suggestion, hyperesthesia of nerve centers, lessened self-control, and increased sensitiveness of the peripheral nervous system. The accident plays a double part in producing traumatic hysteria—first, by its effect on the mind (psychical traumatism); second, by its effect on the body, which anchors the attention to one point. An area of pain or stiffness often serves as an autosuggestion which undergoes morbid magnification when viewed through the distorting medium of hysteria. Erichsen taught that the symptoms of what he named "railway spine" arose from inflammation of the cord and its membranes, a view now abandoned. A blow given to a hysteric person causes a feeling of numbness, and thus negative sensation from local shock may establish the idea of paralysis; or traumatism, acting as a suggestion, may inhibit motor representations, and destroy the normal ideas of motion and feeling (Charcot and Pitre). Terror always causes a feeling of loss of power in the legs, and the terror of the accident may thus develop the idea of paraplegia. The site of a traumatism may localize symptoms; for instance, a blow upon the eye may cause amaurosis or blepharospasm. It is important to remember Charcot's saying that a hysteria long latent and unrecognized may be awakened into obvious activity by a blow or an accident. Pitre shows the same to be true of epilepsy. The mental condition of a hysteric is composed of loss of emotional control, abnormal suggestibility, and concentration on self. Certain forgotten affairs of life, long relegated to the domain of the subconscious, take on associations and establish conflicts which damage mentality. Such concepts may at times come into consciousness, particularly during dreams. Hysteric palsy may be flaccid (imitating disease of the lower neuron) or spastic (imitating disease of the upper neuron). Although muscles waste, there are no reactions of degeneration. In hysteric spastic paraplegia Babinski's reflex and ankle-clonus are absent. A not unusual lesion is hysteric traumatic monoplegia, not coming on at once after the accident, but usually some days afterward, and presenting flaccid muscles, the electric reactions and reflexes remaining normal, but the muscular sense being lost (Pitre). The muscles usually waste. The skin of the paralyzed limb is anesthetic or analgesic. There may be anesthesia limited to a limb or part of a limb, hemianesthesia, or general anesthesia.[1] The edge is sharply defined. Hysteric paralysis is usually associated with the permanent *stigmata of hysteria*—concentric contraction of the visual fields, pharyngeal anesthesia, convulsive seizures, and hysterogenic zones (Clarke and Pitre). The permanent stigmata may be latent. Hysteric phenomena lack regularity of evolution, and they may be produced, altered, or abolished by mental influences or by physical forces which produce no effect on organic disease. In most hysteric conditions the general health is not profoundly impaired.[2] In making a diagnosis of hysteria we must be most careful to exclude malignant disease, organic disease, and imposture, because hysteria is a sort of diagnostic waste-basket into which we cast most things which we fail to understand. Babinski proposes that we should call phenomena hysteric only when they can be produced or can be cured by suggestion ("Brit. Med. Jour.," Jan. 23, 1909, p. 234). Brain tumor may cause hysteric symptoms. Hysteric paralysis or anesthesia imitates, but not accurately, an organic lesion. It does not correspond to any nerve or plexus.

The constant strain, the exhaustion, the expectancy, the homesickness, the privations, the exposures of war are responsible for many cases of hysteria. Many arise in those who have been wounded. In others who have not been wounded and may have served long and gallantly, the overtense strings of the nervous system may seem to relax suddenly or snap asunder. Many cases have been reported in men who

[1] J. Mitchell Clark in "Brain."

[2] Read the works of Thorburn and Pitre.

were near a shell explosion but yet received no obvious physical injury, although it is always necessary to bear in mind that even if no organic injury presents symptoms which permit detection there may be multiple hemorrhages of the brain or of the brain and cord. Hysteria arising in men on the fighting front is called war hysteria or *war shock*. Many writers have called it *shell shock*, a very incorrect term because it implies that all cases are due to shell explosions. We know that many cases result from the numerous strains and depressions of war. If phenomena so induced are purely hysteric they are recovered from entirely. If they have an organic basis, as they may have when induced by the detonation of a high-explosive shell, the patient does not recover completely. We are not justified in regarding bleeding from the ears after a shell explosion as in any sense proof of basal fracture. An explosion may rupture the ear drums and thus cause bleeding. In war shock strange temporary conditions arise; among them are: deafness, dumbness, blindness, convulsions, monoplegia, hemiplegia, paraplegia, states resembling cerebral concussion, symptoms of neuritis, zones of anesthesia, muscular contractures, delirium, mania, tremor, and anterior spinal curvature (Rosanoff-Saloff in "Nouvelle Iconographie de la Salpétrière," No. I, 1916–17).

Treatment is by moral means chiefly. Gain the confidence of the patient. Suggestion is of great value. So is discipline. In many cases separation from family and friends is necessary and isolation is desirable. The Weir Mitchell rest-cure is often the best plan of treatment, and all its details should be carried out faithfully. It is said by some that cases of war shock are best treated in military hospitals, that is, in an environment of discipline. When so treated they get well. If discharged from the service they may spend their days on endless pilgrimages from clinic to clinic.

Malingering.—Persons often pretend to suffer from maladies of the spinal cord or column as a result of accident when no diseases of those parts exist. Some get well upon the rendering of a favorable verdict by a jury (**litigation backs**). In any case always examine carefully, so as to be able to exclude malingering. Note the patient's behavior and motions when his attention is diverted from his disease. *Meningomyelitis* can be excluded if there be no spasm, paralysis, hyperesthesia, paresthesia, or anesthesia at a distance (A. Pearce Gould). If pain has lasted for months; if pressure downward upon the head or shoulders does not increase pain; if the vertebræ are movable and there is no angular displacement, exclude *caries*. Caries is shown by the *x*-rays. Gould states that when there are wasted muscles, when moderate spine movement is painless, but effort in bringing the body erect causes pain in the erector spinæ region, the trouble is a *strain of the erector spinæ muscle*. If the muscle is not wasted and the pain is in bending forward rather than in straightening up, the *vertebral ligaments* are the seat of trouble. Unilateral spasm cannot be simulated. The administration of ether may dispose of a pretended paralysis, the patient moving the suspected extremity while drunk from the anesthetic. Naturally cases of simulation are encountered by army and naval surgeons. Marie ("Brit. Med. Jour.," Aug. 14, 1915) divides supposed hysteric patients into two classes: 1, Unconscious simulators. This class includes neuropaths and victims of hysteria and traumatic hysteria. 2, Exaggerators who have really been wounded, but who multiply and magnify their troubles and in so doing commit "physiologic solecisms."

Anosacral Cysts.—These cysts develop between the sacrum and rectum and originate from remnants of the postanal gut and neurenteric canal. Such cysts may be multilocular or unilocular. They can be detected by a finger in the rectum.

Treatment.—Some of these growths are removed after osteoplastic resection of a portion of the sacrum; others are removed by incising the rectal wall.

Concussion of the Spinal Cord.—This term has no definite pathologic meaning. It is probable that there is such a condition, but, as a rule, the so-called concussion is laceration or contusion of cord substance or capillary hemorrhage. The temporary motor and sensory paralysis and impairment of reflexes so often noted after injuries of the vertebral column is said to be due to *spinal shock*. The term signifies a real clinical condition, but the nature of the underlying pathologic state is unknown.

The **symptoms** are shock, intense pallor, nausea, often vomiting, and sometimes syncope. With this condition special symptoms may be linked—as temporary paralysis, a girdle sensation, numbness and loss of power in the limbs, hiccough, torticollis, coarse tremors, pains in the back and limbs, areas of anesthesia and analgesia—depending on the portion of cord lacerated.

The **treatment** is to bring about reaction and then treat the same as a sprain. Traumatic neurasthenia and hysteria or organic cord disease may follow this injury.

Contusion of the spinal cord may arise from a blow or a sprain, but it is usually due to extreme flexion of the spine. It causes hemorrhage into the gray matter of the cord (*hematomyelia*). The symptoms are motor and sensory palsy and diminished reflexes. Some cases recover, but others end in myelitis.

Wounds of the spinal cord are rare and are very dangerous. A knife is sometimes thrust in between the occiput and atlas. Wounds above the origin of the phrenic nerves cause almost instant death. Gunshot wounds are the most usual form, the cord being damaged by the bullet and by bone fragments.

In the American Civil War gunshot injuries of the cord were very rare ($\frac{1}{4}$ of 1 per cent. of all wounds), but at the present day in war they represent a considerably greater percentage of all wounds, the increase in frequency being due to the increased penetrating power of the modern military bullet. The mortality is at least 60 per cent.

A revolver bullet or a small-caliber bullet fired at long range may produce vertebral fracture without cord injury, and any bullet may fracture a process of a vertebra without cord injury. If the laminæ are fractured the cord is almost sure to be injured. The cord may be concussed, lacerated, or cut across by bone or bullet, or compressed by bone or blood. The bullet may lodge or may perforate. The symptoms depend on the extent of cord damage. Paralysis of sensation and motion and reflex impairment are noted below the injury. The Brown Séquard syndrome results from hemisection of the cord (page 823).

Treatment.—In a suspected gunshot wound of the cord excise the wound in the soft parts, perform exploratory laminectomy, arrest hemorrhage, and relieve pressure if bone is depressed. If a bullet or a bone fragment is lodged, remove it. I operated upon a young man who was shot accidentally twenty years before and who had had complete flaccid paraplegia and paralysis of the bladder and rectum all that time. He sought help because of violent pain in the abdomen and back. The *x*-rays showed a bullet within the canal and in front of the cord. He was operated upon in the Jefferson Hospital. The bullet was found outside of the theca and was removed. It had passed forward between the bone and the theca. In a few weeks spastic paraplegia replaced flaccid paralysis. He lived several years, gaining power slowly all the time, and regaining control of the bowels and bladder. He died of an intercurrent malady.

Injuries of the Spinal Cord in War.—Injuries of the cord as seen in civil practice are usually due to a wide application of violent force (crushes, caving of embankments or roofs of coal mines, falls of masonry, railroad accidents, etc.). The resulting lesion of the cord is extensive, and in most cases operation is of no avail. "In gunshot wounds, on the other hand, a larger proportion of incomplete injuries is seen, and these are due to small missiles which though they hit the spine, do not often make a direct hit upon the theca" (D. M. Hughes in "Brit. Med. Jour.," March 9, 1918).

If the theca should be struck directly by the missile or by a fragment of bone a complete lesion will almost certainly be produced or ensue.

There will be flaccid palsy, absent reflexes and loss of sphincter control. When the cord is exposed by the surgeon the laceration is usually evident, though damage which is not visible exists far wide of the lesion. Occasionally a cord appears uninjured when it has been damaged beyond hope of recovery. Hughes (Ibid.) points out that in incomplete injuries the theca has not been penetrated by bone or bullet and that the resulting paraplegia may be "transitory and flaccid, but apparently complete"—may be for a time flaccid and become spastic—may not appear until after an interval.

The condition may be due to concussion or contusion of the cord, to hemorrhage, to pressure of bone or bullet and later to pus. If a bullet is lodged within the spinal canal it is apt to cause dreadful girdle pains. In cases in which there is persistent palsy or violent girdle pains, or spastic palsy, operation is necessary. Lodged missiles must be removed. Sepsis requires appropriate treatment. When an operation is performed excise the wound.

In but few cases is there recovery of function. Urinary and pulmonary complications are prone to develop. Gray ("N. Y. Med. Jour.," 1918, cvii) points out that local concussion may cause extensive palsy, but it will begin to clear up in a few days.

Compression of the spinal cord may be due to blood or to inflammatory exudate, as well as to displaced bone (see page 821). Hemorrhage within the spinal canal (**hematorachis**) may be outside of the dura or within the dura. Epidural hemorrhage can cause compression symptoms, but seldom does so. Intradural hemorrhage between the dura and the arachnoid causes root symptoms, viz., muscular rigidity, severe shooting pains in the extremities, girdle pain and a zone of hyperesthesia.

Incomplete paralysis and urinary troubles may develop. In subarachnoid bleeding fluid obtained by lumbar puncture is bloody. In rare cases subarachnoid hemorrhage becomes walled off and causes compression. Paralysis from intradural bleeding may be a *crawling paralysis*, one which gradually ascends.

Hematomyelia (*intramedullary hemorrhage*) is hemorrhage into the substance of the cord. It may be small in amount, there may be multiple areas or a large portion of the transverse area of the cord may be involved. In most cases the blood is limited to the gray matter. One segment, two segments, or several segments of the cord may suffer. The symptoms depend on the portion of the cord involved and the area of the damaged part. *Intramedullary* hemorrhage causes pain, a girdle sensation, abolition of reflexes, and paralysis. Spasms, rigidity, and paralysis come on early. Bed-sores may form, and retention of urine and incontinence of feces may be observed.

Treatment.—Most patients with epidural hemorrhage recover without operation. In some operation is necessary to arrest bleeding or relieve pressure. In an operation always open the dura for exploration. If paralysis from intradural bleeding extends rapidly and life is endangered through the probable involvement of a vital center, perform a laminectomy, remove the clot, and arrest hemorrhage. Usually bleeding will be found to have ceased. If not, it can be arrested by sutures or by packing. If an intradural clot is extensive it is proper to make a second laminectomy near the lower end of the spinal column in order to permit the surgeon to wash it out thoroughly. The dura must be sutured and drainage is to be employed. Operation for hemorrhage into the cord substance is usually useless. If there is paraplegia, complete anesthesia of the paralyzed parts, and entire abolition of the deep reflexes, operation is probably useless, but it is justifiable to try it because of a possibility that the cord has not been completely divided. In some cases with persistent paraplegia the operation should be undertaken. If operation is not undertaken, have the patient lie upon his side, apply an ice-bag to the spine, and give morphin hypodermically. To promote absorption of the clot and exudate give a combination of carbonate and acetate of ammonium, order pilocarpin, and employ spinal galvanism and hot douches. Iodid of potassium may be given.

Fractures and **dislocations of the spine** are very rare. The spinal regions most liable to injury are the atlo-axial, the cervicodorsal, and the dorsolumbar (Treves). A vertebra may be fractured alone, but dislocation without fracture, except in the upper cervical region, very rarely occurs. These two lesions, dislocation and fracture, are so often associated that the term *fracture-dislocation* is used by many surgeons to include them both.

Pure dislocations, that is, complete separation of one or both articular processes, have been demonstrated, although in most cases there is associated fracture of a process or of the body (fracture-dislocation). Frazier ("Surgery of the Spine and Spinal Cord") says in 100 cases of injury to the spinal column there were 60 cases of fracture-dislocation, 20 cases of isolated fracture, and 20 cases of pure dislocation. Complete dislocation means complete separation of one or both articular processes. The first is a unilateral, the second a bilateral dislocation. In *subluxation* the surfaces are partially separated.

Diastasis means separation of vertebral bodies, the articular surfaces not being separated. Diastasis is the result of tearing loose of the intervertebral cartilage. In discussing dislocations regard the upper bone as the one dislocated (Frazier, Ibid.). In dislocation capsular ligaments are torn. Other ligaments, muscles, nerve-roots, intervertebral cartilage, cord membranes, or cord may be damaged. Blood may gather outside or inside of the membranes. The cord may be destroyed, incompletely destroyed or pressed upon by displaced bone or by blood-clot. In Frazier's collection of 44 cervical cases there were 9 complete transverse lesions and 22 incomplete lesions. Taking all regions Frazier (Ibid.) says there was cord involvement in 70 per cent. of cases.

The *symptoms* of dislocation are pain, tenderness, preternatural mobility, crepitus, muscular rigidity, and limitation of movement. The limitation of motion is partly due to malposition of the bones and partly due to rigidity of the muscles. The spinous processes are not in line. In a unilateral dislocation one transverse process is prominent. In dislocation of the neck the position of the head is always to be noted. Injuries of the nerve-roots or of the cord producing symptoms nearly identical with those due to fracture and fracture-dislocations will be subsequently considered. In dislocation compression of the cord is more common than laceration. Cervical dislocations may cause immediate death. Death in the first few days after the accident is common.

Dislocations of the Cervical Vertebræ.—It is in the cervical region that pure dislocations are most common. The *x*-rays are of essential means in diagnosticating dislocations.

Forward dislocation of the occiput from the atlas is a very unusual injury which may produce death at once, but does not always do so. The luxation may be complete or incomplete. The odontoid process of the axis may be broken. The chin is bent strongly toward the sternum and the axis projects posteriorly.

In *dislocation of the atlas from the axis* the odontoid process is apt to be fractured. This injury is most commonly produced by a fall, the victim striking upon the forehead. Unilateral luxation is more common than bilateral. The dislocation may be forward, backward, or rotary. The backward form is extremely rare. In a forward dislocation the prominent transverse process of the atlas can be felt by way of the pharynx (Fig. 662).

It is imperatively necessary to discover a fractured odontoid process. If such a fracture exists, even a slight motion is highly dangerous. Dislocations of the lower

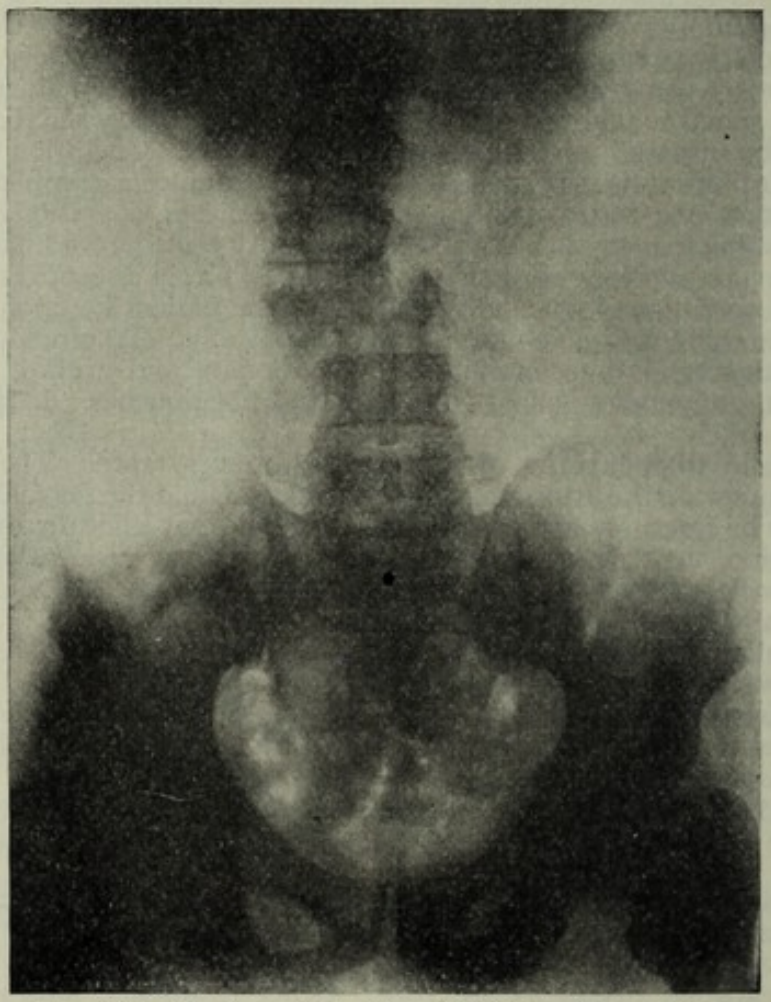


FIG. 659.—Fracture-dislocation of third lumbar vertebra.

sixth vertebræ are more common than the two dislocations just mentioned. Bilateral dislocation forward and unilateral dislocation forward are the most common forms. A bilateral dislocation forward results from violent anterior flexion and sometimes happens to a diver. It is most common between the fifth and the sixth cervical vertebræ and the cord is apt to be damaged. The laminæ, or spinous process, may be broken. In dislocations of any one of the first five vertebræ a pharyngeal prominence may be palpated. The prognosis of cervical dislocations is extremely bad and such patients usually die within a few days. Frazier points out that a unilateral forward dislocation may be due to a blow, fall, or a twist (wrestling), and that the cord often escapes. The head is held as in wry-neck. It is bent toward the side of the injury and the chin is turned away from the injury. Deviation of the spinous processes is noticed. If the vertebral body is torn loose the cord is very apt to be injured. An *x*-ray picture may show no displacement because the body of the vertebra, though displaced at the

time of the accident, returned spontaneously to position. Displacement of the body of a vertebra is apt to damage or even destroy the cord. It is caused by acute flexion.

Thoracic Dislocations.—These dislocations are extremely rare. When such a dislocation is met with it is apt to be between the eleventh and twelfth dorsal or the last dorsal and first lumbar. It may present itself in any of the forms described in the cervical region. The surgeon notes prominence of a spinous process or deviation of the spines. There may be fracture of ribs. The cord may or may not be damaged. The higher up the dislocation, the more dangerous the condition.

Lumbar Dislocations.—These are very rare injuries. Frazier has only been able to find recorded one case of complete luxation of the lumbar vertebræ.

Treatment of Pure Dislocations.—It is desirable to effect reduction at the earliest possible moment consistent with safety. If, however, there are any evidences or only trivial evidence of cord trouble blind reduction should never be effected at once, because of the danger of damaging the cord and the possibility of sudden death. In such cases it is wise to wait and to operate later, although there are cases on record in which, in spite of marked deformity, the patient has gotten well. There is always risk to the future of the cord if the condition is let alone.

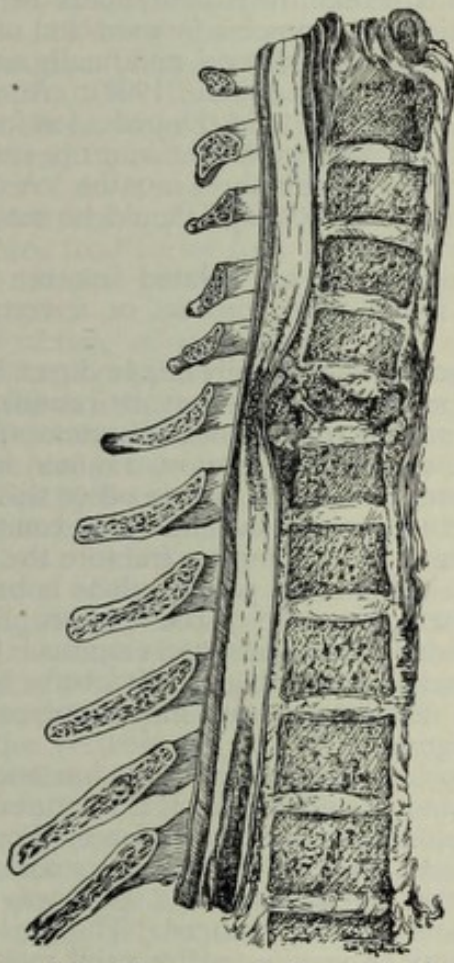


FIG. 660.—Fracture of the cervical spine, cord compressed by bone and blood. Hemorrhage into the cord at the seat of the lesion and below the lesion (Warren Museum). (From Scudder's "Treatment of Fractures"; drawn by Byrnes.)



FIG. 661.—Spine sawed. Fracture of the spinous processes of the seventh cervical and first and second dorsal vertebræ. Fracture of the bodies of the fifth, sixth, and seventh cervical vertebræ with displacement *backward* of the upper fragment. Total crush of the cord. The section passes a little to one side of the cord, which is seen in place, and the staining of the cord by hemorrhage into its substance shows plainly through the membranes even in photograph. The spinous processes of the second and third dorsal vertebræ were found fractured at the operation, and were removed (Thomas).

In treating dislocations some surgeons advocate reduction by the closed method, others by the open method. Whereas the closed method has proved successful in many hands, it is a blind and dangerous procedure. It may cause grievous damage to the cord, and sudden death is no remote possibility when it is attempted. Fracture of the odontoid is a positive contraindication to blind reduction. Furthermore, the open method permits us to remove blood-clot, which, if not removed, would produce grave trouble. If operation is decided on, laminectomy is performed as described on page 827. The following are some of the plans for the blind reduction of dislocations.

Give ether.

Occiput From Atlas.—Patient recumbent. Make traction upon the head. Manipulate and press into place.

Atlas From Axis.—If odontoid fracture is suspected, wait one month. Patient recumbent. Very gentle traction, rotation, and manipulation.

Bilateral Dislocation Forward of a Cervical Vertebra.—Recumbent. Head and neck are brought over the end of the table and held by the surgeon. Make no flexion. Fragments are unlocked by traction in the long axis of the vertebral column. When unlocked usually return to place.

Unilateral Dislocation Forward of a Cervical Vertebra.—Recumbent. Rotate and abduct and so increase existing deformity. Unlock by gentle traction. In a unilateral dislocation Walton's plan is as follows: Give ether while recumbent. Place him sitting in a chair and hold him. Surgeon, standing behind the patient, holds the head with both hands. Slight rotation to carry the dislocated process forward and unlock it. Rock the head toward the sound side and somewhat backward, and finally replace the process by rotation (Clopton in "Interstate Med. Jour.," Jan., 1908). After reducing a dislocation place the patient in bed, elevate the head of the bed a few inches, and immobilize the head and neck of the patient. In four weeks get him up, using a celluloid collar for a support (Fig. 664). Wear the collar for three months. A dislocated vertebral body is not to be reduced blindly. No attempt should be made to reduce dorsal dislocations or lumbar dislocations blindly.

Isolated Fractures of the Vertebræ.—There may be an isolated fracture of a spinous process, an arch, an articular process, a transverse process, or a vertebral body.

Fractures of the Spinous Processes.—These fractures are usually due to direct force, but sometimes to muscular action. Of course, such a fracture may be complicated by a dislocation or a fracture dislocation. There may be fracture of one or more spines. The injury may be met with at any part of the column and is most common in the cervical and upper dorsal region. The tip of a process may be broken off or the fracture may be at the base of a process. The fracture may be incomplete or complete. In an incomplete fracture there is no displacement. In a complete fracture the fragment passes downward and to one side. When the spinous process alone is broken the nerve roots and cord are not damaged. After a fracture of the spinous process we note pain, tenderness, muscular rigidity, impeded movements, and crepitus. Fractures in the lumbar region cause limitation in flexion of the thighs. Fractures in the lower cervical or the upper dorsal region cause interference with movements of the shoulders and arms. The *x*-rays confirm the diagnosis.

Fractures of the Arches.—This injury is most common in the cervical region, and it is usually bilateral. One, two, or several vertebræ may be involved. If a fracture is bilateral there may be marked displacement. The usual cause is direct violence. Forcible bending backward may be responsible. I have seen one case caused as a man drove a high wagon under an archway. His head struck the arch and his spine was bent forcibly over the back of the seat. The nerve roots may be damaged. The cord may be pressed upon, bruised, or lacerated. The injury is manifested by pain, mobility, tenderness evoked by pressure upon the spines, and crepitus on deep pressure or motion. The *x*-rays confirm the diagnosis.

Fractures of the Transverse Processes.—Such fractures are caused by crushes, falls, blows, and occasionally by muscular effort, such as lifting. One or more processes may be broken. The injury is very seldom met with except in the lumbar region. It is usually unilateral. Professor Frazier collected records of 29 cases. It causes pain at the seat of fracture and perhaps pain radiating to the groin, the abdomen, the coccyx, and the sciatic distribution. Spinal movement develops or aggravates pain, and flexion of both thighs causes pain. A man with a fracture of a transverse process, when he tries to pick up an object from the floor, bends like one with Pott's disease. Of course, there is tenderness and crepitus may be elicited by deep pressure. If there

is rotation, the convexity will be toward the sound side. The *x*-rays confirm the diagnosis. The roots of the nerves may be injured.

Fractures of the Articular Processes.—Isolated fracture, limited to the articular process or processes, is very rare, although such fractures are common in association with dislocations of vertebræ. They may be unilateral or bilateral. The cause is indirect force, never muscular action. The usual cause is forcible flexion or forcible extension. Nerve roots may be involved and there is usually persistent crippling pain.

Fractures of the vertebral bodies are usually due to forcible anterior flexion and may be caused by a fall, striking upon the feet, buttocks, or head. A man may fracture the body of a vertebra if he slips when carrying a heavy load on the back. A heavy blow on the back may be responsible. One or more vertebræ may be broken. When flexion is the cause the vertebral body is compressed. The superior fragment usually passes forward but may pass backward. It may remain in deformity, but seldom does so, and when the surgeon sees the case displacement is unusual. The injury is most common in the thoracic region, next in the lumbar region. There is pain aggravated by movement, especially by bending or lifting. There is tenderness and crepitus, and crepitus may be audible through a stethoscope. There may be either kyphosis or angular deformity. The cord may be lacerated or compressed, but usually the cord symptoms are brief.

Treatment of Isolated Spinal Fractures.—Fractures of spinous processes are usually treated by fixation, with plaster of Paris, or adhesive plaster. Union is solid in four weeks. During the first two weeks of treatment the patient should be in bed. If union takes place and deformity and pain continue, the fragment should be removed by operation. In fracture of the arches, if there are evidences of cord involvement after six or seven days, it is wise to operate. In cases without cord involvement fixation and support for four weeks is sufficient. The patient should be in bed the first two weeks of the time.

In fracture of the transverse process most cases get well and are treated by plaster-of-Paris fixation for four weeks. The first two weeks of the time should be passed in bed. If pain persists, we believe there is an ununited fracture or necrosis and advise operation.

Fracture of an articular process is treated conservatively, as above described. Persistent crippling pain calls for operation. Fracture of the body of a vertebra is treated as a fracture-dislocation (see page 824).

Fracture-dislocation.—In 60 per cent. of all severe injuries of the spinal column a fracture is associated with a dislocation.

Fracture-dislocation may be caused by direct force, by indirect force, but very seldom by muscular action. Direct force is causal in bullet wounds, squeezes, and crushes. Indirect force may be flexion, extensive lateral bending, traction, or a combination of two of these movements. Forward flexion is the commonest cause. The head is forced on the chest, the dorsal vertebræ are driven toward the lumbar vertebræ and the lumbar vertebræ toward the sacral vertebræ. A fall of dirt in an excavation, a fall of coal in a mine, a fall of masonry or any other heavy body may be responsible. Hyperextension is an unusual cause. When it happens there is backward dislocation of the vertebra above. The cervical spine is most often involved; the thoracic spine least often. The articular ligaments are lacerated on one or both sides. The intervertebral cartilage is torn loose and the body of the vertebra above moves forward. The anterior inferior edge of the vertebra above makes very violent pressure on the anterior superior edge of the vertebra below, and usually a portion of the anterior margin of the lower vertebra is torn off. In the lower dorsal region and the lumbar region the body of the lower vertebra is often crushed. The cord may not be injured at all. It may be compressed by bone, by blood-clot, or later by inflammatory exudate. It may be lacerated. It may be crushed (Figs. 660, 661).

When we speak of a complete lesion we don't of necessity mean that the cord has been completely divided, but that it has been so seriously damaged that impulses cannot pass upward or downward (Frazier).

Symptoms of Fracture-dislocation.—There is, of course, the evidence of bone injury and pain, which is greatly aggravated by motion, and marked tenderness. There may be angular or lateral deformity and in the cervical region there may be rotation. A displacement which took place at the moment of the injury may remain, but it may undergo spontaneous correction, and when the surgeon sees the case there may be no deformity at all. It is in such cases that the *x*-ray may fail to help us. Usually in fracture-dislocation the spinous processes are out of alignment. Crepitus should never be sought

for. To seek for it is dangerous. There may be no evidence whatever of cord damage, but the examination should be most careful and painstaking to determine this point. The examination must be early, should be repeated at frequent intervals, and the aid of a neurologist is eminently desirable. It is necessary to lay down with the utmost care the area or areas of impaired sensation, muscular palsy, and disturbed reflexes. Early in most cases the suggestion from the symptoms is that there is a complete lesion of the cord. We cannot be certain of this early in the case. The clinical picture may be due to spinal shock. Below the fracture all the reflexes are usually lost, there is loss of all sensation, flaccid palsy, and rapid wasting of the muscles, and loss of control of the bladder and rectum are noted. In a day or two, if the symptoms were due purely to spinal shock, they pass away. If due to a partial lesion, they are modified, and there is some return of motion and sensation. In some cases in which the early symptoms indicated a partial lesion the situation may grow worse because of edema or hemorrhage, and any sensation or muscular power which exists may be lost. If at the earliest moment there is any retention of sensation, any power of motion, any control of the bladder or rectum, any reflexes or any spasticity, there is not a complete division of the cord; hence, the importance of early and prompt examination. By examining promptly and often we may discover what functions that were present are being lost. In a complete lesion priapism may be noted.



FIG. 662.—Fracture of the odontoid process of the second vertebra and dislocation between the first and second vertebra a number of years after injury (from *x*-Ray Dept. of Jefferson Hospital).

Bed-sores are apt to form in the palsied regions (over the heels, tuberosities of the ischium, sacrum, great trochanter, elbow, and scapula).

In cases of fracture-dislocation it is very common to find blood in the urine after a number of hours. This probably results from congestion of the kidney. It is not sufficient for the surgeon to decide that there is a lesion of the cord, he must also determine the level of the lesion. (See Prof. Frazier's fine book on the spinal cord. I have used it freely.)

Traumatisms of the Spinal Cord.—Traumatism may cause spinal shock, hemorrhage (epidural, subdural, or intramedullary), contusion, or laceration. The cord lesion may be complete or incomplete. The force may be a direct blow, a bend, or a twist. A fall upon the feet, buttocks, back, or head may be responsible. There may or may not be vertebral fracture or dislocation or fracture-dislocation. Persistent spinal symptoms in fracture or dislocation are usually due to contusion or laceration. Any of the above-named conditions may cause, below the lesion, complete motor and sensory paralysis with abolition of reflexes. A laceration may be complete or partial. After any severe cord injury tracts degenerate. Ascending tracts degenerate upward and descending tracts degenerate downward. When the cord is injured adjacent segments become edematous and the edema causes a rise in the upper level of sensory palsy.

Symptoms of Traumatic Cord Lesions.—Is there an organic lesion? The early symptoms may deceive the surgeon. Spinal shock alone may for a short time cause all the symptoms of a complete transverse lesion, and yet these symptoms may clear up in a day or two. The presence of the symptoms immediately after the accident and their persistence indicate a complete lesion. If after the accident there is any power of motion, any sensation, any control of the bladder, or any reflex, then a complete transverse lesion of the cord does not exist. The subsequent loss of motion, sensation, or reflexes does not alter this opinion and is regarded as being due to pressure or cord edema. It is vastly important to examine the case early, often, and carefully, and the upper margin of anesthesia should be marked on the skin with an aniline pencil and observed at each examination. In the early hours after an accident it is impossible to affirm that there is a complete transverse lesion. A wait for a few hours will solve the problem, but the delay in operation may prove most disastrous when there in only a partial lesion by permitting degeneration of tracts. Degeneration is very rapid. After spinal shock passes away a complete lesion can be diagnosticated from a partial lesion. In a complete lesion all the muscles which are innervated from below the lesion are in a state of absolute and flaccid paralysis. Reflexes are absent in the same area of innervation. No manifestation of sensation can be elicited. There is entire loss of control of the bladder and rectum. The urine either leaks away or flows out from time to time unknown to the patient. No improvement takes place and trophic symptoms are early and severe. In a partial lesion there is spasticity of muscle groups innervated from below the level of cord damage. Contractures may or may not exist. "Paralysis may not be total" (Frazier, "Surgery of the Spine and Spinal Cord"). The reflexes are increased below the damaged cord segment and the Babinski reflex is noted. Loss of sensation is not complete and the patient may be able to appreciate a change in the position of a limb. There may be some degree of control of the bladder and rectum and the patient may feel it when he passes urine. The condition may improve gradually. Sometimes, though seldom, *priapism* is observed after a cord injury. In incomplete priapism the body of the penis is turgid, but the glans remains normal. There is no pain. In the complete form the penis is erect and pain is severe. Sexual feelings are absent. Urine is passed with difficulty. Bed-sores may arise (page 822). Trophic atrophy occurs in the palsied muscles. Very high temperature has been noted after high cervical injuries.

The Brown-Séquard Syndrome.—This syndrome is only seen typically after hemisection of the cord by a stab. Contusion may cause a more or less modified picture. Suppose a typical case, the lesion being between the fifth and sixth dorsal segments on the right side. Frazier (Ibid.) points out the following symptoms: Complete paralysis of the right lower extremity, usually flaccid at first. Probably temporary diminution or even loss of tactile sensation on the right side, rising on the trunk to the cutaneous distribution of the fifth thoracic nerves. On the right side below the level of the lesion there is loss of the sense of position, of osseous sense, and of appreciation of pressure, but the thermal sense and pain sense are retained. On the left side there is loss of all sense of pain and temperature up to a line a little below that of the sensory loss on the opposite side. On both sides there are sensory disturbances above the anesthetic skin and below the non-anesthetic skin. On the right side there is a zone in which all forms of sensation are lost. On the left side there is a zone of hyperesthesia.

Prognosis of Fracture Dislocation.—The danger is the cord damage, not the bone injury. The greater the cord damage the worse the prognosis, hence a partial lesion gives a far better prognosis than a complete lesion. The less rigid the surgical fixation the greater the danger, as movements may damage the cord anew. The higher the lesion the greater the peril.

Frazier's table shows that in 62 cases of partial lesion there was immediate death in 2 and subsequent death in 12. In 61 cases of complete transverse lesion there was immediate death in 17 and subsequent death in 23. Out of 14 complete cervical cases 4 died at once, 9 later, and 1 was improved. Out of 11 partial cases 2 recovered, 7 were improved, 2 were unimproved, and none died. Out of 14 complete thoracic cases 4 were improved, 2 were unimproved, and 7 died later. Out of 6 partial cases 6 were improved. Out of 4 complete lumbar lesions 4 were improved, and out of 9 incomplete cases 1 recovered, 5 were improved, and 3 died later (Frazier on "Surgery of the Spine and Spinal Cord").

Determination of the Seat of Lesion.—In a complete lesion of the fourth cervical segment there is flaccid paralysis of the four limbs and death from palsy of the diaph-

ragm, hence the respiration during life is costal. There is anesthesia of the skin supplied by the fourth segment and of all the skin below it.

The cord segment above it shows evidences of disturbance, the area of sensory loss rising somewhat because of hemorrhage or edema. Any high cervical lesion causes contraction of the pupils because the fibers from the midbrain to the ciliospinal center are damaged. If the lesion is partial, paralysis, especially in the lower extremities, though at first flaccid, becomes spastic.

In lesions of the fifth cervical segment the symptoms are like those of the fourth segment except that the diaphragm is not paralyzed and the upper line of anesthesia is somewhat lower. In lesions of the sixth cervical segment the upper root of the brachial plexus escapes, hence the shoulder girdle retains some power. Tactile sense is preserved "on the outer and upper surfaces of both arms" (Frazier). Anesthesia of the trunk reaches as high a level as in injury of the fifth segment.

In injury of the seventh segment the shoulder girdle muscles escape, it is possible still to flex the arms and forearms, and the biceps tendon reflex is preserved or even exaggerated (Fig. 663). The bladder and rectum are paralyzed. The sensation is preserved in the trunk through the same areas as noted in the injuries higher up. There is sensory loss in the skin of the inner half of the arms, forearms, hands, in the little finger, the ring finger, and the ulnar half of the middle finger.

Injury of a thoracic segment causes anesthesia and palsy which are sharply marked by the level of the lesion.

In injury of the ninth thoracic segment the upper extremity is undisturbed. There is complete paralysis of the lower extremity of the bladder and the rectum. There is the incontinence of retention, and later, if the lesion be partial, automatic incontinence because of spasticity.



FIG. 663.—Lesion of spine between fifth and sixth cervical vertebræ. Note position of arms, due to paralysis of subscapularis. Brachialis anticus, supinator longus, and deltoid muscles intact. Elbow flexed, shoulders abducted and rotated outward (after Thorburn).

Injury of the second and third lumbar segments causes complete paralysis. The muscles are flaccid even in partial cases. The rectum and bladder are paralyzed and there is anesthesia up to Poupart's ligament. Injury below the second lumbar may cause injury to the nerves of the corda equina. Between the second and third lumbar the nerves may be crushed coming out of the second foramina and the nerves of the cauda equina may be damaged. There is paralysis of the lumbosacral plexus. No reflexes remain below the injury, the muscles rapidly atrophy, the rectum and bladder are paralyzed, all sensation is lost below Poupart's ligament in front and to the upper margin of the sacrum posterior.

If the second lumbar nerve escapes but the lesion involves the third lumbar and the nerves below, the areas of muscular palsy and gluteal anesthesia are not so high and the cremasteric reflex still remains.

In involvement of the fourth lumbar nerves and those below there will be complete anesthesia from the knees down, but preservation of function in the psoas, sartorius, iliacus internus, pectineus and adductors, and some retention of knee reflex. If the fourth nerves are preserved and all nerves below lost the knee-jerks will be normal, there will be anesthesia of the feet and the outside of the legs below the knees, and in addition to the above muscles the quadriceps, the gracilis, and the obturator externus will not be palsied.

If the fifth nerve is spared there is anesthesia of the soles of the feet and the dorsum of the toes and "a narrow strip up the back of the legs to the thighs together with a saddle area on the buttocks" (Frazier). There is paralysisiof the long extensors of the foot and toes, of the peroneus longus and brevis, the pyriformis, the obturator internus, gemelli, the gluteus maximus, and all of the muscles "below this innervation" (Frazier).

If the first sacral nerves are preserved there is a strip of anesthesia extending from the posterior part of the calf up the thigh to the buttock, but there is no anesthesia of the feet. The calf muscles are paralyzed with the flexors of the toes and the feet.

Treatment of Fracture-dislocation.—Blind reduction should not be practised. The attempt to accomplish it may injure the cord anew and in the cervical region may cause sudden death. Laminectomy permits the arrest of hemorrhage and of much

safer reduction. Reduction in the cervical region is effected by laminectomy, traction, and perhaps rotation. In the dorsal and lumbar regions it may be proper to employ traction and manipulation.

If a surgeon does reduce blindly a fracture-dislocation of the cervical region, he should afterward place the patient in bed, elevate the head of the bed a few inches, make traction upon the head, immobilize the neck and head with sand-bags. When able to get about use the collar shown in Fig. 664, and wear it for several months. In the dorsal and lumbar regions recumbency in bed may be sufficient, although the use of a Bradford frame will be better. In all cases empty the bladder every six hours with a soft catheter, which is kept strictly aseptic. Take every precaution to prevent bed-sores. Surgeons have come rather slowly to a belief in laminectomy. One deterrent factor has been the high mortality. Lloyd collected the records of 159 operations and found that 59 patients died almost at once and 39 died later. In Lloyd's collection of 185 cases there were but 24 recoveries and 40 improvements. In 82 immediate operations only 5 recovered. In 103 late operations there were 19 recoveries (John B. Murphy in "Surg., Gynecol., and Obstet.," April, 1907). Some employ purely expectant treatment in vertebral fractures. My own feeling is that when simply a spinous process or some other part is fractured, and there are no cord symptoms, we may treat the patient expectantly, following Burrell's advice, and fixing the patient in bed on a Bradford frame and having him carefully nursed and watched. Reduction by extension and counterextension is dangerous and unjustifiable if there is marked kyphosis even if cord symptoms exist. Burrell maintains that it should only be done if operation is refused, or if there are no cord symptoms and no marked kyphosis ("Annals of Surgery," Oct., 1905). If it is attempted it must be done slowly and as gently as possible because it may cause grave or even irreparable damage to the cord. I fear to delay, and, with Burrell, Lloyd, Walton, and others, operate when the patient recovers from shock if there seems to be even a gleam of hope that operation may help him. To wait when pressure exists means that during every hour of delay the pressure is damaging the cord. Another reason for operating is that we cannot know the condition of the cord without direct inspection. The operation to be performed is laminectomy. As before stated, this is to be done even if we suspect division or hopeless crush of the cord. In some cases, it is true, we may commit the error of operating when there is only concussion, but such a mistake is less grave than to fail to operate when there is bone pressure or hemorrhage. An objection filed by the neurologist against laminectomy is that portions of cord above and below the level of the fracture may have been damaged (see Fig. 661), but, as Lloyd says, this fact does not forbid operation, but renders it necessary to make a wider exploration than has been the custom. In many cases after prompt laminectomy we get some considerable improvement, and this improvement may be sufficient to enable a man to earn a living. It is true that statistics would indicate that late operations have been more successful than early ones, but these figures must be analyzed in the light of the knowledge that many of the fatalities after early operation would have occurred if no operation had been done, and some improvements after late operation would have occurred to as great or a greater degree after early operation. The prognosis of any operation, early or late, is never gratifying, and Thorburn feels no confidence in obtaining improvement except in injuries of the laminæ, hemorrhage, or injuries of the cauda equina, and he says laminectomy in the cervical region is followed by death, and laminectomy in the dorsal region, though not commonly fatal, is seldom followed by recovery of function. Our statistics of early laminectomy will show fewer deaths and fewer useless operations if we do not operate till shock abates. As Lloyd ("Phila. Med. Jour.," Feb. 5, 1902) says: "It is therefore evident that if we operate immediately after the injury we will have failures that should not be charged against the operation itself, and, if possible, we should wait before operating until the question can be settled whether the patient will overcome the shock or will succumb directly to the effects of the injury." All surgeons operate for compound fracture, for hemorrhage, and for cases with marked bone pressure. If early operation were not performed and if pachymeningitis arises, operation is called for.

My own convictions are that if symptoms are significant we should explore as soon as shock has passed away, even if we think it probable that the cord has been divided; and if it is found divided, it should be sutured. If we are in doubt twelve hours after the injury as to whether or not pressure exists, we should explore. If soon after the accident we think pressure by bone or blood exists, we should operate. If the case is improving, we should not operate even if there are pressure signs, unless there is a chance that pressure is due to bone, in which case we should operate. As McCosh

says, pressure by blood or inflammatory exudate may pass away; pressure by bone cannot. Even long after an injury laminectomy may be productive of some benefit.

The rather radical views set forth above regarding the advisability of operating even if the symptoms point to complete division of the cord arose largely from a knowledge of the well-known case operated upon by Stewart for total division of the cord. In a case of gunshot wound of the dorsal spine treated at the Pennsylvania Hospital by Francis T. Stewart, and reported by Francis T. Stewart and Richard H. Harte ("Phila. Med. Jour.," June 7, 1902), an exploratory incision made three hours after injury showed that the spinal cord was completely divided. There was a fracture of the laminæ of the seventh dorsal vertebra. The spines and laminæ of the seventh and eighth dorsal vertebræ were removed. The bullet hole was recognizable in the membranes, and the bullet and some bone fragments were removed. When the dura was opened the ends of the completely divided dorsal cord were found to be $\frac{3}{4}$ inch apart. Stewart freshened these ends and brought them together with two sutures of chromicized catgut. In this case a considerable degree of restoration of function took place. At the time of the operation, three hours after the injury, there were complete paralysis and absence of reflexes below the seat of injury; but sixteen months later the patient was able voluntarily to flex the toes, flex and extend the legs, flex and extend the thighs, and, while sitting, lift an extended leg from the floor. The movements of the lower extremity became more forcible when reinforced by contracting the muscles of the upper extremity while making them. The patient could stand with one hand resting on the back of a chair, and could get herself from her bed to her chair by sliding. The bowels were under perfect control, and there was no incontinence of urine when she was awake, although there was occasionally some when she was asleep. There were occasional cramp-like pains in the lower limbs. The senses of touch, temperature, pain, and position were perfect all over the previously paralyzed parts. Below the knees the localization of sensation was not so accurate. There was a slight amount of muscular rigidity; and on each side, also an ankle and a patella clonus, which were easily exhausted. When the sole of the foot was tickled, the big toe flexed, the thigh abducted, and there was slight contraction of the anterior tibial, the hamstring, and the tensor vaginæ femoris muscles. There were no reactions of degeneration and no trophic changes. There had never been any bed-sores. George Ryerson Fowler ("Annals of Surgery," Oct., 1905) operated on a gunshot wound of the dorsal spine eleven days after the injury. He removed the laminæ of the tenth, eleventh, and twelfth dorsal vertebræ and found the cord divided, the bullet lying between the severed ends. A piece of dura $\frac{1}{8}$ inch wide was intact. The bullet and blood-clot were removed. The cord was sutured by three sutures of chromicized gut, which included the dura, and more sutures were taken through the dura only. The ends of the cord were easily approximated. The patient recovered from the operation. Twenty-six months later voluntary motion was found to be practically lost in the area below the injury, although when supported by the hands he could stand and when in a frame could move a little by a swinging movement. He is able to tell when his bowels or bladder are about to move, and, if furnished promptly with a utensil, does not soil himself. When asleep he passes urine involuntarily. Both legs exhibit spastic rigidity, but there are no reactions of degeneration. Patella reflex on each side exaggerated. Ankle-clonus is found on one side, but not on other. There is complete anesthesia of the affected area, except in a region 5 inches in length on the outer side of the right thigh. Touch is appreciated, but not correctly localized. In connection with the foregoing important cases we would note that Dr. Estes, of Bethlehem, has also operated upon a case of complete division of the spinal cord, in which suturing was apparently followed by some restoration of function.

In the light of these positive reports we must ask ourselves if we have not been wrong in the view that the spinal cord cannot regenerate. If there is even a chance that we have been wrong, we must reverse our former conservative treatment and follow a radical plan. The 3 cases strongly suggest the possibility of some regeneration, but do not prove it. The cord may have appeared to be completely divided and yet minute undivided bundles may have escaped recognition. Again, as Fowler suggests, there may be a nerve anastomosis through an uninjured portion of the dura or between adjacent nerve-trunks which arise above and below the lesion. At my request Dr. Samuel Lloyd, of New York, kindly wrote me a personal communication setting forth his views on this important subject. They are as follows: "The question of the regeneration of the spinal cord after traumatism of the spine deserves careful consideration in all cases that are operated upon. Up to the present time, however, although

a number of operators have reported improvement following suture of the spinal cord in these cases, a careful analysis does not substantiate the fact that that improvement is due to an actual regeneration. It is a recognized fact on the part of all who have had experience with the surgery of the spinal cord that in almost every instance a certain amount of improvement is noted during the first few months. This is probably due to the fact that at the time of the injury minute hemorrhages occur into the adjoining segments, and that pressure is also increased in those portions of the cord by the inflammatory exudate and edema. Within a short time after the injury these conditions improve, and there seems to be an improvement in function; but in every case of spinal suture yet reported the amount of improvement may be explained by these facts. In no instance has there been a complete recovery of function, but in every one there has remained more or less permanent disability. This, however, should not discourage attempts at spinal suture, and in every case operated upon the dura should be opened and the condition of the cord examined. In those cases where a complete destruction has occurred and where the extent of it is not over ¾ inch, it may be possible to cut out the lacerated portions and coaptate the surfaces by a series of sutures placed in the dura. In all these cases the patient should be put up in a plaster retaining bandage in extreme extension, even the head being thrown back so as to relax as much as possible the tension on the line of suture. The operator should be very sure, however, that there are no undestroyed fibers traversing the lacerated area, for the destruction of these in case regeneration did not occur would increase the amount of paralysis." With the views of Lloyd I am in entire agreement, and now I always follow this plan, bearing in mind that it is often impossible to tell whether the spinal cord is completely divided or seriously damaged without examining it, and it can be examined by exploratory operation only; therefore, if the serious symptoms already indicated exist after shock has passed away, exploratory operation should be performed; if pressure exists, it should be removed; and if the spinal cord is found to be completely divided, it should be sutured. It is well to remember that Abbe's experiments have shown that there may be great difficulty in bringing the divided ends of the cord into apposition. In order to effect this it may be necessary to resect a vertebra.

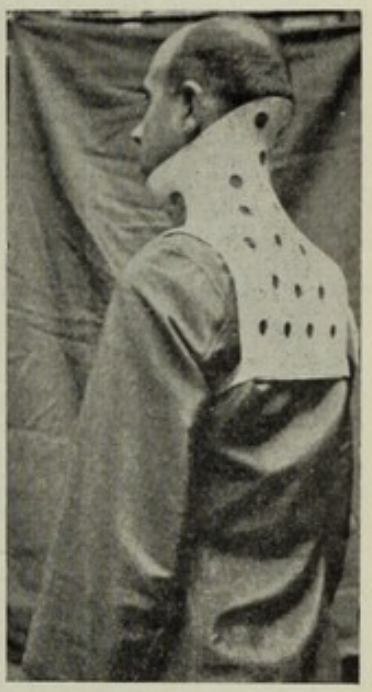


FIG. 664.—Celluloid supporter for fracture of cervical vertebra (Davidson).

Operations on the Spine.—Operation for Spina Bifida.—A. W. Mayo-Robson[1] maintains that operation is not demanded when the sac is of small size and is well protected by sound integument; that operation is improper when a large portion of the column is fissured, or when paraplegia or hydrocephalus exists; that operation is advisable only in meningocele, in cases in which the integument is thin and translucent, in cases in which the cord is flattened out or the nerves are fused. Robson has closed the osseous defect by transplanting periosteum.

Surround the sac by elliptic incisions. Find the neck of the sac, and if it contains no visible nerves, ligate it and cut off the protrusion. Push the stump into the canal. Some surgeons freshen the bone-margins and spring a piece of celluloid beneath them to close the gap. I do not believe this is necessary. Suture over the stump with small sutures of catgut.[2] The wound should be closed in layers.

Ayer's Operation for Diagnosis of Subarachnoid Spinal Block.—(See page 801.)

Treves's Operation for Vertebral Caries.—(See page 653.)

Laminectomy.—The patient lies prone and a sand-pillow is placed under the lower ribs. Make a vertical incision over and down to the vertebral spines, the middle of the incision corresponding to the seat of injury or disease. The sides of the spinous processes and the laminæ are cleared. The periosteum is incised in the angle between the laminæ and spines, and is lifted away from the arches. It is my custom to bore through a lamina on each side of a spinous process by means of Hudson's burrs. When

[1] "Annals of Surgery," vol. xxii, No. 1.

[2] A full consideration of the various plans of operating will be found in an article by Marcy in "Annals of Surgery," March, 1895.

this has been done the spinous process and lamina are easily bitten through and removed. The usual method of operating is as follows: The spinous processes are cut off close to their bases by means of bone-cutting forceps, the laminæ are removed on each side with the same instrument or the rongeur, and the dura is exposed. In some cases of fracture fragments will be found on exposing the vertebra, or a blood-clot will be seen between the dura and the bone; in other cases the dura must be opened by scissors vertically in the middle line while it is grasped by mouse-toothed forceps. After reaching and removing the compressing cause, or after failing to find or remove it, it is best not to close the dura completely, because if we do so cord pressure may result from hemorrhage. The dural wound is left open or is partly closed. I used to insert a drain of rubber tissue, but have given it up. Horsley shows that it is not necessary, and if we refrain from draining we lessen the tendency to headache, temporary pyrexia, and rapid pulse, which frequently follow laminectomy. The superficial parts are stitched with silkworm-gut and dressings are applied.

Albee's Method of Bone-grafting for Pott's Disease of the Spine.—In 1891 Hadra, of Galveston, advocated the treatment of Pott's disease of the spine by wiring the spinous processes of the diseased vertebra to adjacent vertebræ for the purpose of securing fixation. Chipault, in 1895, and Calot, in 1896, did this after forcible correction of angular deformity. Lange buried steel wires on each side of the spine and anchored each one at each end by silver wire (J. T. Rugh in "Internat. Clinics," Vol. I, Twenty-third Series). The object of these operations was to do away with the necessity for an external supporting jacket or brace. The objection to them was the introduction of a foreign material, and the fact that strain caused that material to cut through the tissues and permit relaxation.

In 1911 both Hibbs and Albee, working independently, reported methods for producing fusion of the arches of the vertebræ.

Hibbs ("New York Med. Jour.," May 27, 1911, and "Annals of Surgery," May, 1912) takes strips of the periosteum from the spines and laminæ, transposes the spinous processes, and sutures the periosteum and the supraspinous ligament over these processes. The periosteum is depended upon to produce new bone, which fuses the parts together. This operation, if successful, lessens kyphosis and produces fusion of spines and laminæ. Albee, doubting the reliability of the periosteum as a bone producer, practises bone-grafting. An *x*-ray picture must be taken in order to determine that vertebral bodies are being broken down and the region of such destruction. We thus learn the vertebra or vertebræ which are diseased and where the graft is to be applied. The patient is placed prone. An incision is made to expose the spines of the diseased vertebræ and also one or two vertebræ above and one or two below. Some make a straight incision. Rugh makes a curved incision at one side of the spine and turns back a flap. Each spine is split vertically by a chisel and each split portion is broken and pushed over toward the corresponding side. The interspinous ligaments are cut so as to correspond to the split in the spines. We thus obtain a wedge-shaped incision through bone and ligament.

The length of the cut is measured on a probe. The wound is packed temporarily. The leg is flexed upon the thigh. An incision is made over the anterior surface of the tibia. A wedge-shaped graft of bone is cut by means of a surgical engine, a Gigli saw, or a chisel and mallet. The graft is covered with periosteum on one side and contains some medullary tissue on the other. It is $\frac{1}{3}$ inch thick at its base. This graft is fitted to the unbroken sides of the spinous processes. If the kyphosis is marked, numerous cross-cuts are made with a saw into the thin edge. Thus the graft will be made flexible. No attempt is made to correct forcibly the deformity. Here and there the periosteum is incised to favor the emergence of osteoblasts. The interspinous ligaments are sutured over the graft by sutures of kangaroo-tendon. The incision is closed. The patient is put on a Bradford frame or plaster of Paris is applied. The patient remains recumbent for from six to twelve weeks, then he is allowed to sit up, and soon after to walk, of course, wearing a brace or plaster.

The brace or jacket is removed in five or six months. The results of this operation are excellent. The fate of the bone-graft is a matter of dispute. Some hold that it really lives. Others hold that it is simply a scaffold for new bone. One thing is certain—it strongly stimulates the production of new bone from the raw surfaces of the split spinous processes. New bone comes, and new bone, however formed, constitutes the permanent splint (Albee in the "Post-Graduate," Nov., 1912, and in "N. Y. Med. Jour.," March 9, 1912; J. Torrance Rugh in "Monthly Cyclopedia and Medical Bulletin," Feb., 1913, and in "International Clinics," Vol. I, Twenty-third Series).

Albee ("Amer. Jour. Orthop. Surg.," 1916, xiv) reports 198 personal cases of Pott's disease that were operated on a year or more ago by bone-graft. In 184 cases the disease was arrested. In 2 improvement occurred; up to the date of the paper 12 had died. Six of the 12 were relieved of symptoms of Pott's disease and died of conditions unconnected with the operation.

Puncture of the spinal theca, or **lumbar puncture,** was devised by Quincke for hydrocephalus in 1891, and has been carefully tested by many surgeons. It is the operation for withdrawing cerebrospinal fluid from the subarachnoid space of the cord. It is employed as a means of diminishing cerebral pressure in hydrocephalus, cerebral tumor, uremia, infantile palsy, and tuberculous meningitis, but in these cases it has proved of little or only of temporary therapeutic value. It may be of some service in cerebrospinal meningitis, in acute anterior poliomyelitis, and in delirium tremens. The condition of a patient with traumatic compression is often temporarily improved by the operation. The headache and vomiting caused by brain tumor may be temporarily relieved. In the performance of a brain operation the brain may bulge so that the dura cannot be sutured. Lumbar puncture may make suturing possible. Puncture is the preliminary step of spinal anesthesia. The operation is necessary to introduce serums and drugs into the subarachnoid space. In some cases the examination of the fluid has been of great diagnostic value. The fluid is not only subjected to a naked-eye study, it is also studied microscopically and bacteriologically. If the fluid from the puncture gives no positive finding, the operation should be repeated (Lorgo). When a diagnostic tap is made we must determine the appearance, nature, and pressure of the fluid.

Normally the fluid is clear, transparent, alkaline, and in the adult it is under a pressure of from 7 to 9 millimeters as measured on the mercury manometer. In a child the manometer registers from 5 to 7. Its specific gravity is from 1.006 to 1.008, and from 5 to 10 c.c. will flow out at a tap. It contains a faint trace of coagulable protein, inorganic salts, as does the blood-plasma, a carbohydrate resembling glucose, but no formed elements. The carbohydrate is probably dextrose. In cases of increased tension the fluid flows out more forcibly, rapidly, and profusely (brain tumor, hydrocephalus, meningitis, pneumonia, influenza, and some other infectious conditions). Better and safer than guessing at the pressure by the force and rapidity of the flow is to measure by means of a mercury manometer. When there is meningeal inflammation the specific gravity is increased. In apoplexy and other hemorrhages beneath the cerebral arachnoid, in fracture of the base of the skull, and in hemorrhage beneath the arachnoid of the cord, the blood is apt to enter the subarachnoid space. If it does so the fluid obtained by spinal puncture will contain blood. Laceration of the brain tissue without subarachnoid or ventricular hemorrhage does not make the fluid bloody. The fluid is turbid in purulent meningitis of the cord or brain, may contain many polymorphonuclear leukocytes, and also bacteria. Lumbar puncture is of great diagnostic use in the cerebral hemorrhage of the newborn in tumors of the spinal cord and in some fractures of the base of the skull.

The *chemical* study of the fluid is sometimes of value.

In intracranial and spinal tumors, purulent meningitis, subarachnoid hemorrhage of the brain or cord, and apoplexy coagulable protein is increased. The carbohydrate substance resembling glucose is absent in purulent meningitis and is increased in saccharin diabetes. In most cases of tuberculous meningitis at some period of the disease there is a decrease in carbohydrate. In some cases there is no decrease.

In uremia the chlorids are diminished.

Cytodiagnosis (a microscopic study of the cells of the fluid) may furnish useful information; numerous polymorphonuclear leukocytes are found in meningitis. Lymphocytosis suggests a tuberculous lesion rather than an acute meningeal inflammation. Lymphocytosis occurs also in syphilis of the brain and cord, locomotor ataxia, paresis, and uremia.

Bacteriologic study by cover-glass preparations or cultures may give important information. In over 74 per cent. of cases of tuberculous meningitis of the brain membranes the fluid contains bacilli. Stadelmann has reported 37 cases in which tubercle bacilli were found in the fluid.[1] In tuberculous meningitis the fluid may or may not contain tubercle bacilli. In cerebrospinal meningitis the cerebrospinal fluid contains the meningococcus. In this disease diagnostic puncture is unnecessary if the nasal mucus contains the Diplococcus intracellularis. The operation of lumbar puncture is simple, and if done with proper precautions and upon selected cases is harmless.

[1] "Berl. klin. Wchnschr.," July 8, 1895.

The point to be punctured is sterilized with iodin and is located, the patient lying upon the right side with the left knee drawn up and the back arched. Our object is to enter the needle below the cord and in the space between the two roots of the cauda equina. The best point in an adult is just below the third lumbar vertebra and in the midline. This point is safe even in a child from one to three years. In a child up to one year the tap should be made through the fourth interspace instead of the third. In an adult the conus medullaris terminates on a level between the first and second lumbar vertebræ, in a child up to three years of age on a level with the second lumbar vertebra, in a child up to one on a level with the third lumbar vertebra. A line drawn from the summit of one iliac crest to the summit of the other iliac crest crosses the spine of the fourth lumbar vertebra. A tap above it enters the third interspace, below it the fourth interspace. Anesthetize with novocain. The patient must not straighten up during the operation. If he does, the needle may be bent or broken. A suction apparatus is not to be used, as it might cause hemorrhage. A Pravaz syringe is employed. The needle should be of platinum which may bend, but will not break. It should be 3 inches in length, is guarded by the surgeon's index-finger, and the point is inserted ½ inch to the right of the median line pointing to between the selected lumbar vertebræ. It is pointed upward and a little inward under a spinous process. It enters the canal in the middle line. In a child the needle enters the canal at a depth of from 2 to 3 cm.; in an adult, at a depth of from 4 to 5 cm. The fluid is permitted to fall drop after drop into a sterile test-tube. In some cases only a few drops of fluid can be obtained; in other cases many cubic centimeters may be removed. It is not wise to draw for diagnostic purposes over 5 c.c. from a child and 10 c.c. from an adult. If we evacuate too much cerebrospinal fluid the brain stem descends as the fluid flows and may become jammed in the foramen magnum. Such compression may cause sudden death from respiratory failure. There is distinct danger of the accident in cases of brain tumor, particularly in tumor of the cerebellum, and there is decided danger in severe traumatic compression of the brain. The flow should be spontaneous and suction ought not to be used. After operation the patient must remain in bed for twenty-four hours, with the head low for the first twelve hours. The erect posture is to be assumed gradually. To let a patient sit up or walk about soon after puncture is dangerous. Sometimes nausea, vertigo, and severe headache follow the operation, and sudden deaths have been reported. It is probable that lumbar puncture is free from danger in a healthy person. It has certain dangers in uremia, intracranial hemorrhage, and intraspinal hemorrhage. It brings definite peril in meninigitis, brain abscess, and brain tumor because it may cause the brain-stem to sink in the foramen magnum and so be responsible for respiratory failure. If we decide upon puncture in a case in which brain tumor is suspected, keep the patient recumbent for at least twenty-four hours before the operation, perform the puncture while the patient is upon his side and the head is lower than the body, keep him in bed for forty-eight hours after operation, the head being kept low for the first twelve hours of this period. The erect position is to be assumed gradually (Schoenbeck in "Arch. f. klin. Chir.," 1915, cvii).

The Mingazzini-Foerster Operation in Tabes.—Painful crises of tabes are not connected with the vagus, but originate in the posterior roots. Mingazzini suggested intradural division of the posterior sacrolumbar nerve-roots for unbearable pain in the lower extremities due to tabes.

Foerster follows a like method in treating gastric crises. He divides the posterior dorsal roots on both sides from the sixth to the ninth. Sauvé divides the posterior roots from the fifth to the eleventh. Some of these operations have been notably successful. Many have failed (Leriche, Delbet, Nocquot). In at least one case the condition was aggravated (Doerr in the "Wien. med. Woch.," No. 45, 1911). Intradural operations have a decided mortality. For the pains and crises of tabes some surgeons advise extradural division within the canal of the posterior roots (Guleke). Frankl advocates an operation without laminectomy. He exposes the intercostals from the fifth to the seventh and avulses them with the corresponding posterior roots. Jaboulay employed stretching of the solar plexus. Delbet and others find it useless. It is necessary to remember that tabetic crises occur only early in tabes and cease later when the root fibers are destroyed. Operation is justifiable only when nutrition is dangerously interfered with, or when the pains occur so violently and often as to be unbearable. The posterior roots may be divided for spastic paralysis, for intractable neuralgia, and for athetosis. The roots selected depend upon the area of palsy, the seat of pain, or the region of athetosis.

Chordotomy (*Schuller's Operation*).—This operation should only be attempted by

a trained neurologic surgeon. Its aim is the relief of pain and it substitutes anesthesia for pain. The cord has been incised for spasticity, gastric crises, the pains of meningomyelitis, and of inoperable tumors of the spinal cord. The columns divided and the level selected depend upon the condition. The operation may mean division of the anterolateral columns, of the cerebellar tracts, of the posterior columns, or a median longitudinal incision ("Surgery of the Spinal Cord," by Charles H. Frazier).[1]

Intradural Root Anastomosis in Cases of Vesical Paralysis.—Kilvington ("Brit. Med. Jour.," 1907, vol. i) suggested intraspinal anastomosis of nerve-roots. He found by experiments on dogs that the last lumbar root, when joined to the roots of the second and third sacral nerves, gives contraction to a palsied bladder. Bird, at the suggestion of Kilvington, did the operation on a human being, but it was a failure. Frazier, in a case of Mills's, anastomosed the root of the last lumbar to the roots of the third and fourth sacral nerves. There was decided improvement (Frazier and Mills, "Jour. Amer. Med. Assoc.," Dec. 21, 1912). N. Sharpe ("N. Y. Med. Jour.," 1916, civ) advocates the operation for paralysis of the lower limbs when little or no improvement could be expected from braces or tendon transplantation. He advocates using the twelfth dorsal, the second lumbar, or the third lumbar as the energizing root. He advocates a two-stage operation. The first stage is laminectomy; in the second, the theca is opened and the anastomosis made.

Horsley's Operation for Chronic Spinal Meningitis and the Decompression of Bailey and Elsberg.—Sir Victor Horsley ("Brit. Med. Jour.," Feb. 27, 1909) states that during the past ten years he has operated on a number of cases for what he calls chronic spinal meningitis. Such cases are commonly confused with tumor, are much more frequent than tumors, and are often cured or greatly improved by operation. The first published case of this sort was reported by Spiller, Musser, and Martin ("Univ. of Penna. Med. Bulletin," March, 1903). Martin performed laminectomy, found a "circumscribed meningitis," and cured the patient. In these cases a fluid accumulation is found and this fluid is stagnating and under pressure. The cord passes into a condition of sclerogliosis. The symptoms are pain, advancing loss of power in the legs, perhaps slight kyphosis, and eventually progressive and fatal paraplegia (compression paraplegia).

The pain in these cases involves an extensive area, not as in extramedullary tumor a small area supplied by one or two nerve-roots, and there may be hyperesthesia over an entire extremity, which does not occur in extramedullary tumor (Horsley, Loc. cit.). Horsley has never seen absolute abolition of tactile sense. The operation consists in laminectomy, opening the theca, washing it out with mercurial solution (1 : 500 followed by 1 : 2000), and closing without drainage. Bailey and Elsberg ("Jour. Amer. Med. Assoc.," March 9, 1912) suggest the term *spinal decompression* for laminectomy and opening of the dura when no lesion is located or found. They believe that in such cases the laminectomy and opening of the dura do the good. A number of other intradural conditions may perhaps be benefited by the operation. Some remarkable cases have been reported. I operated on a case of supposed transverse myelitis. On inspecting the cord no lesion was discovered, yet the patient made an apparently complete recovery from his trouble. I am satisfied that in some cases the operation is of great value. Why it ever improves a case I do not know. That it may I do know. In none of the cases reported by Bailey and Elsberg were there any signs of pressure. Elsberg ("Jour. Nervous and Mental Dis.," 1911) pointed out that laminectomy and incision of the dura often produce an immediate effect on spinal reflexes. In many cases within half an hour knee- and ankle-jerks become depressed and remain so from several hours to twenty-four hours. This condition probably results from change of pressure modifying circulation. Elsberg and Bailey ("Jour. Amer. Med. Assoc.," June 10, 1916) advocate exploration in the cervical and dorsal regions, but caution us not to expose the cauda equina without very strong indications. The cauda is extremely sensitive to pressure changes, and bladder and rectal symptoms may arise after mere exposure of the conus.

XXIV. SURGERY OF THE RESPIRATORY ORGANS

(Dr. Hubley R. Owen, Chief Surgeon of the Fire and Police Departments of Philadelphia, and Professor of Clinical Surgery in the Woman's Medical College, who has had a large experience in cases of asphyxia, did me the favor to revise the section on Asphyxia.)

Asphyxia.—By asphyxia or apnea is meant incomplete oxygenation or non-oxygenation of the blood arising from interference with or cessation of the respiratory act.

[1] Cortical spasticity may be treated by lumbar sympathectomy.

If the respiratory act is labored and difficult, but has not ceased, the condition is termed "dyspnea."

We apply the name of orthopnea to the upright sitting posture assumed by a patient with severe dyspnea.

Asphyxia is a common mode of death. A man may be apparently dead from asphyxia and yet be capable of resuscitation. If breathing has ceased for ten minutes from drowning, poisoning by carbon monoxid gas, electric shock, effects of an anesthetic, or any other form of asphyxia, its restoration is usually impossible (Henderson, "Jour. Amer. Med. Assoc.," 1916, vol. 67).

The terms "smothering," "stifling," and "suffocation" mean prevention of the entry of a sufficient amount of air into the lungs to properly aërate the blood.

The causes of asphyxia may be classified as follows (Rose and Carless, 9th ed., page 929):

1. Conditions arising from the presence of abnormal contents within the air passages, such as, a foreign body, blood from a ruptured aneurysm or cut throat, pus from an abscess, water in cases of drowning, serum, as in edema of the lungs, diphtheritic membrane, or the presence of poisonous gases, such as carbon monoxid, carbon dioxid, etc.

2. Causes arising in the walls of the air passages, such as, diminution of their lumen from inflammatory congestion, as in edema of the glottis; cicatricial cyanosis; neoplasm; or occlusion by the root of the tongue after partial excision of that organ.

3. Extrinsic causes are those arising outside the air passages, such as, strangling; hanging; garroting; the presence of tumors, such as goiter; retropharyngeal abscess; and, under exceptional circumstances, displacement backward of the sternal end of the clavicle.

Asphyxia may also be caused by great pressure on the chest or abdomen, and acute pneumothorax.

Asphyxia may be due to paralysis of the respiratory center, as from an overdose of chloroform.

Asphyxia may be due to an overdose of any of the anesthetics, such as ether or ethyl chlorid.

Severe electric shock may cause asphyxia, either by the resulting muscular spasm or because of actual respiratory paralysis.

Symptoms of asphyxia may arise suddenly or slowly, depending upon the cause. Foreign body in the air passages, edema of the glottis, severe trauma of the chest, electric shock, or hanging may cause immediate symptoms of suffocation. There is apnea. The face becomes cyanotic; the eyes are prominent, sometimes even bulging; the patient clutches at the throat, or even tears the tissues of the neck in an attempt to relieve the feeling of suffocation; the veins of the neck are prominent; the pulse is rapid and weak; the individual may bleed from the nose, rectum, or other mucous membranes; and there may be involuntary passage of urine; the chest heaves, making respiratory attempts; and, after a short time, the heart stops beating.

Although there may be complete apnea and the patient may be apparently dead, yet the cardiac action may be perceptible for some minutes after the patient has ceased to breathe.

Asphyxia caused by illuminating gas, smoke, or sewer gas may cause initial symptoms of giddiness, nausea, vomiting, rapid pulse, and rapid respiration before actual apnea occurs.

Treatment in General.—The treatment of asphyxia depends largely upon the cause.

In general it may be said that the surgeon should at once endeavor to determine the cause and should particularly ascertain if the symptoms arose gradually or suddenly. As a rule, a gradual asphyxia is due to some intrathoracic lesion. If the asphyxia occurred suddenly the surgeon must examine the neck and chest externally to detect any sign of injury. The mouth should be examined, the tongue pulled forward, and the glottis felt by the finger to see that no foreign body is blocking the upper air passages. A foreign body, such as a toy, is not an uncommon cause of asphyxia in a child. A drunken man will occasionally choke while attempting to swallow food too fast or food improperly masticated. High foreign bodies can be removed with the finger or with a hemostatic forceps. A drunken man may be asphyxiated by vomitus.

The patient will do best in a free draft of fresh air.

It may be possible to excite respiratory activity by dashing hot water and then

cold water on the face and chest. A number of these alternate applications should be made.

The application of electricity to the phrenic nerve may be helpful (the anode at the root of the neck and the cathode over the epigastric region).

If there is cardiac dilatation, bleeding is urgently indicated.

When the patient is breathing, inhalations of oxygen, or 95 per cent. of oxygen and 5 per cent. of carbon dioxid, are indicated.

If laryngeal obstruction is present, tracheotomy or intubation should be performed.

In most cases of asphyxia artificial respiration is necessary.

Artificial respiration is resorted to in case of suspended breathing from any cause.

Among the more frequent causes are: The inhalation of smoke, illuminating gas or other poisonous gases; drowning; profound anesthesia; opium-poisoning, and electric shock.

It should be inaugurated at the earliest possible moment.

There are several methods of artificial respiration. One method may have an advantage over another in a certain type of case, as will hereafter be described.

Before resorting to any method the author deems it advisable to loosen the clothing about the neck, chest, and abdomen and to free the mouth of any foreign body, such as false teeth, mucus, chewing gum, tobacco, etc. In many articles giving instructions as to the manner of instituting artificial respiration it is frequently stated not to delay even sufficiently long to loosen or cut the clothing. If two persons are present, it is well for one to immediately begin the artificial respiration and the second to examine the mouth for foreign bodies, and to cut or loosen the clothing.

Artificial respiration should never be delayed until we can transport the patient to a room or to a house, as such delay might be fatal. Of course, the patient should be taken to the fresh air if asphyxia was due to illuminating gas or other poisonous gases, but as soon as fresh air is reached artificial respiration must be at once instituted.

Never delay artificial respiration in anticipation of the arrival of any mechanical apparatus for performing it.

In a case of drowning artificial respiration should be instituted at once. The patient is removed from the water, whether it be to a boat, a pier, or the beach. Do not wait to transport the patient to any building, tent, or hospital.

If edema of the glottis, malignancy of the tongue, or if any immovable foreign body obstruct the air passages, tracheotomy should be performed before attempting artificial respiration.

When making artificial respiration the operator should not desist because respirations are not established in a few minutes, but, on the contrary, should persist for an hour or more. Cases of drowning, opium-poisoning, asphyxia from smoke, etc., have been resuscitated after artificial respiration had been administered for almost an incredible period of time.

During the performance of artificial respiration it should be remembered that the patient must be cared for as in shock—the body kept warm, frictions being applied by the hands or rough towels, and massage being practised over the heart.

Enemas of hot coffee and stimulating hypodermic injections should be given.

The author prefers an enema of 5 ounces of coffee with 1 ounce of brandy, and a hypodermic injection of camphorated oil or of strychnin, gr. 1/20, or atropin, gr. 1/75.

One of the oldest methods of artificial respiration and the one most suited to children is mouth-to-mouth insufflation. In this method the operator holds the child's tongue forward with a suture, holds the patient's nostrils closed, and then, after taking a deep inspiration, blows directly into the patient's mouth. The air is then expelled from the patient's lungs by direct pressure on the walls of the thorax. This procedure is repeated sixteen times a minute.

Artificial respiration should never be stopped when the patient has taken one or two breaths, but should be continued until respiratory movements have become regular and normal.

The patient must be carefully watched for fear of secondary apnea.

While making artificial respiration the operator must be careful not to use too great violence, as harm, rather than good, might then result.

Hall's Method.—The first systematic attempt to deal with the subject of artificial respiration was that of Marshall Hall in 1857. His method was adopted by the Royal

Humane Society and by the National Life Boat Institution. The following directions were given for performing this method:

"Place the patient on his face, supporting the chest on a folded coat or other article of dress. Turn the body very gently, but completely, on the side and a little beyond, and then directly on the face—alternately repeating these measures deliberately, efficiently, and perseveringly fifteen times a minute only. (When the patient reposes on the thorax, that cavity is compressed by the weight of the body and expiration takes place. When he is turned on the side this pressure is removed and inspiration occurs.) When the prone position is resumed make equable, but efficient pressure with traction along the back, removing it immediately before rotation on the side. (The first measure augments the expiration; the second commences inspiration".)

Silvester's Method.—In the following year, 1858, Dr. Henry R. Silvester ("Brit. Med. Jour.," 1858, p. 576) came to the conclusion that the proper manner of performing artificial respiration was to imitate as nearly as possible the natural movements, and especially the elevation of the ribs. The Silvester method is popular among many. It cannot be used if there has been any injury to the chest or to either arm. It cannot be used in a pregnant woman. To make artificial respiration by this method the patient is placed on his back, with a folded coat or blanket under the shoulders. The mouth is



Fig. 665.—Silvester's method of artificial respiration. Step one.

examined for foreign bodies; the tongue is pulled forward and held by forceps or a suture, or tied with a string. The operator, kneeling at the head of the patient, grasps the forearms between the elbows and wrists and circumducts the arms upward and outward, meanwhile making traction until the arms are perpendicular to the body (see Fig. 665). By this movement the chest is expanded and inspiration is accomplished. The arms are now brought slowly to the sides of the chest and firm pressure is made for two to three seconds, thus forcing air from the lungs and causing expiration (Fig. 666). This procedure should be repeated fifteen times a minute.

In 1871 Howard described a method ("Brit. Amer. Med. Society," 1871, vol. 22). The procedure as laid down by Dr. Howard is as follows:

"*Rule No. 1.*—To expel water from the stomach and lungs strip the patient to the waist and if the jaws are clenched separate them and keep them apart by clasping between the teeth a cork or small piece of wood. Place the patient face downward, the pit of the stomach being raised above the level of the mouth by a roll of clothing placed beneath it. Throw your weight forcibly two or three times upon the patient's back over the roll of clothing, so as to press all the fluids in the stomach out of the mouth.

"*Rule No. 2.*—To perform artificial respiration quickly turn the patient upon the back, placing the roll of clothing beneath it, so as to make the breastbone the highest point of the body. Kneel to the side or astride of the patient's hips, grasping the front part of the chest on either side of the

pit of the stomach, raising the fingers along the spaces between the short ribs. Brace your elbows against your sides and steadily grasping and pressing forward and upward, throw the whole weight upon the chest, gradually increasing the pressure while you count 'one,' 'two,' 'three.' Then suddenly let go, with a final push, which springs you back to your first position. Rest erect upon your knees while you count 'one,' 'two.' Then make pressure as before, repeating the entire motions at first about four or five times a minute, gradually increasing them until about ten or twelve times. Use the same regularity as in blowing bellows and as seen in natural breathing, which you are imitating. If another person is present let him with one hand, by means of a dry piece of gauze, hold the tip of the tongue out of one corner of the mouth, and with the other hand grasp both wrists and pin them to the ground above the patient's head."

This method is not applicable if there is any injury to the chest nor in a woman who is pregnant.

Laborde's Method.—In 1897 Dr. J. B. V. Laborde ("Le Traitement Physiologique de la Mort") described his method of artificial respiration. Laborde's method is only indicated when the Schäfer method is contraindicated. Laborde's method rests on the assumption that systematic and rhythmic traction on the tongue produces respiratory reflexes and causes contractions of the diaphragm, hence establishing respirations. The tongue is grasped by forceps or by a piece of gauze held between the forefinger and thumb and is pulled well out of the mouth with considerable traction. It is held for



Fig. 666.—Silvester's method of artificial respiration. Step two.

two or three seconds and is then relaxed. This procedure is repeated about fifteen times a minute. When a certain amount of resistance is felt it is a sign that respiratory function is being restored. Noisy respiration first occurs, termed "inspiratory hiccough." It can be readily realized that Laborde's method cannot be used if there is disease or injury of the tongue.

Bowles's Method.—The following method is described by Dr. R. L. Bowles:

"Treat the patient at once, on the spot. Undo any tight clothing. Kneel and place the patient on the right side and quickly wipe out the mouth and throat. If there are no signs of breathing spread a handkerchief on the ground where the patient's mouth will come and carry out movement No. 1. Turn the patient flat on the stomach and at once, with wide-spread hands, press gently but firmly for three or four seconds on the back of the ribs and on both sides to squeeze out the froth, fluid, or foul air. Then suddenly remove the hands to allow entrance of air by the natural recoil of the ribs and proceed to Movement No. 2. With the right hand grasp the patient's left shoulder and, with the left hand, take his left wrist, place it against his left hip, and roll him upward over on his right side. This movement should take about two seconds. Repeat first and second movements in succession for ten minutes, or more if necessary, when some of the froth or fluid will have drained away from the lungs, and then proceed to Movement No. 3. Each time the patient is rolled from the stomach to the right side take hold of the left or uppermost arm and raise it above the head in a line with the body (Fig. 667). This movement expands the chest still more and

allows air to enter the upper left lung. Then bring the arm down to the side, roll the patient on the stomach (Fig. 668) and begin again at Movement No. 1, and continue each movement in succession as before for an hour, or until signs of natural breathing begin. Always turn the



Fig. 667.—Bowles's method of artificial respiration. Step one of movement three.

patient on the right side, never on the left, and under no circumstances on the back. From time to time wipe away the froth from the mouth and nose. The neck should be kept fairly straight



Fig. 668.—Bowles's method of artificial respiration. Step two of movement three.

and the chin away from the breast-bone; the head may then be left to take care of itself, and the face will take no harm, as it will remain chiefly on its side, and yet perfect drainage will be insured."

Schäfer's Method.—It is the approved method of artificial respiration for asphyxia from any cause, providing there has been no injury to the chest. This method is



Fig. 669.—Schäfer's method of artificial respiration. Step one.

contraindicated in a woman who is pregnant. This method has been adopted by the Bureau of Mines, Washington, by the Conference Board of Physicians in Industry,



Fig. 670.—Schäfer's method of artificial respiration. Step two.

by the National Association of Police and Fire Surgeons ("Transactions Royal Medical and Surgical Society," 1904, vol. 87, p. 809, and "The Harvey Lectures," 1907–08, page 223).

The following is the method as described by Dr. Schäfer in his Harvey Lecture:

"This method, which I have called the prone pressure method of artificial respiration, is performed in the following manner: The subject, whether a drowned person or not, is allowed to lie prone, *i. e.*, face downward, no preliminary manipulation of the tongue being required. The operator kneels or squats either across or on one side of the subject facing the head, and places his hands close together flat upon the back of the subject over the loins, the fingers extending over the lowest ribs. By now leaning forward upon the hands, keeping the elbows extended, the weight of the operator's body is brought to bear upon the subject, and this not only compresses the lower part of the thorax but also the abdomen against the ground, the pressure being fairly equably distributed (Figs. 669, 670). The result of this is that not only is the thorax diminished in extent from before back, but, owing to the pressure which is communicated to the abdomen, the viscera are compressed and tend to force the diaphragm up, so that the thorax is diminished in capacity from above down. This is no doubt the reason why the pressure method when applied in the prone position is more effective than when applied, as by Howard, in the supine position. The pressure is applied not violently, but gradually, during about three seconds, and is then released by the operator swinging his body back, but without removing his hands. The elasticity of the chest and abdomen cause these to resume their original dimensions and air passes in through the trachea. After two seconds the process is again commenced and is continued in the same way, the operator swinging his body forward and backward once every five seconds or about twelve times a minute, without any violent effort and with the least possible exertion. This last condition, viz., the absence of muscular exertion other than that involved in swinging forward and backward, renders it possible to continue the process without fatigue for an indefinite time. It can further be carried out unaided, by a woman almost as well as by a man, by children upon children; it hardly requires to be taught—a simple demonstration sufficiently teaches it to a large audience. Its advantages in drowning cases over any method which involves the supine position are sufficiently obvious, for with it there is no risk of obstruction by water or mucus or the contents of the stomach, which cannot accumulate in the throat, but must come away by the mouth; and the tongue, in place of falling back, as in the supine position, falls forward, and is unable to produce obstruction.

"The Royal Life Saving Society has now decided to teach this method to the exclusion of any other. I have little doubt that this decision will result in the saving of many lives which would certainly be sacrificed by the employment of the comparatively complex methods hitherto practised. For these require special training and in some cases considerable muscular power to carry out, and some at least are of doubtful efficacy."

Intratracheal Insufflation.—This consists in forcing air by external pressure through a tube which passes through the mouth and larynx into the trachea. The air, under the influence of the same force which drove it in, emerges between the tube and the tracheal wall. The air stream is to be interrupted several times a minute for only about two seconds at a time (S. J. Meltzer in "Keen's Surg.," vol. 6). (See Insufflation Anesthesia, page 1205.)

Artificial Respiration by Mechanical Apparatus.—The first mechanical device employed for rendering artificial respiration was described by Horwath, and later by Dr. George Fell ("Buffalo Med. and Surg. Jour.," vol. 28, 1887–88, page 14). This consisted of an ordinary bellows to which was attached a rubber tube. The tube was inserted into one nostril, the other nostril was left open, but the mouth held closed. By sudden compression of the bellows the lungs are inflated to a considerable extent, and by repeating this inflation rhythmically respirations can be continued. In extreme cases this method was used with the tube inserted into the trachea, either through the mouth or after a preliminary tracheotomy.

The **pulmotor** and the **lungmotor** are devices for the administration of artificial respiration. Neither apparatus has lived up to the expectation held by most, and many observers believe that both are dangerous. The Bureau of Mines and the National Association of Police and Fire Surgeons strongly advise against the use of either apparatus. The Schäfer method is the method of choice (Y. Henderson, "Jour. Amer. Med. Assoc.," 1916, lxvii; "Transactions Association of Police and Fire Surgeons," 1923; "Report of the Amer. Gas Association," 1923; "Report of the Committee on Resuscitation from Mine Gases," Technical Paper No. 77, Dept. of the Interior, Bureau of Mines, Washington, 1914; "Amer. Gas Association, Accident Prevention Report of Committee," 1923, pages 14, 15):

"Since at the present time the use of resuscitation apparatus, such as the lungmotor and the pulmotor, is wide-spread, and since it is evident that if such apparatus is at hand it is employed, even if the breathing of the patient requires no assistance, the question arose as to whether exuberant use of positive pressure ventilation might not cause immediate cardiac or circulatory failure in seriously gassed patients. It is known that artificial respiration of positive type increases, at each blow, the pulmonic blood-pressure by compressing the pulmonary capillaries. The load which can

be thrown suddenly upon the right ventricle in this way may be considerable, and, accepting the fact that such machines as the lungmotor and pulmotor occasionally do drive the full air delivery of the instrument into the alveoli, the possibility of doing harm is easily recognized. It has, however, been shown by workers for the commission in a series of experiments upon cats, poisoned with illuminating gas, that this apprehension in regard to positive pressure respiration apparatus is unfounded. In the same investigations lung rupture did not occur even though extreme pressures were used.

"Since pneumonia is a fairly frequent and very serious sequel of gas poisoning and since one-fourth of gassed patients receiving hospital treatment have excess fluid in their respiratory tracts, the question was asked as to whether positive ventilation, if effective, might not aid in the distribution of infected mucus to the alveoli and so increase the incidence of pneumonia. A series of experiments upon dogs and cats has shown that artificial respiration carried on through a mask by an instrument such as the lungmotor does cause an increase in the amount of tracheal material which reaches the lungs. The possibility, therefore, exists that positive pressure artificial respiration, operating through a face mask, may increase the incidence of pneumonia after gassing.

"Since little data exists as to the actual ventilating efficiency of the lungmotor and the pulmotor, experiments have been performed upon dogs which have shown that, while non-breathing animals (curarized) can be kept in good condition by such devices, the amounts of air delivered have to be modified in accordance with the condition of the animal at the moment. An experienced physiologist can do this successfully, but out of medical hands and with the simple directions which can be given non-medical life savers, it is not probable that the machines can be operated with the success that is attributed to them.

"The investigators were surprised to find how readily small amounts of obstruction in the upper air passages stopped the air flow when positive ventilation was being used. It is this fact which necessitates constant watchfulness upon the part of the operator and readiness to adapt the volume of air delivered to the needs of the patient.

"A further practical difficulty in using positive pressure respiration through a face mask was found in experiments upon individuals apneic after forced breathing and upon the bodies of persons dead less than two hours. This consists in the ease with which leaks occur around the edges of the mask. These leaks are invariably greater when air is blown in than when it is sucked out, since during the latter maneuver the skin of the face is drawn against the rim of the mask and seals off some of the leakage. As a consequence, the victim, upon whom the face mask is not adjusted with the greatest accuracy, experiences a gradual diminution in the size of the chest, and an interference with alveolar air exchange which cannot be advantageous.

"Finally, the question of the actual efficiency of the Schäfer prone pressure method of artificial respiration was reviewed and the conclusion reached that this method is even more efficient than has been supposed. That is, evidence exists which indicates that the Schäfer method is not simply our best reliance for brief emergencies but that, through its use, life may be sustained over considerable periods of time in persons unable to breathe." ("Report of the Committee on Resuscitation from Mine Gases," Ibid.)

The development of a new procedure, due to the work of Dr. Yandell Henderson and H. W. Haggard, is a most important contribution to the treatment of asphyxia (see page 844).

Carbon Monoxid Poisoning.—Carbon monoxid is a colorless, odorless, tasteless, neutral gas, lighter than air and almost insoluble in water. It is physiologically harmless and inert, excepting in one respect, and that is, it forms a compound with the hemoglobin called carbon monoxid hemoglobin, which nullifies the power of the red blood-corpuscles to carry oxygen to the tissues. Carbon monoxid has an attraction for hemoglobin 250 times greater than oxygen, but it forms no permanent compound with the blood, nor does it induce any lasting destruction in the oxygen-carrying power. The action of carbon monoxid in the body is purely asphyxial. The damage to the tissues occurs during the time they are deprived of oxygen. No further damage occurs after the blood is freed of carbon monoxid, but degeneration caused by the damage may go on. Air containing 0.05 and 0.02 per cent. of carbon monoxid may be dangerous if inhaled over a long period of time; 0.2 per cent. inhaled for four or five hours, 0.4 per cent. for one hour, or only a few inhalations of 2 to 5 per cent. may cause death. If a man breathes 0.1 per cent. of carbon monoxid air he will absorb 0.007 pint per minute. The blood may be one-half saturated, or contain 1 pint of carbon monoxid before the average man becomes weakened. He must breathe 0.1 per cent. for two and one-quarter hours before the blood becomes half saturated. A working man breathes three times the amount of air used by a man at rest, hence he would be effected in one-third the time. Workers who are exposed to small quantities of carbon monoxid gas for a long period of time may establish a great tolerance. Such workers have a marked polycythemia, 5,500,000 to 5,600,000 red blood-cells per cubic millimeter. The hemoglobin remains normal, but there is a marked increase of the eosinophils. As long as nature is able to compensate there may be no symptoms, but sooner

or later there is a break in the compensation, nature is no longer able to form the new blood-corpuscles and serious symptoms may ensue. The red blood-cells and hemoglobin are both decreased; anemia, digestive symptoms, nervous symptoms, anorexia, and insomnia may follow.

Carbon monoxid is the poisonous element in illuminating gas, in the gas exhausted from automobiles, and the ordinary smoke from fires. It is also found around blast furnaces. Coal gas contains 7 per cent.; water gas, 30 per cent. It exists in engine rooms where gas engines are used, around coal, coke, and charcoal fires, where there is incomplete combustion, and carbon monoxid is sometimes found in living rooms where an open fire is used. The gas may be found in buildings having defective furnaces, chimneys, or gas stoves without flue connections. It is also found in stoke rooms, in gun turrets on battleships, in petroleum refineries, and in the LeBlanc soda process in cement and brick plants. In underground work carbon monoxid may appear as the result of shot-firing, mine explosions, mine firings, or in tunnels from automobile gases, or from coal- or oil-burning locomotives (Dr. R. R. Sayers and H. R. O'Brien, "Public Health Reports," vol. 37, Part I, 1922, page 271).

Deaths have been reported resulting from working in a closed garage where an automobile engine was left running. Some of the deaths were accidental, while others were suicidal. It is an easy and painless way to commit suicide, and leaves but little suspicion.

An analysis of the exhaust from a medium-sized automobile shows 4 per cent. carbon monoxid, 3.6 per cent. carbon dioxid, 12 per cent. oxygen, and 80 per cent. nitrogen.

Traffic patrolmen in congested and narrow streets of the city, where automobile traffic is held up at frequent intervals, often complain of frontal headache, anorexia, dizziness, and nausea at the end of a day's work. These same symptoms are often found among employees of garages and auto repair shops, especially if such garages and repair shops are poorly ventilated.

Experimental studies of the presence of carbon monoxid in the air along Fifth Avenue, New York, showed the presence of much carbon monoxid. (For quantitative determination of carbon monoxid in the air see article by R. R. Sayers, W. P. Yant, and G. W. Jones in "Safety Engineering," Sept., 1923.)

On a damp, humid day the amount of carbon monoxid was increased. Towers for patrolmen on traffic duty may relieve the danger of this condition.

Poisoning by illuminating gas becomes more common each year. In 1922 there were 1100 deaths caused by illuminating gas reported by ten of the largest companies in the United States—791 were suicides and 309 accidental (Report "Amer. Gas Association," 1923, 342 Madison Ave., New York, page 39). In 1923 there were 211 deaths from illuminating gas in Philadelphia—88 were suicides (30 per cent. of all suicides—284—were due to illuminating gas) and 123 were accidental. The number of cases has increased since the substitution of the so-called water gas for coal gas. The coal gas formerly used was not nearly so dangerous. Coal gas contains about 7 per cent. carbon monoxid. In comparatively recent years, however, in order to reduce the cost and simplify the manufacture, water gas has been used. This is developed by forcing steam through incandescent coals or coke. To this water gas hydrocarbons are added (methane, etc.). Jones in "Amer. Jour. Med. Sci.," 1909, vol. 137, gives as further reasons for the marked increase in poisoning by illuminating gas, first, the concentration of the population in cities; second, increased susceptibility to emotional states and insanity. Suicide from illuminating gas has grown in frequency, due to the means being at hand, the known painless nature of the death, and also to the fact that the sale of certain toxic drugs to the layman is now forbidden.

It is a well-known fact that the leak may not be in the building itself, but the gas, having escaped from a broken main, may travel through the ground, following the pipes leading to a house, for some distance, and finally enter the cellar of a house, and eventually find its way through the entire house. This is especially likely to occur in winter when the heating of the building causes active motion of the atmosphere, thus drawing gas into the house by aspiration.

The leak may occur from faulty meters, especially the slot meter requiring the inmates of a house to deposit a coin for the use of so many cubic feet of gas. Leaks may be caused by breaks in gas mains due to the constant and heavy traffic over our city streets.

Employees of gas companies are occasionally overcome while working in the ditches in the city laying or repairing gas mains. Yet among all such cases that have

occurred in the city of Philadelphia there has been no fatality. This is due to the careful first aid instruction given to the men by the physicians connected with the United Gas Improvement Company. The men are not only instructed, but they also carry a first-aid kit, and are competent to give immediate first-aid treatment not only to fellow employees, but to the general public.

Symptoms of Carbon Monoxid Poisoning.—*Illuminating gas poisoning* has been divided into the acute and chronic forms. There is some evidence in reports, to support the theory of chronic gas poisoning. Dr. F. S. Rossiter, of the Carnegie Steel Co., in a personal communication states that from his own observation of workers who are exposed to small quantities of carbon monoxid gas for long periods of time he has noticed an undoubted conservative action on the part of nature to establish a great tolerance for carbon monoxid. At first nature tries to compensate by forming more red blood-corpuscles; that is, a polycythemia. The percentage of hemoglobin remains about normal, but there is an increase in eosinophils. No embryonal nor other unusual forms of corpuscles are formed. The color of the blood is cherry red, due to fixation of the hemoglobin by the carbon monoxid gas. As long as nature is able to compensate there may be no symptoms, but sooner or later there is a break in the compensation, and nature no longer forms the new red blood-corpuscles. There develops a leukopenia, a reduction in the hemoglobin, and a series of symptoms resulting in anemia, digestive symptoms, nervous disturbances, anorexia, constipation, and general debility (page 839).

Rossiter also states that there may be no impression on the nervous system, and that the workmen may become sluggish and show a deficiency in muscular power, as well as a sluggish mentality.

The investigating commission of occupational diseases in Illinois reported that of 24 workers in various plants who were frequently exposed to gas very few were found to be in good physical condition. It was extremely difficult to say how much of this was due to the gas and how much to alcoholism, venereal diseases, and insanitary living. The majority seemed to be below the average mentally. Ninety-seven per cent. used alcohol—70 per cent. admitted they used it to excess. One constant and suggestive feature presented itself, and that was the deficient muscular power, as indicated by the hand dynamometer. Some workmen complained of loss of memory, indigestion, headache after leaving work, loss of sexual power, and general malaise—while others had no symptoms whatsoever of the cumulative action of gas.

Several factors are involved in gassing, such as the length of exposure to the gas, the percentage of carbon monoxid in the gas, the personal idiosyncrasies and general condition of the patient. Irregular habits, alcoholism, poor health, and chronic constipation appear to render the patient more susceptible. The poisonous action of the gas is accelerated by increased exertion, such as running, lifting, climbing, etc., due to the increased rapidity of breathing. While at rest only about one-third of the oxygen brought by the blood to the tissues is used. About two-thirds is used during muscular exertion, hence the blood may become one-third saturated with gas while at rest and no symptoms be experienced, but if the patient becomes active he may collapse because of the deficiency of oxygen.

A workman may be exposed to a small amount of gas all day. His work may not require much physical exertion, but perhaps after he leaves his work it may be necessary for him to climb a steep hill. When he reaches the top he may collapse, proving that as long as he does not exert himself too much a sufficient amount of oxygen is carried by the blood to his tissues, but the extra amount demanded by the climbing cannot be supplied because his blood is partially saturated with carbon monoxid.

Again, if a man is working in an atmosphere of carbon monoxid and leaves it to recuperate, but returns before all of the carbon monoxid in his blood has been displaced, it is obvious that it will not take as much gas to bring his blood up to the point of partial saturation, and he will feel the effects in less time than if he had not been previously exposed to the carbon monoxid.

Atmospheric conditions play some part in gassing, as there is more rapid diffusion of the gas on a clear, windy day. On damp, foggy days the atmosphere seems to act as a blanket, preventing the diffusion of the gas.

The first symptoms usually noticed are dimness of vision, yawning, malaise, and frontal headache. During the early stage there is occasionally cerebral excitement. The pupils are dilated; the pulse is slow from stimulation of the pneumogastrics, the temperature usually remains normal; the cutaneous vessels are dilated; the limbs are weak, especially the knees; there is dizziness, nausea, and perhaps vomiting. There

may be muscular twitchings. There is a feeling of discomfort in the head, vertigo or dizziness, often preceded by a throbbing sensation in the head or throbbing of the vessels of the neck. There is a rise in the blood-pressure. There is rarely actual dyspnea, but if the poisoning is sudden there may be cyanosis.

The above symptoms may be termed the first stage of gas poisoning.

In the second stage the patient is unconscious, but respirations are still in progress. The respirations may be rapid and stertorous, or may be of the Cheyne-Stokes type. The blood-pressure falls; temperature may be elevated; the pulse is increased in rate; there may be loss of power in groups of muscles and the sphincters. At times there are tetaniform convulsions. The temperature varies from 99° to 103° F. Occasionally the temperature may rise rapidly, reaching 105° to 110° F. These cases usually terminate fatally. A great rise of temperature is usually coincident with the development of edema of the lungs. The high fever is not due to the edema, but is probably due to the overwhelming toxemia. There is loss of control of the reflexes due to the action of the gas on the cortical centers. This toxemia is purely hemolytic in origin. The tongue is swollen and is cherry red. The same peculiar cherry red color makes its appearance on the neck, trunk, and buttocks. The blood, if drawn, is seen to be bright cherry red in color, and will show, by the spectroscope, the presence of carbon monoxid.

Following the above symptoms apnea is noted, the heart becomes very rapid, weak, and intermittent; there is muscular rigidity; the jaws may be stiff; the hands assume the tetany position; the toes are extended; the skin is usually cyanosed, cold, and dry, and occasionally blebs appear on the extremities and on the back.

At the time of death the hemoglobin is usually combined with the carbon monoxid gas to the extent of 60 to 80 per cent.

Edsal ("Jour. Amer. Med. Society," 1907) believes that, with the exception of the spectroscope, the best test is the Hoppe-Seyler test. The blood containing carbon monoxid if treated with twice its volume of a solution of sodium hydrate gives a cherry red color when spread on a porcelain plate, while blood not containing carbon monoxid is changed to a dirty brownish mass.

Katagamas's test consists in adding to 10 c.c. of blood, diluted with water, 2 c.c. of ammonium sulphid solution, and 2 c.c. of 30 per cent. acetic acid. Carbon monoxid blood gives a bright red precipitate, while normal blood gives a greenish precipitate.

These tests should be used in cases of coma of uncertain origin. Pettenkofer insists upon the importance of searching for gas poisoning as the cause of the trouble when various persons in the same house have a tendency to awaken in the morning with headache and nausea.

For the pyrotannic acid method for the quantitative determination of carbon monoxid in the blood and air see article by R. R. Sayers, W. P. Yant, and C. W. Jones in "Safety Engineering," Sept., 1923. This test is performed as follows:

> To a small test-tube, about $\frac{5}{16}$ inch inside diameter, add 1 c.c. of a 0.5 per cent. solution of potassium citrate. Take 0.1 c.c. of patient's blood from a puncture of a capillary and add quickly to the above solution. Then add 1 c.c. of a mixture of equal parts of a 2 per cent. solution of pyrogallic acid and a 2 per cent. tannic acid, which has been freshly prepared. Invert once or twice to assure thorough mixing. Allow to stand ten minutes and then compare with a color standard and read the percentage of carbon monoxid.

This method is fairly accurate and the amount can be estimated to within 3 to 5 per cent., even by one who is inexperienced.

Mice and birds, especially canary birds, may be used to detect carbon monoxid in the atmosphere. This plan is far superior to the chemical tests because it requires no technical experience, can be used frequently, and is more approximately accurate, as it shows 1 per cent. of gas. The rate in which changes occur in canary birds is far more rapid than in man. They show symptoms correspondingly quicker. Canary birds are better than mice, as they are more sensitive, show symptoms of distress sooner, and can be easily seen, as they sit on their perches.

Details showing relative susceptibility of mice, birds, and man:

0.1 per cent. CO—Man showed giddiness in two hours; mice in ten minutes.

0.15 per cent. CO—Canary showed distress in three minutes and fell from perch in eighteen minutes.

0.2 per cent. CO—Canary showed distress in one and a half minutes and fell in five minutes.

0.25 per cent. CO—Mice showed partial collapse in fifteen minutes, distress in eight minutes, died in two hours—man had headache in twenty minutes; later became ill.

0.29 per cent. CO—Canary fell in two minutes.

0.46 per cent. CO—Mice in distress in two minutes; collapsed in four minutes.

0.6 per cent. CO—Mice helpless in two minutes—man unaffected in ten minutes, although blood examination showed one-fourth saturation.

0.7 per cent. CO—Mice distressed in one minute.

Pathology.—The pathology of gas poisoning consists principally in the characteristic cherry red spots on the surface of the body, the cherry red color of the blood, and the same color of many or all of the organs. There is usually intense hyperemia, or occasional small free hemorrhages into all the organs. Nephritis is usually present, and is apt to be the acute hemorrhagic type. There may be small scattered hemorrhages throughout the brain and cysts may form as the result of softening.

Carbon monoxid poisoning produces a characteristic lesion of the brain, namely, a bilateral ischemia, necrosis of the lenticular nucleus, especially the globus pallidus. For complete study of the changes in the brain caused by gas poisoning see article by Hill and Semerak ("Jour. Amer. Med. Assoc.," Aug. 24, 1918).

Complications of Gas Poisoning.—There may be acute congestion of the lungs, edema, emphysema, or an actual pneumonia. Of 860 patients admitted to the larger hospitals of Boston, New York, and Philadelphia, 5.9 per cent. developed pneumonia.

Sequelæ.—Rossiter (Ibid.) states that the old theory that the blood-corpuscles are destroyed by gas is erroneous, as it has been proved that the corpuscles again become normal immediately after the gas has been driven out of the blood, which takes from a few minutes to several hours, depending upon the amount of gas absorbed and the method of treatment. All of the damage occurs during the time the gas is circulating in the blood, depriving the tissues, especially the brain, of oxygen. Degeneration originally caused by this lack of oxygen may continue to progress after the blood has been freed of the gas, giving rise to other symptoms, principally nervous manifestations. These symptoms are most liable to occur in those of advanced years and disappear in from several weeks to a few months. Such symptoms are nervousness, insomnia, headache, and, in the more severe cases, intention tremors, loss of sexual power, delirium, neuritis, transient hemiplegia, confusional insanity, leptomeningitis. Encephalomyelitis, prolonged fever, and glycosuria have also been reported. It is very difficult, however, to tell whether these after-effects are due to the carbon monoxid poisoning or whether they may not be due to other causes, such as syphilis, alcoholism, arteriosclerosis, etc. It must be remembered that the end-results vary according to the condition of the brain and nervous system before the gassing occurred, as previously existing lesions may have been accentuated.

Rossiter states that he has never seen any serious after-effect, although some of his patients were unconscious several hours, and in one case the patient did not regain consciousness for three days. Several of his patients complained of muscular pains and headaches lasting a few days—2 patients were partly demented for several days and another for two weeks, but all of these cases made an uneventful recovery.

Prognosis should be based on the age of the victim, time of the exposure, the intensity and duration of coma, the condition of the blood, and the character of the pulse and respiration. Usually a short exposure to illuminating gas means a case amenable to treatment, and which will recover promptly. Longer exposure, or exposure of the aged and feeble, makes a far worse prognosis. Of 860 hospital cases investigated by the American Gas Committee, 14.5 per cent. were fatal. Of course, it is assumed that these 860 were all serious cases, as all required hospital treatment.

Treatment.—The treatment of illuminating gas poisoning must be prompt and heroic. In the mild cases, in which there is neither coma nor apnea, the patient should be removed to an atmosphere free from the poison and immediately placed in the reclining posture.

The most important factor in the treatment of cases of carbon monoxid poisoning is the early elimination of the carbon monoxid from the blood. R. R. Sayers and W. P. Yant ("Public Health Reports," 1923, 38, 2053–2074) have made an exhaustive study of the use of air, oxygen, and a mixture of carbon dioxid and oxygen in the treatment of such poisoning. They draw the following general conclusions: Recovery depends to a great extent upon early elimination of the carbon monoxid from the blood. The rate of elimination depends on the percentage of oxygen in the inspired air and on the rate and depth of respiration. When a person has been gassed

to such an extent that 35 or 40 per cent. of the hemoglobin of the blood has combined with carbon monoxid, administration of pure oxygen causes the elimination of the carbon monoxid to proceed four times as rapidly as in normal air. If 8 to 10 per cent. of carbon dioxid be added to the pure oxygen prior to its administration, deep and rapid respiration is produced, and the carbon monoxid is eliminated five to six times as rapidly as in normal air. Every victim of carbon monoxid poisoning not under a physician's care should be caused to breathe oxygen in the purest available form for at least twenty to forty-five minutes. It is also recommended that physicians treat the poisoning with the mixture of oxygen and carbon dioxid whenever possible; otherwise they should use pure oxygen.

Rest is an essential element. It is often difficult to make rescuers understand the importance of rest in the treatment of poisoning by carbon monoxid at blast furnaces, gas plants, etc. The probable reason for walking up and down men who have been gassed is that the rescuers feel they must be doing sometning, even to the extent of ignoring the state of shock into which the patient has fallen (Dr. F. M. Legge, "Gas Age-record," Oct. 21, 1922, page 519).

One of the essentials in treating shock, according to Dr. F. M. Legge, Medical Inspector of Factories, London, is to keep the patient warm, and, therefore, treatment in the open air is inadvisable if there is a room available. The damage done to the heart muscle itself by carbon monoxid gas is the principal reason why rest should be enjoined. Cases have been known to suddenly collapse and death has followed such slight exertion as walking home. These cases were probably due to damage inflicted upon the heart itself.

I have frequently seen cases of bronchitis follow exposure in the treatment of gas poisoning; that is, patients who were exposed to gas were awakened from their sleep and quickly removed in night clothing to the street.

Nausea and a feeling of fulness in the stomach can be relieved by the administration of effervescent sodium phosphate or a Seidlitz powder. This procedure will usually cause vomiting and give relief.

Ammonium bromid given internally and an ice-bag applied to the head will relieve headache. Hoffman's anodyne or the aromatic spirit of ammonia act as useful stimulants and carminatives. Caffein, digitalis, and strychnin should be given when indicated. They will hardly be necessary unless the victim is in the second stage; namely, of coma, or in the third stage; namely, apnea.

The above sets forth the treatment of the mild case of carbon monoxid poisoning.

The patient suffering with carbon monoxid poisoning in the second stage is unconscious, but still breathing. Respirations should be carefully watched. This case can be best treated by the administration of 95 per cent. oxygen and 5 per cent. carbon dioxid. A gassed patient, when breathing, should not be given artificial respiration, but should be placed and kept in a position ready for artificial respiration should breathing cease. Start the inhalation of oxygen plus carbon dioxid immediately. The work of Henderson and Haggard (Ibid.) has demonstrated that the treatment of carbon monoxid poisoning by the administration of oxygen plus 5 per cent. carbon dioxid is more efficient than by oxygen alone. As has been stated, carbon monoxid combines with the hemoglobin, displaces the oxygen, and the harmful action of gas poisoning results from the oxygen deprivation. The most effective physiologic means for breaking down the combination of carbon monoxid and hemoglobin is offered by the mass action of oxygen; that is, in the presence of large amounts of oxygen, carbon monoxid is forced out of the hemoglobin molecule more rapidly than in lower oxygen concentrations.

The most effective physiologic stimulus to respiration is carbon dioxid.

Because of these facts and because of the observation that in gassed persons the carbon dioxid content of the body is low, owing to the period of excessive breathing which precedes the stage of shallow respiration and respiratory failure, Henderson and Haggard have advocated the use in gassed cases of inhalations of 5 per cent. carbon dioxid with 95 per cent. oxygen. They have shown in gassed animals and in themselves that this mixture, because of the carbon dioxid content, causes a great increase in respiration. This respiratory increase fills the alveoli with a very high percentage of oxygen and thus displaces carbon monoxid from the hemoglobin molecule with the greatest possible expedition. They have also shown that the breathing of this carbon-dioxid-oxygen mixture is attended with no danger to the subject. Following these observations, Henderson and Haggard tested the carbon-dioxid-oxygen treatment upon gassed persons in New York City. Further experience with the method,

both in reviving gassed persons and in hastening recovery from etherization, has served to increase the confidence in the wisdom and safety of a treatment which not only meets an immediate emergency but also, by shortening the period of oxygen lack, reduces the frequency, after gas poisoning, of unfortunate sequelæ (C. K. Drinker and W. B. Cannon, "Carbon Monoxid Asphyxia," "The Problem of Resuscitation," "Jour. Indust. Hyg.," 1922–23, vol. 4, page 463; C. K. Drinker, K. R. Drinker, L. A. Shaw, and A. C. Redfield, "Carbon Monoxid Asphyxia," "Artificial Respiration," "Jour. Indust. Hyg.," 1922–23, vol. 5; Y. Henderson and H. W. Haggard, "The Treatment of Carbon Monoxid Asphyxia by Means of Oxygen and Carbon Dioxid Inhalation," "Jour. Amer. Med. Assoc.," 1922, vol. 79, page 1137).

This H. H. Inhalator (Fig. 671), made by The Mines Safety Appliance Co., may be used if the patient is breathing. If, however, the patient requires artificial respiration, such artificial respiration is administered by the Schäfer method, and the oxygen plus carbon dioxid is administered by holding a mask over the patient's face during the administration of artificial respiration. This inhalator is equipped with a headgear to hold the mask in place, but, personally, I have never been able to get a mask to fit properly with a headgear. I believe that whenever possible the mask should be kept in place by the operator's hands, so that the jaw can be held forward, and the mask can be kept free at all times of mucus, vomitus, etc.

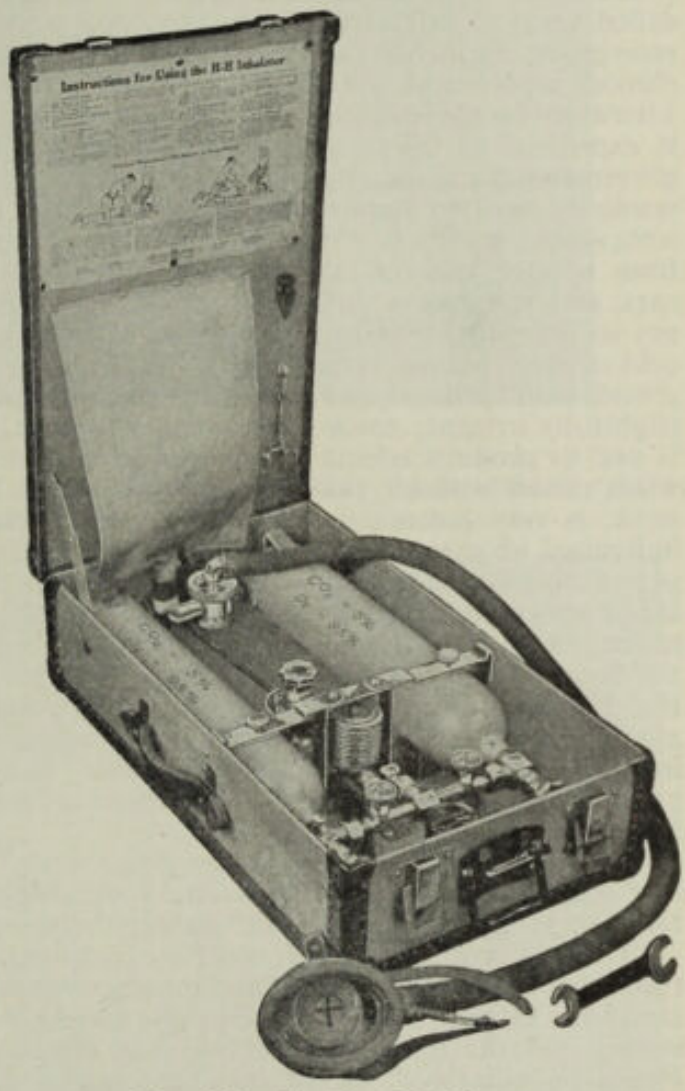


FIG. 671.—The H. H. Inhalator

Some surgeons have recommended blood transfusions with or without venesection. Doctors Sherman and Rossiter, of the Carnegie Steel Company, state, in their opinion, blood transfusion in carbon monoxid poisoning is contraindicated, and, in supporting their theory, write me as follows:

"When one understands the blood chemistry and reactions that take place in this form of poisoning, the above statement becomes clear.

"It is an accepted fact that this gas forms no permanent nor poisonous compound in the blood, nor does it induce any lasting deterioration in the oxygen-carrying power of the corpuscles; the red blood-cells are not destroyed, but promptly resume their oxygen-carrying function as soon as the gas is displaced, which may be from a few minutes to several hours, depending on the amount of gas absorbed and the method of treatment.

"The compound formed between the gas and the hemoglobin, carbon monoxid hemoglobin, is readily broken up in the presence of air or pure oxygen, the latter acting four times as quickly as the former. This breaking up of the compound, or displacement, begins immediately upon the removal of the patient to the fresh air, and the length of time required for the complete elimination depends on the amount of gas absorbed and the method of treatment.

"All the damage done takes place while the patient is inhaling the gas and while it is circulating in the blood, depriving the tissues, especially the brain, of their oxygen supply. No further damage is done after the blood has been freed of the gas and the

tissues begin to receive oxygen, but, of course, any degeneration caused by this deprivation of oxygen may go on. There is no known method of restoring normality after parenchymatous degeneration has once been initiated.

"From the foregoing statements it will be seen that transfusion would be of no benefit, since all the damage occurs while the patient is inhaling the gas and during the time it is circulating in the blood, and that no further damage takes place after the tissues begin to again receive oxygen, which I believe takes place as soon as he takes a few breaths of fresh air. The red blood-cells, not being destroyed, can be made normal very readily by the proper treatment; viz., inhalations of pure oxygen. In order to derive any possible benefit from transfusion it would have to be done almost immediately after the patient was removed from the gas, which would be impossible."

Smoke Asphyxia.—One of the first duties required of an intern in a city hospital is ambulance service, and in the performance of such duty he is not infrequently called upon to attend fires. In fact, any physician may be called upon in such an emergency, and while on the fire ground may meet cases of asphyxia by smoke. The clinical aspect and the treatment of such cases are not taught in the class room. Literature on the subject is scanty. It is for these reasons that the author has deemed it expedient to insert a few words regarding it. There are several factors which govern the character of smoke cases. There are many different kinds of smoke. All smoke is hard to respire, but some is worse than others. Some smoke is merely irrespirable, while other smoke is not only irrespirable, but is highly poisonous. Smoke from lumber, baskets, clothing, cotton waste, blankets, felt, varnish, furniture, paper, rags, and wet hay is difficult to tolerate; whereas smoke from pitch, tar, and oils is not so pungent. Smoke impregnated with fumes of ammonia (met with at fires at cold-storage plants, breweries, laboratories, cleaning establishments, etc.); sulphur dioxid, chlorin, or pepper and other spices (fires in spice mills and grocery stores) is frightfully irritant; smoke containing sulphuric or nitric acid is highly irritating and is apt to produce edema of the glottis and lungs. The smoke of burning celluloid, when mixed with air, may form prussic acid. Banana oil, used in paints for metal work, is very poisonous. The hotter the smoke, the more irrespirable it is. The individual idiosyncrasies or susceptibilities of the person play an important part. It is remarkable how city firemen can accustom themselves to remaining in a smoke-laden atmosphere. The older members of the fire department can tolerate smoke much longer than those recently appointed. Firemen learn that the best air is near the floor, or near the nozzle of the hose. There is a current of air along the floor and the smoke naturally tends to rise, and the water carries through the hose a certain amount of air. Whenever possible a fireman always keeps near the floor and by the hose when working in a smoky building. If he should leave the hose he will be in grave danger of getting lost in a smoke-ladened room. I know of several deaths from this neglect.

For clinical purposes smoke asphyxia may be divided into three stages: In the first stage the victim is conscious; in the second stage consciousness is lost, but respirations are still present; in the third stage there is apnea.

The first symptoms which occur are coughing, a choking sensation, dizziness, severe throbbing in the head, nausea, and muscular weakness. The eyes are inflamed, watery, and burn intensely. The man coughs and tries to vomit. The face may be hot and sweaty, yet the hands will be cold and clammy. The pulse is slow, but bounding. Headache is intense. If at this time one is able to reach a window or leave the building to get fresh air he will quickly recover.

He should be removed to a spot where the air is free from smoke and should be laid on a blanket. All constricting clothing should be loosened, and the face should be fanned. If he gags or attempts to vomit, but cannot do so, he may be given a drink of an effervescent salt, such as a Seidlitz powder or a dessertspoonful of effervescent sodium phosphate in a tumbler of water. Before prohibition firemen had great faith in weiss beer. It made them belch and vomit, and thus relieved them of much of the mucus and gases in their lungs and in their stomachs. In this manner it acted as does an emetic dose of ipecac in the first stage of bronchitis.

Whisky has often been given to firemen, but it is most injurious. A fireman who is a whisky drinker stands smoke poorly, and to take whisky after having been overcome with smoke only adds to the headache, nausea, and incapacity.

Usually after vomiting has been induced, and after the fireman has had fresh air, he is able to return to his work. If he does not rapidly recuperate, or should he be overcome a second time, he should not be allowed to return to a smoky atmosphere.

If a fireman, who has been overcome by smoke, has a chill he should be sent to a hospital. His usefulness is at an end for that fire. When a man becomes uncon-

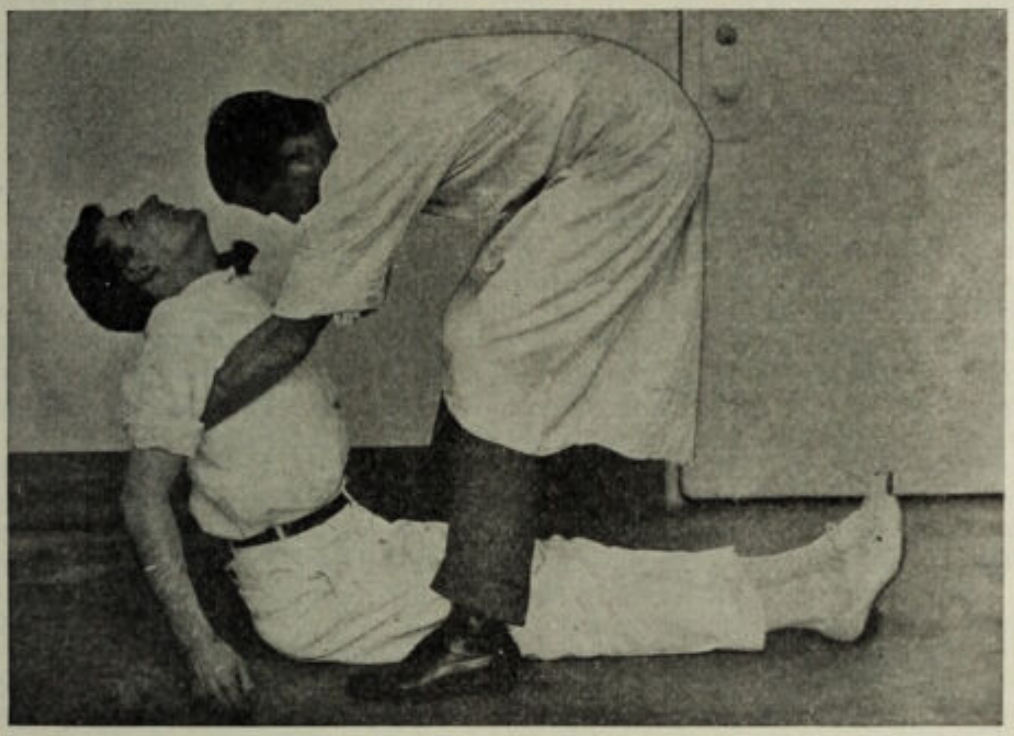


FIG. 672.—Fire carry. Step one.

scious his comrades carry him to the street. Pictures of a very quick and satisfactory fire carry are shown in Figs. 672–674.



FIG. 673.—Fire carry. Step two.



FIG. 674.—Fire carry. Step three.

It is unusual for a man who is conscious to be able to walk out of a smoky building and yet to lose consciousness only after reaching the fresh air unless the smoke was impregnated with illuminating gas.

When an unconscious man is carried from a smoky building he must be taken to a spot where the air is free from smoke; his clothing must be loosened; and his body kept warm with blankets. His hands and face should be rubbed with a coarse towel, and oxygen plus 5 per cent. carbon dioxid (a tank of which should be carried on all ambulances and patrol and rescue wagons) should be administered.

If the circulation or respiration is weak a hypodermic injection of strychnin or atropin should be administered. When able to swallow he can be given a stimulant by mouth (as Hoffman's anodyne or the aromatic spirit of ammonia), or if he is trying to vomit he may be given effervescent sodium phosphate or a Seidlitz powder. Black coffee is an excellent stimulant. He should not be given anything by mouth until he is entirely conscious and able to swallow. This is mentioned emphatically because we have seen attempts made to pour whisky or some other stimulant down the throat of an unconscious fireman. The danger of such a procedure is obvious, as it may choke the victim to death. As soon as practicable he should be removed to the nearest hospital. The man should be taken to the *nearest* hospital. But if the receiving ward of that hospital is overcrowded, as may well be the case during a serious fire, he should then be taken to the next nearest hospital.

The third stage of asphyxia by smoke is characterized by suspended respirations, *i. e.*, apnea. The lips are cyanotic; the skin is cold and clammy; the pupils are fixed and usually dilated; the conjunctival reflex may be absent; the mouth may be open or, on the other hand, the teeth may be tightly clenched; the pulse is weak and fluttering, even imperceptible; there is usually bleeding from the nose and mouth. Involuntary evacuation of urine and feces may occur. A man in this condition should never be placed in an ambulance to be taken to the hospital until respiration has been established by artificial means. I have seen stupid, assertive policemen and inexperienced ambulance surgeons on many occasions insist on putting such cases in an ambulance or patrol wagon. Such a case should be quickly laid on his back, all mucus cleared from his throat and mouth, and all constricting clothing loosened, torn, or cut away. Artificial respiration is at once instituted. The Schäfer method is the best method to use. Oxygen should be administered or, preferably, oxygen plus 5 per cent. carbon dioxid. The body should be covered with blankets and, if necessary, the man must be stimulated with strychnin, atropin, camphor, etc. When respirations have been established he may be removed to the nearest hospital. As a rule the man should be kept in the hospital at least twelve to twenty-four hours. He may then go home if no complication has arisen.

In severe smoke cases there is a tympanitic percussion note well above each collarbone due, I believe, to blocking of bronchial tubes by spasm. This condition may be present often for several hours, and then subside. In cases of edema of the glottis from inhalation of irritant vapor, tracheotomy should be performed and artificial respiration given—oxygen plus carbon dioxid passing in through a tracheotomy tube.

It is imperative that the first-aid kits of all ambulances contain a tracheotomy set. I was compelled to do a tracheotomy with a penknife on a fireman lying on the pavement. A chill or series of chills not infrequently follows smoke asphyxia, and a man who has had a chill must always be sent to a hospital. If the smoke has been impregnated with ammonia a piece of gauze or a handkerchief should be saturated with vinegar and held over the face so that the vapor may be inhaled. On the other hand, a few whiffs of diluted ammonia should be given after the inhalation of the fumes of acids. The eyes should be carefully treated. They should be washed with boric acid solution or, if the eyes have been burned by flame or by acid, a few drops of olive oil or albolene placed in each eye.

Cocain should never be used in the eyes of a fireman if the fireman is to return to the fire, as such a procedure renders the cornea anesthetic and subsequently burns or foreign bodies will cause severe ulceration. Pieces of lint or gauze are placed on ice and transferred when cold to the eyes. They are changed at frequent intervals. After the acute eye symptoms have subsided it may be necessary to wear dark glasses for several days, and to use an astringent eye wash.

To relieve headache an ice-bag can be applied to the head and bromid should be administered by mouth. Bromid also relieves the severe nervousness which often ensues upon a "smoke knock-out."

Occasionally bronchitis or even bronchopneumonia may occur. Even after mild smoke cases there is usually a cough for several days, the sputum being streaked with black, carbonaceous material.

Inhalation of the vapor of irritant fumes, such as nitric acid, sulphuric acid, or

ammonia, is apt to cause edema of the glottis, edema of the lungs, and death. The acute edema may not occur for several hours after the inhalation. The treatment of edema of the glottis is immediate tracheotomy, with the administration of artificial respiration. The treatment of edema of the lungs consists of venesection, hypodermic injection of camphorated oil, the administration of atropin, digitalis and adrenalin chlorid, and counterirritation of the chest.

Hanging.—A physician is occasionally called upon to treat a case of attempted suicide by hanging. In Philadelphia during the year 1923 there were 38 cases of suicide by hanging. In these cases there is neither a fracture nor dislocation of the cervical vertebræ, as may occur in legal execution by the drop. The victim is dead or almost dead because of obstruction of the trachea and pressure upon the great vessels of the neck or perhaps upon the pneumogastric nerves.

Treatment.—The subject, after being cut down, is treated by artificial respiration. External heat is applied and an enema of hot coffee containing an ounce of brandy may be administered. When there is distinct lividity, perform venesection. Galvanism of the phrenic nerve is advisable. Even after respirations have been established there is for some time the greatest danger of relapse, of apnea, and death.

Throttling.—When an assailant grasps his opponent's throat with the hands and squeezes the windpipe or larynx forcing it against the vertebræ the victim is said to be throttled. The ordinary fighter makes the attack from in front. The garroter seizes his victim's throat from behind. Death from throttling is death by asphyxia plus an influence from the pressure on the great vessels.

Treatment as for hanging.

Drowning is asphyxia caused by having the mouth and nose submerged in fluid, air thus being excluded from the lungs. It is not only water that may be responsible for drowning. An individual may be drowned in mud or in a cesspool. Drowning is a common accident. Every year in the United States there are at least 15,000 deaths from drowning. In Philadelphia during the year 1923 there were 63 accidental deaths by drowning, 14 suicides, and 1 homicide.

Many are drowned because they become hysteric when they fall by accident or are thrown into the water. They attempt to scream. With each scream they use all of the air contained in the lungs; then when a breath is taken water is apt to be inhaled with air. This increases their fright and hysteria. If one who does not know how to swim falls overboard if he or she will keep the mouth shut, breathe through the nose and try to tread water or paddle "dog fashion" the head can be kept above water for a far greater length of time than if one becomes immediately hysteric and uses up the strength quickly and to no advantage.

Every child should be taught to swim and learn to have confidence in the water. Every boy and girl should be taught to row and sail a boat, to become accustomed to the wind, tide and water, and to realize the dangers of each.

Phenomena of Drowning.—A person who is drowning becomes frightened, screams, attempts to wave the arms, struggles to catch hold of any one or anything that seems to be within reach. He may sink at once, never to rise to the surface again, or he may sink and then rise to the surface once, twice, or even a number of times. There is no physiologic reason why a person when drowning should rise to the surface three times, as is the common belief. During the struggle air and water are inhaled and, as a rule, some of the water is expelled by violent coughing and vomiting. During drowning some water is certain to be drawn into the bronchial tubes. It is doubtful if any water enters the air vesicles. They become distended with carbon dioxid and other gases (J. M. Booger). While this struggle is going on the blood becomes less and less oxygenated, exhaustion deepens, and finally the patient sinks to rise no more. Some air is forced from the lungs, causing bubbles on the surface of the stream. The ears ring; the muscles are convulsed; the mind wanders; merciful insensibility arrives and death follows. During the mental wandering the memory may take clear and extensive, or irregular and incoherent journeys through the events of years or a lifetime, but this does not always occur. The duration of the death struggle is uncertain. It may be very brief or it may last a considerable time. The weaker a person is, the sooner it is over. It is probable that death usually occurs in two minutes after the final sinking. In spite of some especially trained divers being able to remain under water as long or even longer than this, we may conclude from all data that fatal asphyxia is probable at the end of two full minutes' submersion of the head (Draper's "Legal Medicine"). A man may die when under water from some cause other than drowning; for instance, syncope, apoplexy, or heart disease.



FIG. 675.—Method of breaking grip—front strangle hold (Owen).



FIG. 676.—Breaking strangle hold (Owen).

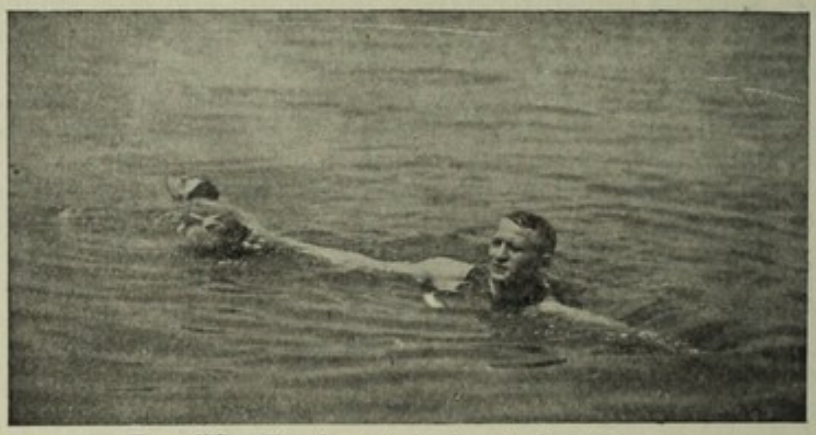


FIG. 677.—Towing victim by the hair (Owen).



FIG. 678.—The tired carry. No. 1 (Owen).

When a man is taken from the water apparently drowned his face is swollen and cyanotic; the conjunctivæ are reddened; the tongue is swollen and often caught between the teeth; the hands may clutch weeds or mud from the bottom; the body is cold to the touch; the mouth contains fluid which may be bloody; fluid of an identical nature can be drawn from the air passages; the stomach also contains water which has been swallowed. In most cases the victim is pulseless and there is apnea. In less grave cases there is a pulse or perhaps only an occasional heart beat, and possibly an occasional gasp.

Treatment.—A person who has been submerged under the water for more than two minutes is usually dead. Yet because of this it should not be deemed useless to try to resuscitate one who has been submerged for a greater length of time. In fact cases which have been submerged for five minutes or more have been resuscitated. As Draper says: "The evidence as to time may be incorrect, and there are probably exceptional people who would not drown in two minutes. Resuscitation has been successful after five minutes, and one case is recorded of a recovery after twenty-five minutes" (Draper's "Legal Medicine").

The common practice of blowing into the victim's mouth is of no avail, and is but a waste of valuable time, as most or all of the breath goes into the stomach. The popular practice of rolling the victim on a barrel is a poor excuse for artificial respiration, and exhausts a living subject. The emergency treatment should be inaugurated the second the victim is taken from the water—whether he be in a boat, on a pier, or on the beach. Time should not be taken even to remove him to a nearby building, emergency tent, or hospital, nor even to loosen the clothing. The patient should at once be put in the prone posture, a folded coat or blanket placed under the chest, so that the head is lower than the chest, and artificial respiration by the Schäfer method immediately instituted. While this is being done the mouth can be opened, the tongue drawn out, and any foreign matter removed. The clothing may then be loosened or rapidly removed. Hot-water bottles and blankets can be placed around the body and legs. When the individual makes any effort to breathe, help each respiration along. Hypodermic injections of strychnin or atropin may be given. An enema of 8 ounces of hot coffee and 1 ounce of brandy is of value.

Oxygen plus carbon dioxid can be given while artificial respiration is being administered. Artificial respiration is maintained until the patient breathes naturally and until all cyanosis has passed away. As soon as the patient can swallow he should be given hot coffee and brandy.

If minute follows minute and the patient does not breathe we must still continue our efforts, as artificial respiration should be used for at least an hour before it is justifiable to abandon hope of reviving the victim. Even after respirations have been established the patient must be carefully watched for some time and treated as for shock, because secondary respiratory failure is not uncommon.

After resuscitation there is danger from exhaustion and of bronchopneumonia.

Rescuing a Drowning Person.—It is not uncommon for one who becomes frightened while in the water to clutch his rescuer, and often the rescuer has a difficult problem to free himself from the victim's grasp. Methods of breaking such grasps are shown in Figs. 675, 676.

Methods of carrying a swimmer who has become fatigued are shown in Figs. 677, 678.

Diseases and Injuries of the Nose and Antrum

Fractures of the Nasal Bones.—(See page 498.)

Foreign bodies in the nose (see Poulet on "Foreign Bodies in Surgery") are usually introduced through the anterior nares, but in rare instances during swallowing they enter by way of the posterior nares, a sudden expiration being the cause of the entry. During vomiting foreign bodies may enter the posterior nares. Small particles are often expelled spontaneously; larger pieces collect mucus and epithelium and become fixed. Some materials swell after lodgment. Others become encrusted with lime salts. Seeds may sprout. In very rare cases insects enter and lodge. Cases are on record of leeches, taken in with drinking-water, passing into the nasal fossæ from the pharynx. In the tropics flies may deposit within the anterior nares larvæ which develop with great rapidity. A foreign body is usually near the floor and may be between the vomer and turbinate bones. It may shift after lodgment.

Treatment.—In many cases general anesthesia is required. Illuminate the nostril, and, if the foreign body can be seen, insert a hook back of it and effect its removal

by means of forceps. Some foreign bodies must be pushed back into the nasopharynx. Occasionally expulsion may be effected by inserting a rubber tube into the unblocked nostril and telling the patient to blow forcibly through the tube. In serious cases a specialist should be summoned to remove a portion of the turbinated bone or to perform whatever operation he may think best.

Inflammation and Abscess of the Antrum of Highmore (the Maxillary Antrum).—The source of this disease may be inflammation within the nose or periostitis around the roots of the teeth which are in relation with the antral floor. Apical disease of the roots may be demonstrable by the *x*-rays only. In some cases the natural opening into the meatus is patent; in other cases it is partly or completely blocked. Caries and necrosis may arise. The **symptoms** are pain, edematous swelling of the face, and thinning of the bone so that it may crepitate under pressure. When pus has formed, if the antral opening is patent, certain positions of the head will cause a purulent flow from the nose, and if a speculum is inserted pus may be seen as it flows into the nose. The opening of the maxillary antrum into the nasal channel is at the summit of the antrum; hence the antrum drains when the head is inverted. The ethmoidal cells and frontal sinus drain best when the patient is upright. Wipe the interior of the nose and place the patient with his head between his knees. If the nostril fills with pus, it comes from the antrum (Cobb). In severe cases the jaw expands, the eye protrudes, and great tenderness of the alveolus exists. Percussion exhibits a dull note. In making a diagnosis it is well to take the patient into a dark room, insert an electric light into the mouth, and note the diminution of light transmission on the diseased side as contrasted with the sound side. Transillumination may be easily practised by the use of a cautery electrode, protected by a small glass vial. Any cautery battery may be employed (plan suggested by Ohls). Exploratory puncture will settle a doubtful diagnosis. This may be by way of the lower meatus, the canine fossa, or the alveolar process.[1]

Treatment.—Before pus forms order the use of hot fomentations and remove any diseased teeth. When pus has formed, evacuate it at once. Before performing a severe operation try the effect of opening into the antrum from the nose by means of Krause's trocar, followed by insufflations of iodoform. If these procedures fail, other means may be employed. If the disease arises from a carious tooth, pull the tooth and push a trocar through its socket into the antrum. If the teeth are sound, raise the upper lip, bore a hole with a large gimlet or with a bone-drill above the root of the second bicuspid tooth and 1 inch above the edge of the gum. A counteropening should be made into the inferior nasal meatus. A drainage-tube is pulled from the first opening into the nose and is allowed to protrude from the nostril. Irrigate daily with normal salt solution. In three or four days discontinue through-and-through drainage, but prevent the first opening closing until the discharge ceases to be purulent. In severe cases make a free incision through the canine fossa by means of a chisel.

Distention and Abscess of the Frontal Sinus.—The anatomy of the frontal sinus is extremely variable. It is not constant in size or in shape. The right and left sinuses are nearly always asymmetric and "either or both may be present in duplicate or triplicate" (J. Parsons Schaeffer in "Annals of Surgery," Dec., 1916). The usual cause of abscess is an injury which may long antedate the symptoms. This injury causes or leads to blocking of the infundibulum; secretion accumulates and distends the sinus, and in some cases pus forms. In many cases the fluid slowly accumulates, and it may require years to produce marked symptoms. In other cases infection takes place early or existed from the start, and the symptoms are positive and violent. If the outlet into the nose is not permanently blocked, the fluid will discharge itself from time to time. In the chronic cases there is seldom much pain. The chief sign is a swelling of the inner or upper part of the orbit, which swelling progressively increases and finally displaces the eye. If at any time acute symptoms supervene, there will be pulsatile pain, discoloration, and tenderness.

Treatment.—In some cases it is possible to pass a trocar upward from the nose into the sinus, and so drain and irrigate. In most cases an incision should be made through the soft parts, and the sinus be opened by a trephine or chisel. After the sinus has been opened it must be curetted. The opening into the meatus should be restored and enlarged, and a drainage-tube must be passed from the forehead incision into the nostril. I usually prefer to open the sinus by making an osteoplastic flap in the anterior wall.

[1] Cobb in "Boston Med. and Surg. Jour.," May 7, 1896.

Diseases and Injuries of the Larynx and Trachea

Edema of the Larynx (*Edema of the Glottis*).—The causes of edema of the larynx are: acute laryngitis; chronic diseases, such as tuberculosis, malignant disease, or syphilis; inflammatory disorders, such as diphtheria and erysipelas; acute infectious diseases; Bright's disease; aneurysm; whooping-cough, pneumonia; quinsy; wounds of the larynx; wounds of the neck; scalds and burns of the larynx, and the inhalation of hot smoke, steam, or of irritating vapors, such as those of ammonia, nitric acid, or sulphur.

The **symptoms** are sudden and rapidly increasing dyspnea, respiratory stridor, huskiness of the voice, and finally aphonia. The swollen epiglottis may be felt with the finger and may be seen with the help of a mirror.

Treatment.—In cases in which edema of the larynx is not excessively acute, introduce a gag between the teeth, hold the mouth open, take a knife wrapped to within ¼ inch of its point, make multiple punctures into the epiglottis, and favor bleeding by the inhalation of steam. In severe cases perform intubation or tracheotomy.

Wounds and Injuries of the Larynx.—The larynx may be injured internally by foreign bodies, and externally by blows and cuts. A condition often met with is *cut throat*, the result usually of a suicidal attempt on the part of the patient or a homicidal effort on the part of an assailant. The cut of the suicide is usually in front; as a rule, it misses the great vessels, but divides the cricothyroid or thyrohyoid membrane. The epiglottis may be incised, or even be cut off. If a large vessel is cut, death rapidly occurs. The immediate dangers of cut throat are hemorrhage, suffocation by blood in the wind-pipe and bronchi, by displacement of parts, and entrance of air into veins. The secondary dangers are bronchopneumonia, infection and sepsis, exhaustion, and secondary hemorrhage. The remote dangers are stricture and fistula (Keetley).

Treatment.—In wounds of the throat arrest hemorrhage, remove clots from the larynx and trachea, bring about reaction, asepticize the parts as well as possible, suture the deeper structures with silver wire, catgut, or kangaroo-tendon, and the superficial parts with silkworm-gut, dress antiseptically, and place a bandage around the head and chest so as to pull the chin toward the sternum. If laryngeal breathing is much interfered with, perform tracheotomy. Feed the patient through a tube until union is well advanced. The old method of leaving the wound open is to be condemned. When sutures are used, primary union may be obtained. This fact was proved by Henry Morris.

War Wounds of the Larynx and Trachea.—Because of its mobility the larynx is seldom injured. Sudden death may occur when the larynx is struck. If a bullet penetrates the larynx or trachea, stenosis is apt to follow. These cases may be treated by division or by gradual dilatation. Gradual dilatation is carried out above the tracheotomy tube (Canuyt in "Jour. de med. de Bordeaux," 1916, lxxxvii).

Scalds of the Glottis.—(See section on Burns and Scalds.)

Foreign Bodies in the Air-passages.—The lodgment of foreign bodies in the air-passages is a frequent accident. A multitude of different things have been reported as having lodged in the air-passages. Small solid bodies are usually expelled by coughing. Liquids and solids rarely pass beyond the larynx (except in laryngeal disease or palsy, wounds of the floor of the mouth, cut throat, and in people unconscious or very drunk). In vomiting during or after the administration of an anesthetic or in the vomiting of drunkards the vomited matter may find its way into the larynx or lungs. There is great danger of this accident in an operation upon a patient with intestinal obstruction who has stercoraceous vomiting. In most instances of foreign bodies lodged in the air-passages it will be found that the object was being held in the mouth when a sudden deep inspiration was taken (often during laughter).

The **symptoms** are *immediate*, due to obstruction by the body and by spasm; and *secondary*, due to the situation of the body and the changes it undergoes or induces.

Lodgment in the pharynx causes violent dyspnea. The body can be seen or felt.

Lodgment in the Larynx.—A foreign body may lodge in the superior opening of the larynx, in the rima, or in the ventricle. In a severe case the patient fights madly for air; his face becomes livid and cyanotic; his veins stand out prominently; speech is impossible, though he may make noises and utter harsh cries; violent coughing begins, and then vomiting; he tries to force a finger down his throat and clutches at his neck; sweat pours from him; he feels a sense of impending dissolution, and he falls unconscious, with incontinence of feces and urine.[1] In a less severe case violent dyspnea

[1] See Moullin's graphic description in his "Treatise on Surgery."

gradually departs and the patient lies exhausted; but dyspnea and cough are liable to recur suddenly at any time because of spasm, and they may be induced by a change of position. These attacks of fierce spasmodic cough are not at first linked with expectoration, but after inflammation begins there is a profuse and often bloody expectoration. Inflammation follows more rapidly after the lodgment of a sharp or irregular body than it does that of a round or smooth one. Inflammation is apt to produce edema of the glottis, bronchopneumonia, or ulceration and necrosis of the larynx. Any sort of foreign body in the larynx may at any moment produce spasmodic dyspnea, and is always very liable to cause edema of the glottis. The body if bony or metallic can be detected by the *x*-rays. A body may remain lodged in the ventricle for a long time without producing symptoms.

Lodgment in the Trachea.—The immediate symptoms of a foreign body in the trachea depend on the shape and weight of the body, and whether it becomes fixed in the mucous membrane or moves to and fro with the air-current. A smooth, heavy body falls to the tracheal bifurcation, and, if it does not enter a bronchus, moves with every breath, and by its movement causes violent laryngeal spasm, cough, and whooping inspiration without aphonia. The patient is often conscious of the movements of the foreign body, and the surgeon may detect them by the stethoscope. The foreign body may be found by the *x*-rays. A foreign body in the trachea is liable to cause death by suffocation, or it may ascend so as to be caught in the larynx, or may even be expelled. Irregular or sharp bodies lodge in the mucous membrane, produce inflammation, frequent cough and expectoration, and finally lead to ulceration. Bodies which swell from heat and moisture tend to lodge and to become fixed (seeds may sprout).

Lodgment in a Bronchus.—Foreign bodies in the bronchi seriously endanger life. They usually lodge in the right bronchus. The right bronchus is more nearly the direct continuation of the trachea than the left bronchus. When a small area of lung is obstructed the obstructed side shows diminished respiratory movement and murmur with occasional whistling sounds and large moist râles; the percussion note is at first normal and later dull. When an entire lobe is obstructed all respiratory sounds are absent over it, and over the unobstructed lung respiration is exaggerated; the percussion note over the obstructed area is at first resonant, but becomes dull. The *x*-rays will often enable the surgeon to detect foreign bodies in a bronchus. Lodgment in a bronchus may cause bronchopneumonia, abscess, hemorrhage, and even gangrene. In some few cases the body is expelled spontaneously. In rare instances people have lived for years with lodged foreign bodies. If death does not soon follow the lodgment of a foreign body, an abscess is very apt to form.

Professor Chevalier Jackson ("Amer. Jour. Med. Sciences," Nov., 1918) points out an important symptom of the presence of a foreign body in the trachea or bronchi. He calls it the *asthmatoid wheeze*. The surgeon listens for it with his ear near the patient's open mouth. In some cases it is audible at a considerable distance. In true asthma the wheezing is more apt to be associated with râles than in a foreign body case.

Treatment.—If a foreign body lodges in the pharynx, try to pull it forward; if this fails, it may be wise to push soft bodies back into the esophagus. In lodgment in the larynx or below, if the dyspnea is very urgent, at once perform tracheotomy. The tracheotomy is done for the dyspnea, not to permit of removal of the foreign body, although we used to follow that plan. The foreign body should be removed by aid of the bronchoscope (see page 862). If the symptoms are not so urgent, get a complete history of the accident and find out the nature of the foreign body. Be sure that a foreign body is really retained in the respiratory tract, and then try to determine what its situation may be. A person sometimes imagines a body is lodged when it has been expelled or even when it has never been in the larynx, trachea, or a bronchus, but has been swallowed.

Tracheotomy may be required in croup, diphtheria, Ludwig's angina, substernal goiter, subglottic edema, angioneurotic edema of the larynx, laryngeal or tracheal stenosis, as a preliminary operation to laryngectomy, or to plastic closure of a laryngeal fistula. Dr. Chevalier Jackson, mentions among other indications, respiratory arrest not due to organic brain disease (renders artificial respiration much more efficient), unilateral laryngeal palsy with development of bilateral palsy or adductor spasm, and the dyspnea due to foreign bodies (the operation is for dyspnea, not to aid removal). The operation is used at times in laryngeal syphilis and tuberculosis in hope of giving rest to the diseased part.

Chevalier Jackson (Ibid.) calls attention to the dangerous inefficiency of the cannulæ usually found in shops. The standard cannula is too short. It may fit when first introduced, but swelling may force it out of the trachea. It should not be fenestrated. Dr. Jackson's cannulæ are longer than the standards. An extremely long one may be needed in a case of substernal goiter.

Jackson insists on the harm done by the terms "high and low tracheotomy." The trachea should not be opened above the third ring, and in subglottic edema the opening should be below the third ring. It is most undesirable to open the cricothyroid membrane because of the probability that stenosis will develop. The cricoid cartilage should never be divided. Its division makes stenosis inevitable. Even if it seems probable that the tracheal opening must be made low (below the thyroid isthmus), don't make a short and low incision. Such an incision is very deep, fills with blood at once, and does not give room for safe work. In every tracheotomy make the long incision we will soon describe, expose the trachea high up, and feeling the rings from above downward decide where the tracheal opening should be made.

Tracheobronchoscopy.—Killian, of Freiburg, devised a bronchoscope for introduction through a tracheotomy wound. I have used the endoscope in this manner. Later Killian devised a straight instrument which could be used through the mouth and larynx, tracheotomy being unnecessary.

Brüning, of Freiburg, improved the instrument.

My colleague, Professor Chevalier Jackson, has devised a tracheobronchoscope through which he has succeeded in removing many foreign bodies from the trachea and from a bronchus. In Jackson's highly trained hands the instrument is incomparably useful, but an untrained man with it would be like or, rather, would be worse than an untrained man with a cystoscope. Removal can nearly always be accomplished by a skilled bronchoscopist. It may fail. Occasionally a cutting operation will be required. If the bronchoscope fails and the patient is in danger of death, we must cut through the chest wall. Reach the foreign body by resection of ribs posteriorly. Intratracheal anesthesia will prevent pulmonary collapse.

Operations on the Larynx and Trachea

Tracheotomy.—Local anesthesia is entirely satisfactory. The patient may be placed supine with a sand-pillow under the neck and with the head thrown over the end of the table. If a child, Liston used to wrap it up to the neck in a sheet to pre-

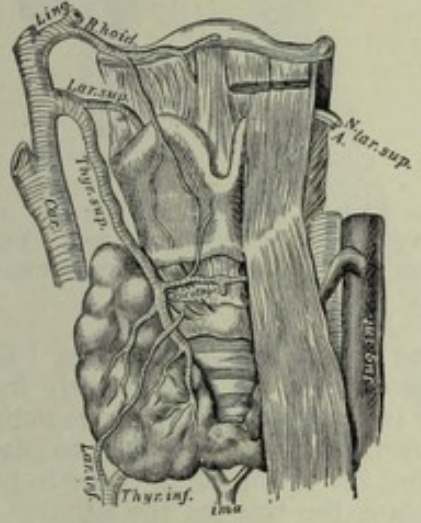


Fig. 679.—Blood-supply of the larynx and trachea (Esmarch and Kowalzig).

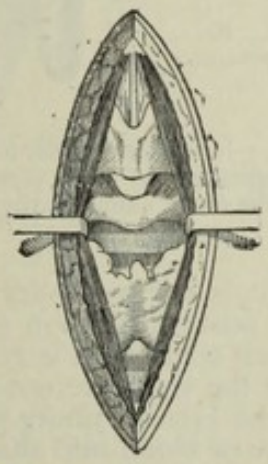
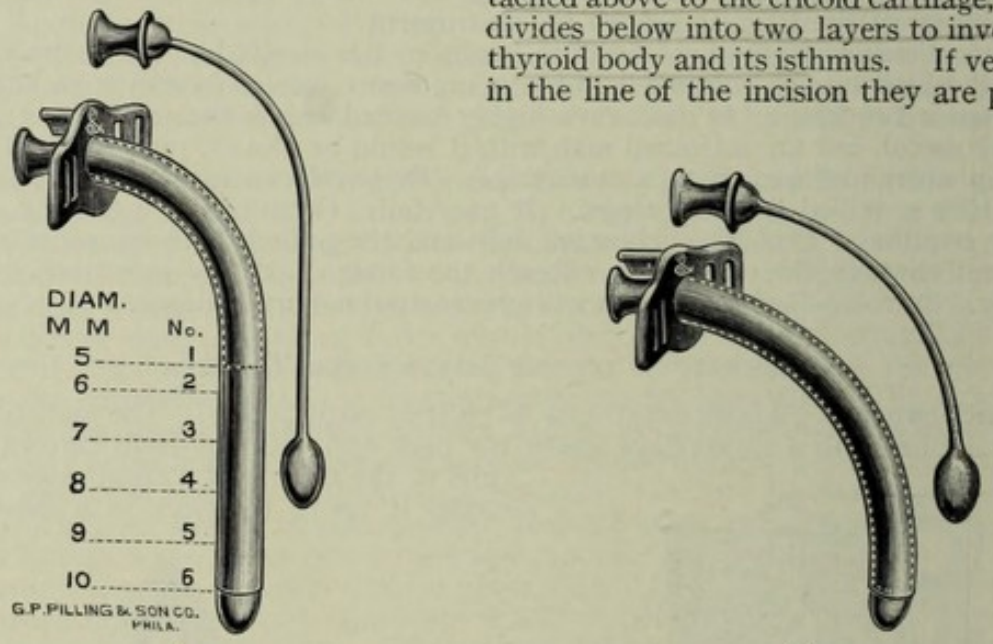


Fig. 680.—Parts exposed in tracheotomy (Esmarch and Kowalzig).

vent movements of the limbs, would seat himself on a chair, place the child upon the nurse's lap, and take its head between his knees. The head must be exactly in the middle line and extended (in an adult this gives $2\frac{3}{4}$ inches of trachea above the manubrium; in a child of ten, $2\frac{1}{4}$ inches; in a child of six, about 2 inches). The operator stands to the right side when the patient is supine. If bleeding is profuse when the surgeon is ready to open the trachea, place the patient in the Trendelenburg position with the neck extended. The trachea in an adult may be opened above or below the isthmus of the thyroid gland. It can be pulled down during the operation. The isthmus in an adult usually lies over the second and third rings (Figs. 679, 680).

The isthmus in a child usually lies over the first ring, or even over the space between the cricoid cartilage and the first ring. The operation well below the cricoid cartilage is far less likely to be followed by stricture and by stenosis than is operation through the cricothyroid membrane or operation which divides the first ring. The latter plans should never be employed.

High up the muscles are distinctly separated (Fig. 679), the main vessels of the neck and the inferior thyroid vessels are not encountered, the anterior jugular veins are small and have very few transverse branches, and the trachea is near the surface (Treves). Lower near the sternum the trachea is deeply placed, the great vessels are nearer the middle line and bleeding will be profuse. The surgeon accurately locates the cricoid and thyroid cartilages. An incision is begun at the upper border opposite the thyroid notch, and is carried to just above the sternal notch. This incision allows the index-finger to feel the tracheal rings. As Jackson says, they feel like a "wash board" (Ibid.). Treves advises the operator to steady the skin of the neck with the fingers of the left hand and to cut with the unsupported right hand (if the hand be supported, the respirations will interfere with the operation). The skin, the superficial fascia, and the anterior layer of the cervical fascia are incised, the sternohyoid and sternothyroid muscles are separated, and the fascia over the trachea is divided. This fascia is attached above to the cricoid cartilage, and it divides below into two layers to invest the thyroid body and its isthmus. If veins are in the line of the incision they are pushed



A *B*

FIG. 681.—Jackson's tracheotomic cannula: *A* shows cane-shaped cannula for use in intrathoracic compression or other stenoses; *B* shows full-curved cannula for regular use. Pilots are made to fit the outer cannula, the inner cannula not being inserted until after withdrawal of pilot (Jackson).

aside, but it is not necessary to take the time to apply double ligatures. Even if bleeding is profuse, as soon as the trachea is opened and air enters freely into the lungs, venous congestion is relieved and bleeding is apt to cease. If hemorrhage be violent and the veins are not at once caught by forceps, it may be well to place the patient in the Trendelenburg position before incising the windpipe in order to prevent the entrance of blood into the lungs. Before opening the trachea the isthmus of the thyroid gland, if in the way, is pushed upward or downward; if it cannot be pushed down sufficiently a transverse incision is made through the fascia at the upper border of the cricoid cartilage, and the fascia and the isthmus with it are lifted off the trachea (Bose's method). Follow Jackson's plan and use the thumb and middle finger of left hand as retractors and the index-finger to steady the trachea. The tube is not to be opened above the third ring. Open the tube precisely in the middle line. The back of the knife is turned toward the sternum, a finger being held upon the blade to prevent too deep a cut being made. The knife is plunged, as if it were a trocar, into the midline of the trachea, and three rings are divided from below upward. The moment the trachea is opened spread the wound apart by means of forceps or a dilator and lower the head. If respiration does not begin, make artificial respiration. As soon as two or three good breaths have been taken turn the patient on the side to premit fluid to flow out

readily. In croup or diphtheria remove membrane (by means of a feather and a solution composed of bicarbonate of sodium 2 oz., glycerin 1 oz., water 10 oz.—Parker).

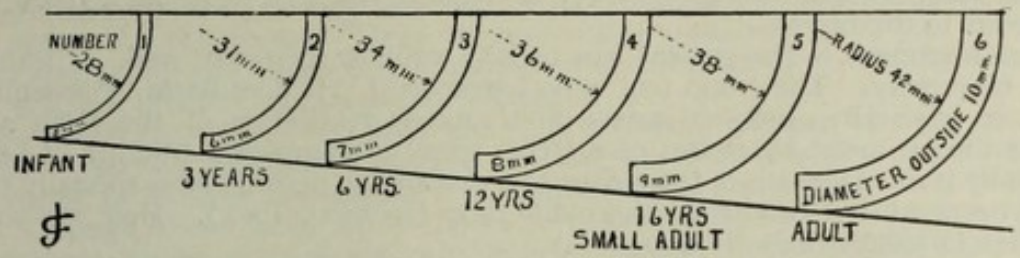


FIG. 682.—Scale of correct size and radius of curvature of Jackson's tracheotomic cannulæ for the various ages. Cannulæ conforming to these specifications are made by George P. Pilling & Son Co., Philadelphia (Jackson).

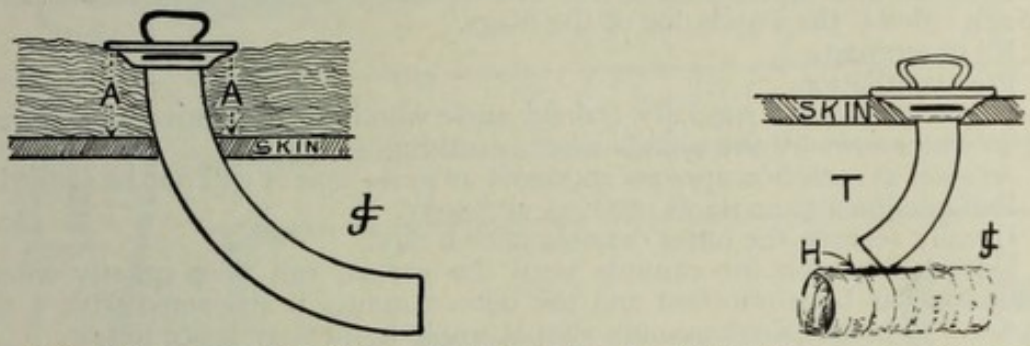


FIG. 683.—Schema showing thick pad of gauze dressing filling the space A, and used to hold out Jackson's full-curved cannula when too long, prior to reactionary swelling and after subsidence of the latter. At the right is shown the manner in which the ordinary cannula of the shops permits a person to asphyxiate, though some air is heard passing through the tracheal opening, H, after the cannula has been partly withdrawn by swelling of the tissues T (Jackson).

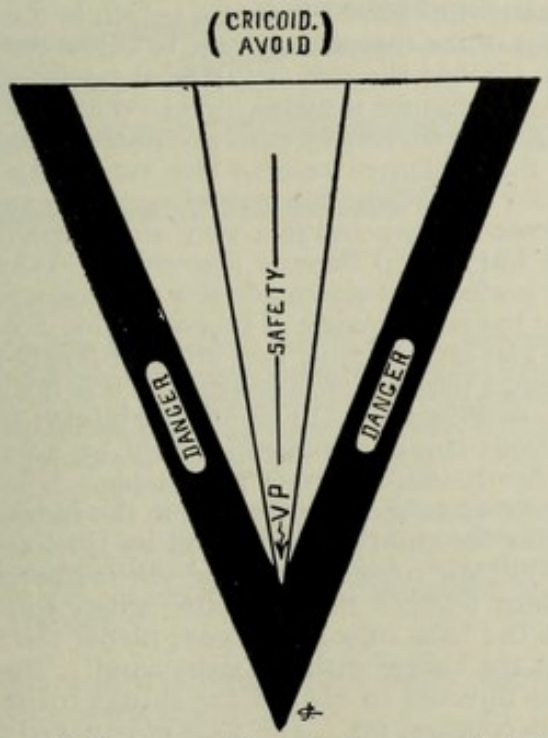


FIG. 684.—Schema of practical gross anatomy to be memorized for emergency tracheotomy. The middle line is the safety line, the higher, the wider. Below, the safety line narrows to the vanishing point VP. The upper limit of the safety line is the thyroid notch until the trachea is bared, when the limit falls below the first tracheal ring. In practice the two dark danger lines are pushed back with the left thumb and middle finger, thus throwing the safety line into prominence (Jackson).

The tube is inserted as follows: The edge of the cut is grasped with the dissecting forceps, the mucous membrane being included in the bite; the head is placed erect and the tube is introduced. Secure the tube by tapes, and suture the wound below the tube.

Dressing.—Large pieces of gauze are packed around the cannula. Jackson (Ibid.) then places a bib of gauze on the surface, under the tapes and around the stem of the cannula, and pins it to the tapes. Over the front of the neck he places a "filter piece" and pins it to the tapes.

After-treatment.—The patient can usually swallow perfectly well. Cleanse the mouth frequently. The croup tent is no longer used. It does harm by lessening the supply of fresh air. Jackson insists on thorough ventilation of the room and on keeping the air moist by means of a steam spray of compound tincture of benzoin. A specially trained nurse is of the greatest service and no person unless specially trained should be permitted to change the outer tube (Jackson, Ibid.). Here are some of Chevalier Jackson's rules (Ibid.):

1. Change the filter piece as soon as it is soiled, no matter how often.
2. Brush teeth after taking food and rinse the mouth frequently with alcohol and water, 1 to 5.
3. Bromids and opium derivatives are forbidden because they stop cough and "the cough reflex is the watch dog of the lungs."
4. No croup tent.
5. Free ventilation.
6. If possible have a specially trained nurse who is fit to remove and cleanse the tubes and who knows by the sounds when breathing is clear.
7. As soon as secretion appears sponge it away so that it will not be sucked in.
8. Remove inner cannula as often as necessary.
9. Usually remove the outer cannula once a day.
10. Do not abandon the cannula until the patient can sleep quietly when the inner cannula has been removed and the outer cannula is stoppered with a tightly fitting cork. A proper sized cannula affords ample by-passage space for air.

Quick laryngotomy is repudiated except for a very sudden and desperate emergency. It may be demanded to save life, for instance, when the operation is done in the dark. It will almost surely be followed by stenosis and perichondritis. It must never be attempted upon a child under thirteen years of age because of the small size of the cricothyroid space before this age (Treves). The operation is performed as follows: Make an incision 1¼ inches in length in the middle line, from above the level of the lower edge of the thyroid cartilage to below the level of the lower border of the cricoid cartilage. Divide the skin, superficial fascia, and deep fascia, separate the cricothyroid and sternothyroid muscles, divide the deep layer of fascia, and cut the cricothyroid membrane transversely just above the cricoid cartilage. The tube must be shorter than the ordinary tracheotomy tube. An operation which opens vertically the cricothyroid membrane, the cricoid cartilage, and the upper rings of the trachea is called *laryngotracheotomy* and is a very objectionable procedure.

Intubation of the Larynx (*O'Dwyer's Operation*).—Bouchot conceived the idea of intubation; O'Dwyer perfected it and made it a genuine scientific proceeding. The instruments required for the performance of this operation are a mouth-gag, an instrument to hold the tube and introduce it, and an instrument for extracting the tube. The collar of the tube has a perforation through which is fastened a piece of silk with which the tube can be withdrawn. The child is wrapped in a sheet to secure the limbs, is seated in a nurse's lap, and its head is held by an assistant. The jaws are opened and held apart by the self-retaining mouth-gag. The surgeon sits in front of the patient, wraps a piece of rubber plaster about the index-finger of his left hand, and passes the finger into the child's mouth until its tip touches the epiglottis. He introduces the holder and tube (observing if the silk is free) along the surface of the tongue until the obturator touches the epiglottis; raises the epiglottis with the left index-finger, and passes the tube into the larynx; places the left index-finger against the tube, and withdraws the holder with the right hand. The silken thread is tied to the ear, and the nurse is directed to employ the thread to remove the obturator if it becomes obstructed or is coughed up. The tube is removed in two or three days; if breathing is easy, it is not reintroduced; but if dyspnea recurs, it is replaced for two or three days more. If, in introducing the tube, a mass of false membrane is pushed before it into the trachea, breathing ceases, and, if the mass is not at once coughed up, tracheotomy must be performed. Feed these patients on semisolids rather than upon liquids (mush, soft eggs, and cornstarch); and if trouble occurs in swallowing these articles, feed by the rectum or by means of a nasal or an oral tube. In opium-poisoning, in asphyxia, in acute traumatic pneumothorax, and in cerebral injuries intubation may be associated with the use of an aërating apparatus.

Chevalier Jackson's Direct Laryngoscopy, Bronchoscopy, Esophagoscopy, and Gastroscopy.—(My distinguished colleague, Dr. Chevalier Jackson, Professor of Bronchoscopy in the Jefferson Medical College, did me the honor to write the following section for this book.) These are procedures using self-illuminated tubes that serve as specula for the endoscopic examination and treatment of the interior of the larynx, trachea, bronchi, esophagus, and stomach.

The endoscopic tubes (Fig. 685) are without lenses and are straight and rigid instruments, serving, as do other specula, to draw out of the way tissues that obstruct direct vision, or to draw the tissues to be inspected into a new position in the line of sight. Through these tubes many ingenious instruments, such as forceps, sponge-holders, loops, hooks, bougies, etc., are used for various procedures, such as removal

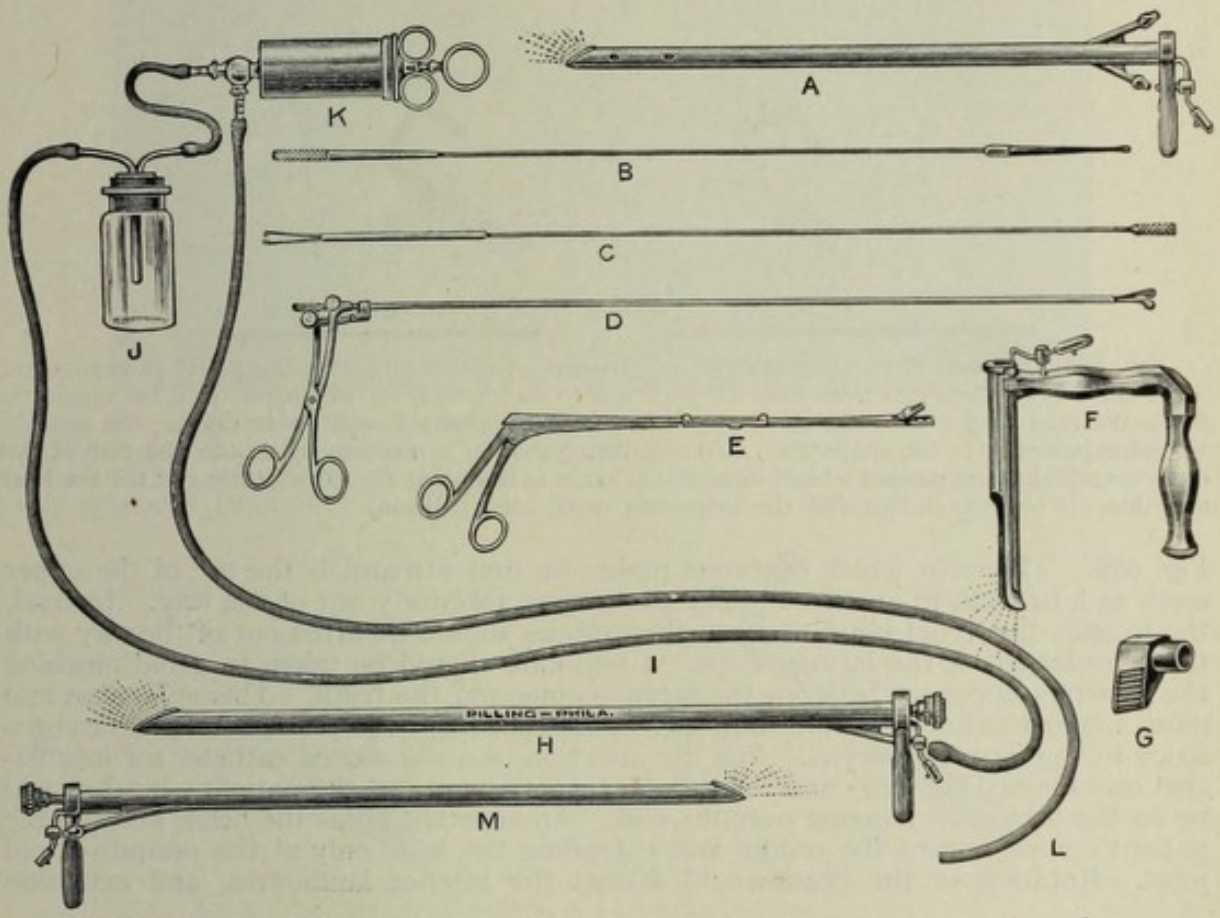


FIG. 685.—Jackson's instruments for direct laryngoscopy, bronchoscopy, and esophagoscopy: *A*, Bronchoscope; *B*, bougie for esophagoscopic bouginage intended only for use through the esophagoscope under guidance of the eye; *C*, sponge-holder for sponging the field and obtaining specimens of secretion; *D*, forceps for removing foreign bodies; *E*, forceps for removing tissue; *F*, laryngeal speculum, called also slide speculum and direct laryngoscope; *G*, Moore's bite-block; *H*, esophagoscope with tubing (*I*) leading to aspirator (*J*, *K*) for removal of secretions. The tubing (*L*) is connected with the positive pressure side of the syringe (*K*) for use when needed to blow out obstructions, such as clots of pus, food, etc., that have been aspirated into the drainage canal of the esophagoscope. At *M* is shown a gastroscope and pyloroscope. A motor-driven aspirator is preferable to syringe form where portability is not required. These instruments are made by George P. Pilling & Son Co., Philadelphia. (Jackson.)

of foreign bodies, dilatation of strictures, diagnosis of disease by inspection, and by removal of specimens of tissues and secretions.

Anesthesia.—For direct laryngoscopy, bronchoscopy, and esophagoscopy in children no anesthetic, general or local, is needed after skill in peroral endoscopy is acquired. The procedures are not painful, though disagreeable and somewhat terrifying. Cocain is dangerous in children and other local anesthetics are unsatisfactory. Ether anesthesia is only slightly more dangerous than in ordinary surgical work. General anesthesia is absolutely contraindicated in dyspneic patients, either adults or children. In adults no anesthetic is needed for esophagoscopy or gastroscopy. For direct laryngoscopy and bronchoscopy in adults the cough reflex may be lessened by the hypodermic injection of morphin in full dosage. This, with the local painting with a

small quantity of a 10 per cent. solution of cocain, using small gauze sponges which are kept in the sponge-carrier (Fig. 687), will suffice in skilful hands. The inexperienced operator will require the patient to be fully relaxed by general anesthesia, preferably ether.

Direct laryngoscopy is so called in contradistinction to ordinary indirect laryngoscopy in which the operator looks not directly at the larynx, but at a reversed image of it in a mirror. Instead of looking down back of the tongue with the aid of a throat mirror the tongue is dragged forward out of the way with the direct laryngoscope. Though easier of accomplishment in some patients than in others, the larynx of any human being can be exposed to view by direct laryngoscopy unless the jaws are so ankylosed that the mouth cannot be opened. The technic of the method is shown in

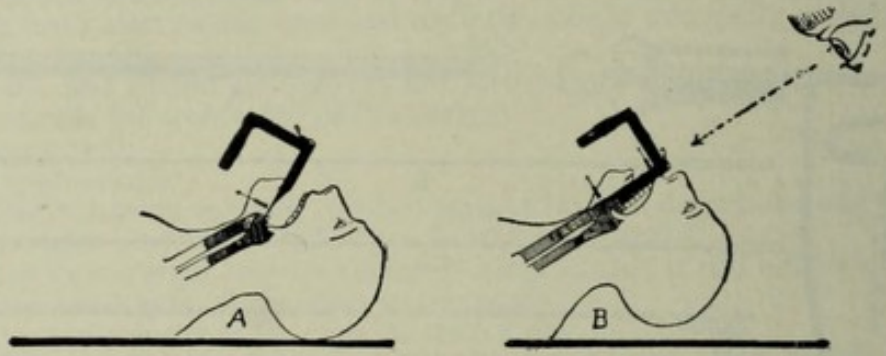


FIG. 686.—Schema illustrating manner of exposure of the larynx with the direct laryngoscope. At *A* the laryngoscope has been inserted posterior to the dorsum of the tongue until the epiglottis has come into view. The laryngoscope is then inserted about 1 centimeter deeper, the spatula tip going posterior to the epiglottis. A strong lifting motion is now exerted in the direction of the dart, even lifting the patient's head high off the table as shown at *B*. The glottis and the tracheal axis thus are brought in line with the observer's visual axis (Jackson).

Fig. 686. The error which everyone makes on first attempt is the use of the upper teeth as a fulcrum in an effort to *pry* the tongue anteriorly out of the way. Instead, the tongue, the hyoid bone, and attached tissues should be lifted out of the way with the spatular tip of the laryngoscope. Great care should be taken to avoid pinching the patient's upper lip between the laryngoscope and the teeth. This will cause real pain, vastly harder to endure than any annoyance from the presence of the laryngoscope in the laryngopharynx. For the insertion of a silk-woven catheter for insufflation anesthesia (Fig. 688) and for endolaryngeal operations the patient's head should be on the table, not hanging over the end. An assistant holds the head, keeping the patient's nose toward the ceiling and extending the head only at the occipito-atloid joint. Rotation of the head would distort the interior landmarks, and extension

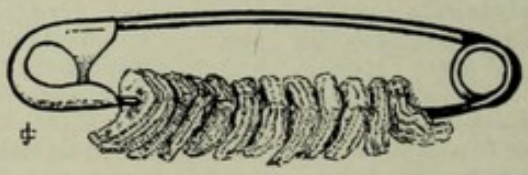


FIG. 687.—Manner of keeping endoscopic sponges. About a dozen of one size are transfixed on a safety-pin, wrapped, the size marked on the wrapper, and then sterilized, to be opened only as needed. About 5 dozen sponges of each of the 4 sizes should be kept on hand. Only one sponge is placed in the sponge-carrier at a time. These sponges are made by George P. Pilling & Son Co., of Philadelphia, and are known as "bronchoscopic sponges" (Jackson).

distributed throughout the cervical spine would obtrude a rigid convexity of the posterior pharyngeal wall. The essential part of the procedure in exposure of the larynx with the direct laryngoscope is, however, the lifting motion (Fig. 686) made as if to suspend the patient by his hyoid bone with the tip of the spatular end of the laryngoscope. Keep the patient's head high. Much less anteriorly displacing effort is required if the laryngoscope is passed at the side of the tongue (preferably the right side), but experience is required to recognize the thus distorted landmarks.

Papilloma and other benign growths of the larynx are removed with the cupped alligator forceps. Specimens are removed with cutting forceps (*E*, Fig. 685). In case of large growths the forceps or snare may be passed along the outside of the



FIG. 688.—Direct laryngoscopy for the introduction of a silk-woven catheter for intratracheal insufflation anesthesia. The patient's head is on the table, but elevated. The anesthetist has exposed the larynx by lifting strongly with the spatular tip of the laryngoscope inserted posterior to the epiglottis (Jackson).

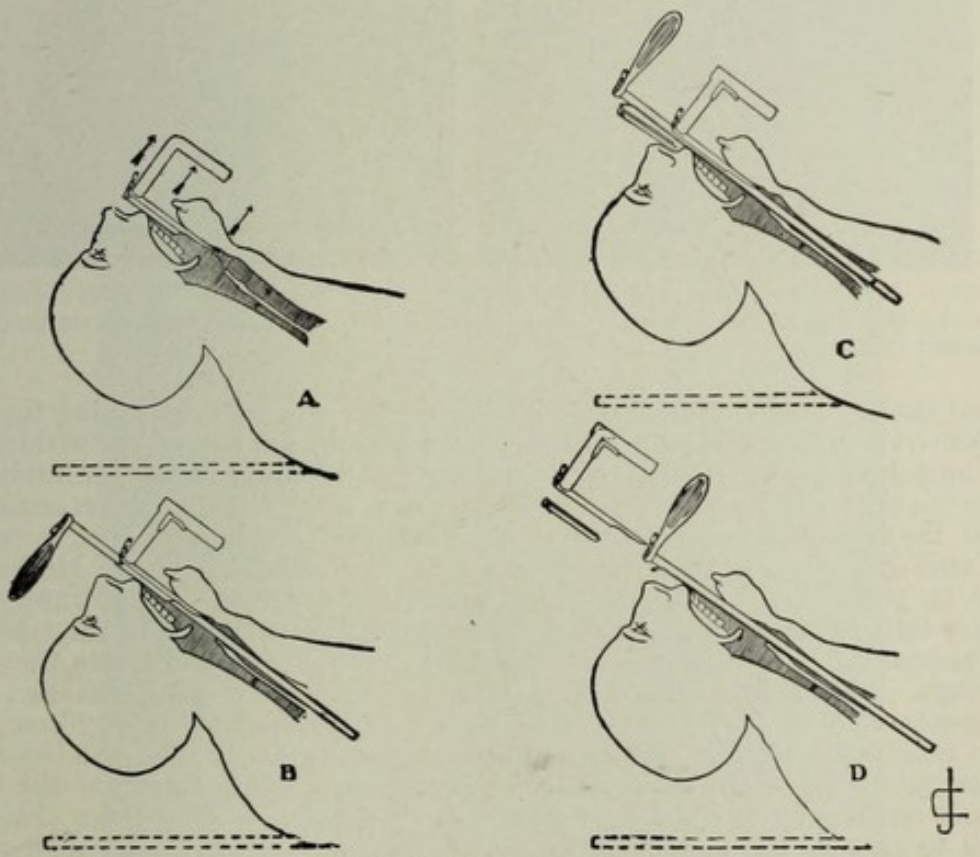


FIG. 689.—Schema illustrating the technic of oral bronchoscopy. The portion of the table here shown under the head is, in actual work, dropped all the way down perpendicularly. It appears in these drawings as a dotted line to emphasize the fact that the head must be above the level of the table during introduction of the bronchoscope into the trachea. *A*, Exposure of larynx; *B*, bronchoscope introduced; *C*, slide removed; *D*, laryngoscope removed, leaving bronchoscope alone in position. The handle of the laryngoscope in *C* and *D* should be shown as rotated down to the left (Jackson).

laryngoscope, the latter being used only for ocular guidance of the forceps when it comes into view at the distal end of the tube.

Bronchoscopy.—The first step in the introduction of the bronchoscope and the chief technical difficulty to be mastered is the exposure of the glottis by direct laryngoscopy (*q. v.*). Once the art of doing this is mastered, both procedures, exposure of the larynx and the introduction of the bronchoscope, should not require more than a minute, usually less. The bronchoscope can be inserted in any patient whose mouth can be opened. As in all manual procedures, practice is necessary. When direct laryngoscopy is done for the introduction of the bronchoscope, the patient's head is brought beyond the head of the table sufficiently far to bring the middle of the patient's scapulæ to the edge of the table. This permits of the patient's head and neck being moved about so as to facilitate following with the bronchoscope various bronchial axes; *but during the introduction of the bronchoscope the patient's head must be maintained as high, the occiput 10 cm. above the table.* If the head is allowed to drop into the Rose position great difficulty in introduction will be encountered. The head is held by an assistant, as shown in Fig. 700.

In Fig. 689 a repetition of Fig. 686 is shown at *A*, a strong lifting motion being exerted in the direction of the dart. When the glottic chink is seen the bronchoscope, lighted by its own separate cord, is inserted, its handle pointing outward horizontally to the right. The eye of the bronchoscopist is then transferred from the laryngoscope to the bronchoscope. The lip of the latter is then insinuated through the glottis into the trachea. The laryngoscope is then removed by withdrawal of first its slide,

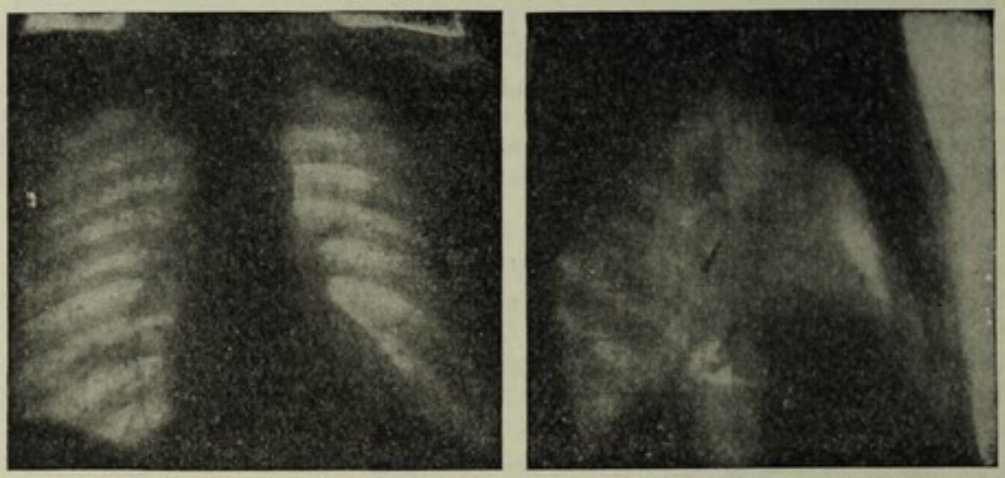


FIG. 690.—Large fence staple in lung of man aged forty-three years. Removed bloodlessly by bronchoscopy through the mouth after two years' sojourn. Complete cure of septic pulmonary focus resulted (Jackson).

afterward itself. If the laryngoscope is allowed to come outward during the removal of the slide there will not be room enough for the withdrawal of the slide without pulling out the bronchoscope so far as to risk withdrawal of the distal end of the bronchoscope from the trachea. This accident would require repetition of the whole procedure. The fact that the bronchoscope is in the trachea and not in the esophagus, is recognized by the strong expiratory blast, the absence of voice, and the visible tracheal rings. It must be remembered, however, that there is a slight pseudorespiratory current through a tube in the esophagus, that a very small bronchoscope in the trachea may permit phonation, and that endotracheal inflammation may obliterate the visibility of the rings. The trachea stands open, whereas the cervical esophagus does not; but the posterior wall of the trachea collapses forward, especially in children, and the thoracic esophagus remains somewhat open when an endoscopic tube is in place. Some practice is therefore required to be prompt in making sure that the bronchoscope does not enter the esophagus instead of the trachea. To prevent this accident it is well to give a little additional lift to the laryngoscope at the moment when the bronchoscopic tube-mouth is inserted into the glottis. Once assured the bronchoscope is in the trachea, the laryngoscope is detached and the bronchoscope is inserted deeper into the tracheobronchial tree. The bifurcation is the first important landmark to be identified. To avoid missing it, and passing unknowingly into the right bronchus, the patient's head is moved slightly to the right, and the left wall of the trachea is watched in order to be certain of exposing the left bronchial orifice. The

lip of the bronchoscope, which corresponds to the handle of the instrument, is always turned toward any orifice it is desired to enter, the patient's head being moved to the

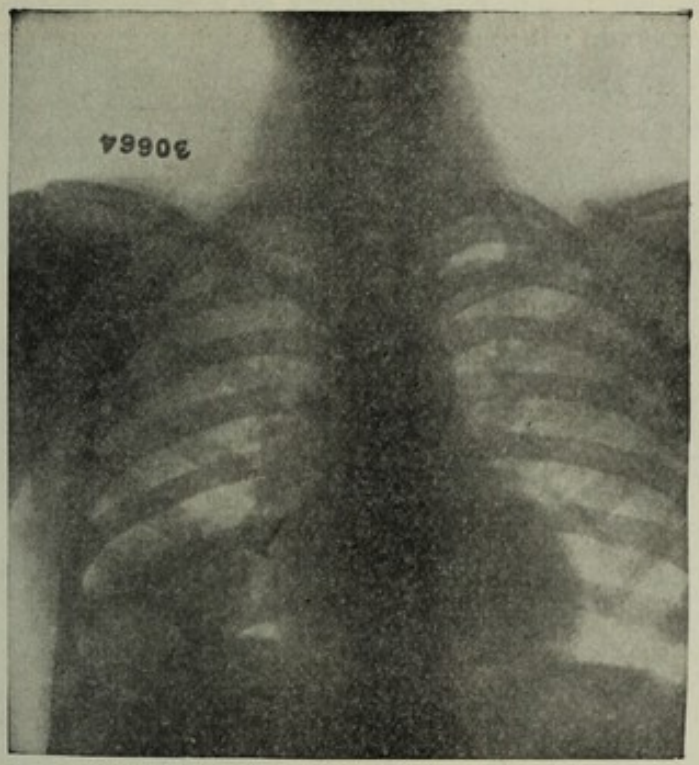


FIG. 691.—Radiograph showing tack in the right main bronchus of a boy aged eight years. Tack removed by oral bronchoscopy without anesthesia, general or local, in four minutes (Jackson).

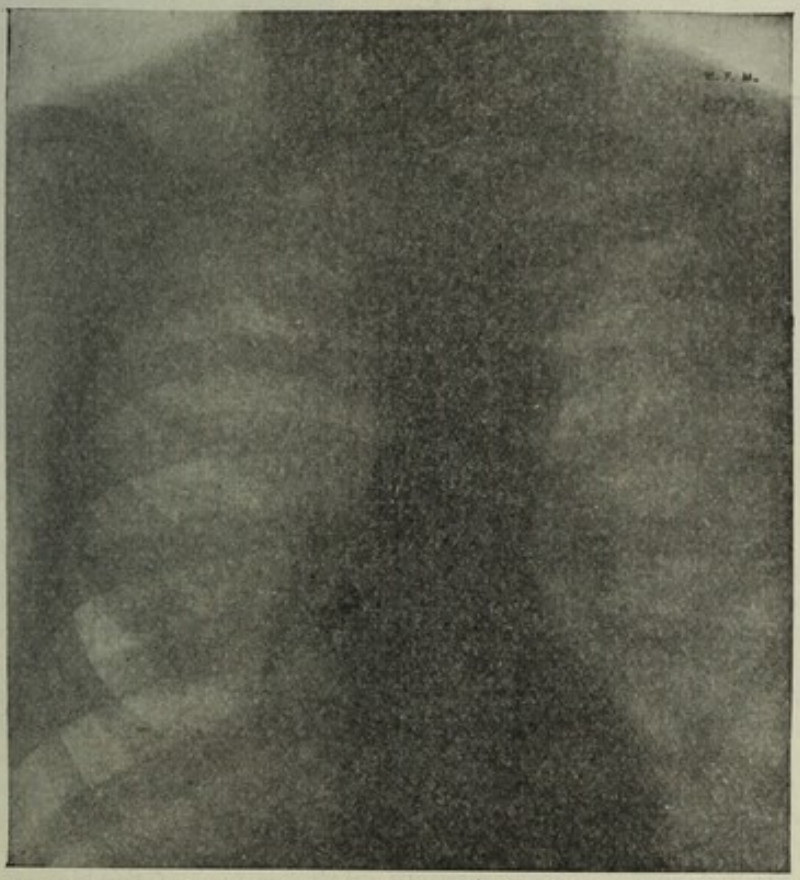


FIG. 692.—Roentgenogram showing atomizer-tip in right lung of a man, aged fifty-eight years, where it had been for a year and a half. Removed in two minutes, fifty-five seconds under local anesthesia by peroral bronchoscopy. Complete cure of lung suppuration resulted (Jackson).

opposite side. The middle-lobe bronchus is given off anteriorly, being the largest of all anterior branches. To enter it, the lip of the bronchoscope is turned upward

and the patient's head is lowered far below the position proper for introduction of the bronchoscope through the glottis. All the time the bronchoscope is in place great care must be taken not to pinch the patient's lip between the bronchoscope and the upper teeth, which would cause pain and distress infinitely greater than the presence of the bronchoscope in the lung. The lip is held out of the way by the bronchoscopist's left thumb, after the laryngoscope is removed, the thumb and index-finger together fixing the tube against the upper teeth. As with any other surgical procedure, a "dry" field is necessary for clear vision. In bronchoscopy the sponge is inserted with a carrier (*C*, Fig. 685) until the sponge emerges at the distal end of the bronchoscope. If the patient does not cough, he is asked to do so. In either case the secretions are coughed into the bronchoscope, from which they are withdrawn by pulling out the sponge-carrier, just as a pump lifts the water that is above the plunger. Secretions

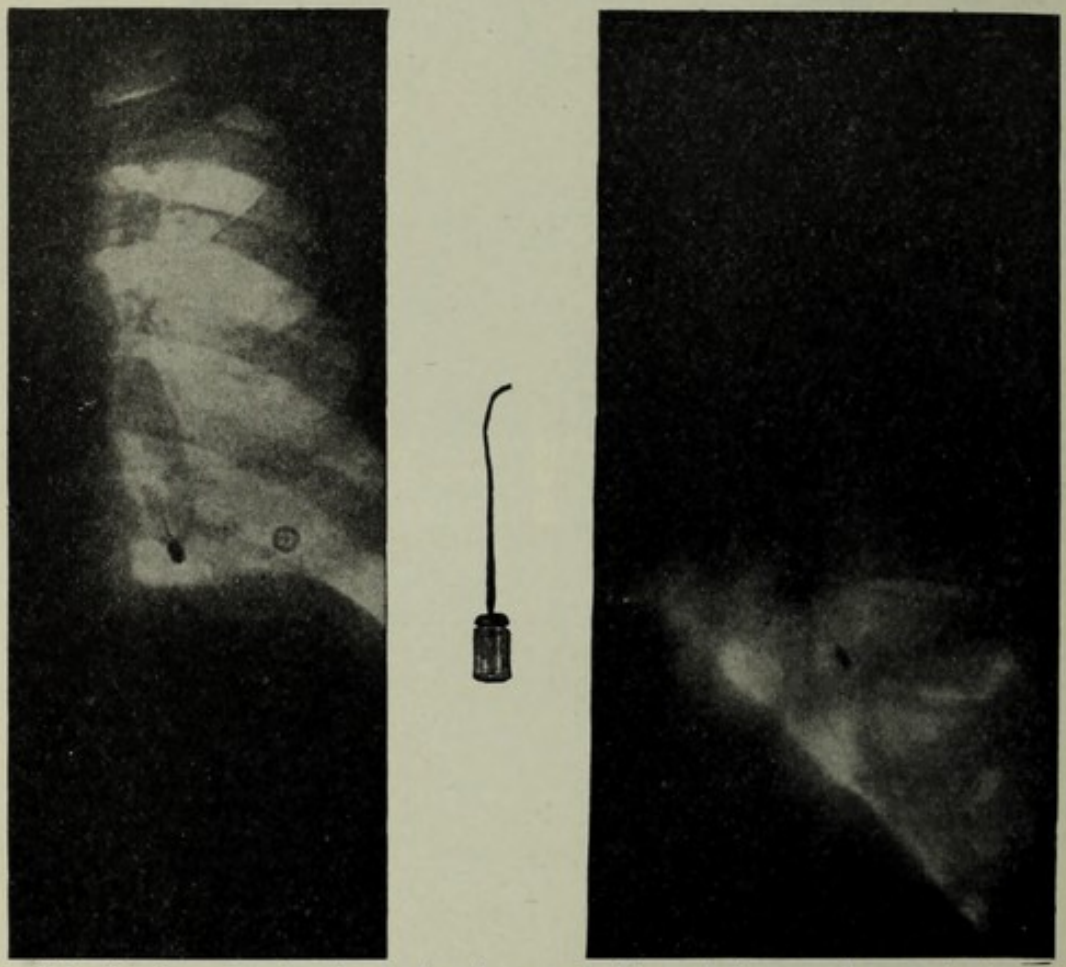


FIG. 693.—Radiographs showing a dental root-canal broach in a small posterior branch of a larger posterior branch of the inferior-lobe bronchus of a man of thirty-nine years. The foreign body is seen just above the dome of the diaphragm in the anteroposterior radiograph, though really in the part of the lung down back of the dome, as shown in the lateral radiograph. Removed through the mouth by bronchoscopy under local anesthesia. This shows from how low a position a foreign body may be removed by bronchoscopy. The full length of a 40-centimeter bronchoscope was necessary to reach it. (From "Peroral Endoscopy," by Chevalier Jackson, Text-book, 1914.)

are also removed by aspiration through the auxiliary canal in the bronchoscope or by an independent aspirating tube inserted from time to time through the bronchoscope.

Duration of Bronchoscopy.—This is of such vital importance, especially in case of children, as to merit a separate paragraph. The author's work has demonstrated that the reaction after bronchoscopy, other things being equal, is directly as the duration, and, after a certain limit, directly as the square of the duration. A fifteen-minute bronchoscopy may be repeated every ten days for months without injury to the health of an infant, whereas a single bronchoscopy may be fatal if continued for an hour. This refers only to the procedure of bronchoscopy *per se*. Of course it may be modified by various factors, such as the disturbance of the epithelium in the presence of pus, the use of unsterile instruments, etc. A safe working rule, to be

modified as deemed best in the individual case, is: One hour in adults, half an hour in children, fifteen minutes in infants. As a matter of fact, however, in most cases in our clinic the foreign body is removed by the bronchoscope in less than five minutes.

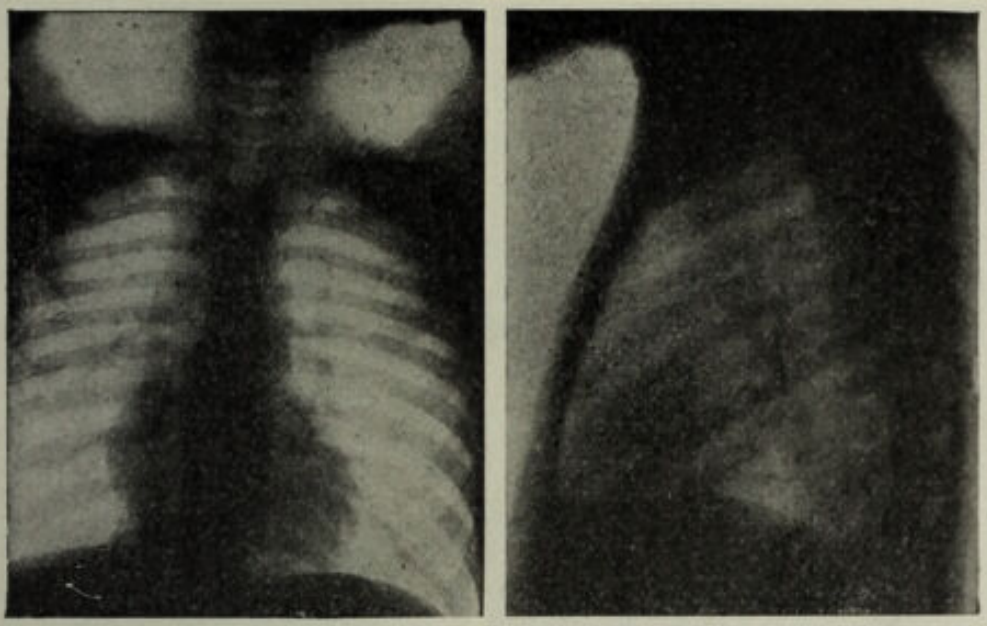


FIG. 694.—Radiograph of a boy, aged eleven years, showing nail that had been in lung for about four years, producing all the symptoms of bronchiectasis. Bronchoscopic removal of the foreign body without anesthesia resulted in complete cure (Jackson).

Bronchoscopic removal of foreign bodies from the trachea and bronchi has been successful in our clinic in over 98 per cent. of our cases. In 506 cases there were 11 failures to remove. The mortality, taking the cases as they came, the condition being good or bad on admission, was 1.7 per cent. In no case was mortality directly attrib-

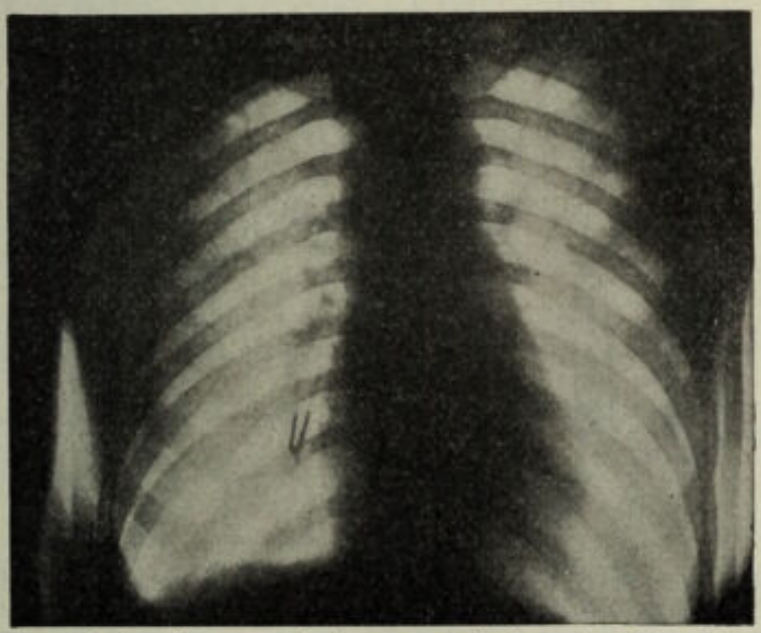


FIG. 695.—Radiograph showing a staple in a posterior branch of the inferior lobe bronchus, 10 centimeters (4 inches) below the bifurcation of the trachea, in a man aged forty-four years. Staple was turned (version) and removed bloodlessly by bronchoscopy through the mouth. (See Fig. 697.) (Plates made by Dr. George W. Grier. Author's case.)

utable to bronchoscopy. Of 116 cases of lung abscess due to foreign body of prolonged sojourn (one to thirty-six years) complete cure followed oral bronchoscopic removal in 110 cases.

Extreme care is necessary to avoid tearing the bronchi in the use of forceps, and especially in the extrication of entangled pointed foreign bodies such as tacks, nails,

pins, safety-pins, etc. In all cases of pointed objects (which are almost invariably point upward) great care is necessary to extricate the point first and to get it into the tube-mouth before any traction is made; otherwise the slightest traction will cause

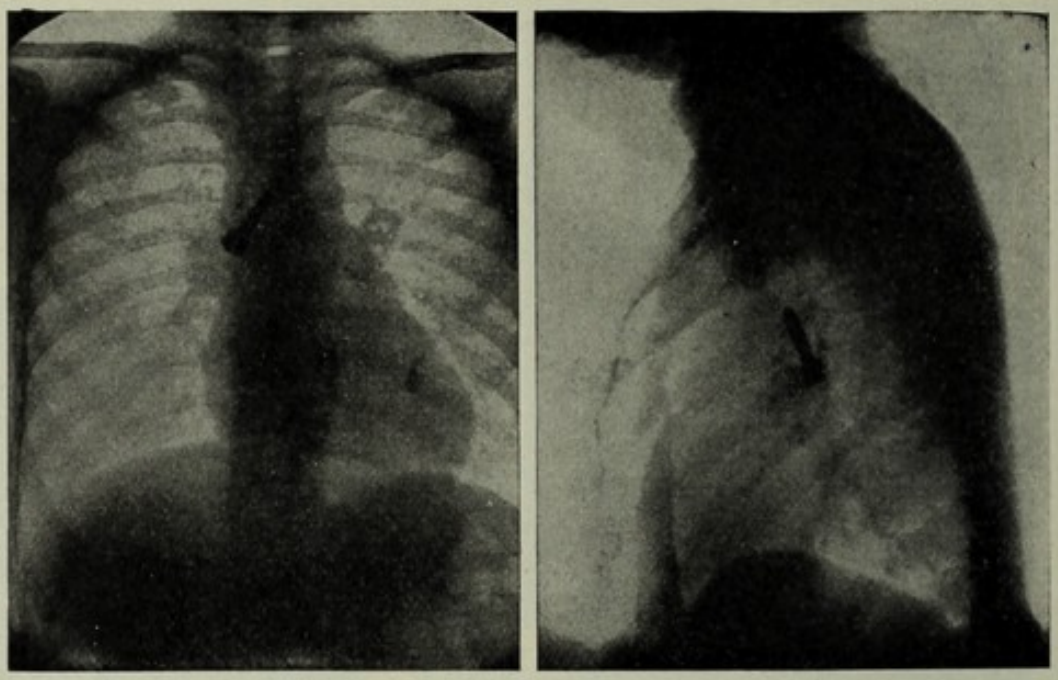


FIG. 696.—Radiographs showing an iron casting in the right bronchus of a child of eight years. Foreign body removed by peroral bronchoscopy without anesthesia in six minutes, fifty-two seconds (Jackson).

the point to rip in, and crosswise fixation will not only defeat removal, but will rupture the bronchial wall and result almost certainly in death from mediastinal emphy-

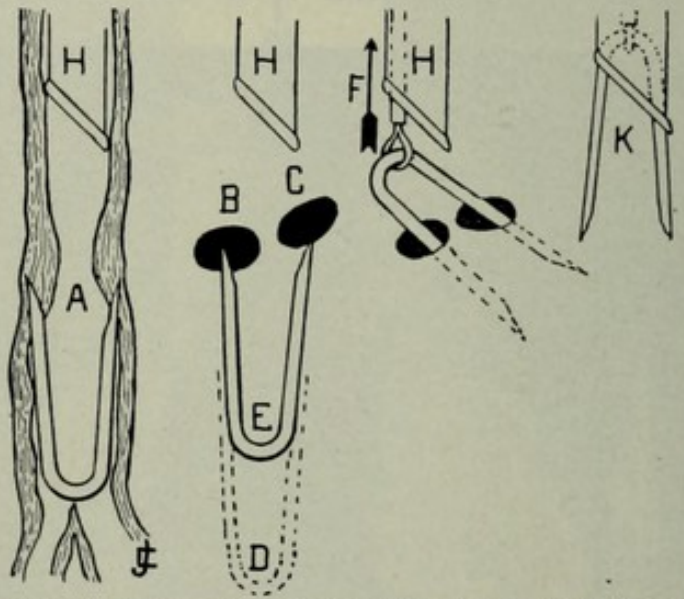


FIG. 697.—Schema illustrating removal, by version, of bronchially lodged staples or double-pointed tacks. H, Bronchoscope; *A*, swollen mucosa covering points of staple. At *E* the staple has been manipulated upward with bronchoscopic lip and hooks until the points are opposite the branch bronchial orifices, *B*, *C*. Traction being made in the direction of the dart (*f*), by means of the rotation forceps, and counterpressure being made with the bronchoscopic lip on the points of the staple, the points enter the branch bronchi and permit the staple to be turned over and removed, with points trailing harmlessly behind (*K*). This method slightly modified has now been successfully used in 12 cases, without mortality. (See Fig. 695.) (Jackson.)

sema or septic mediastinitis. The cardinal rule is that no harm should be done, and if gentle methods are not successful in, say, twenty-five minutes in case of children, further effort should be postponed for a week, when another radiograph should be taken and a new bronchoscopic effort may be made. While it is true that if not

removed a foreign body in the lung will prove fatal, there is no immediate danger that would justify ruthlessly tearing the foreign body out at all hazards. If no harm is done further study of the mechanical problem involved will almost certainly succeed in solving the problem of safe removal. A few of the many problems and their solutions are illustrated in Figs. 697 and 698. If the greatest care be not taken a very simple and easy problem of removal may, by an improper touch or traction, be converted into an exceedingly difficult problem. In fully half of our cases this has happened before coming to our clinic. Soft, friable objects, such as nut-kernels, maize, beans, egg-shells, glass, and the like, must be grasped with a delicately gaged

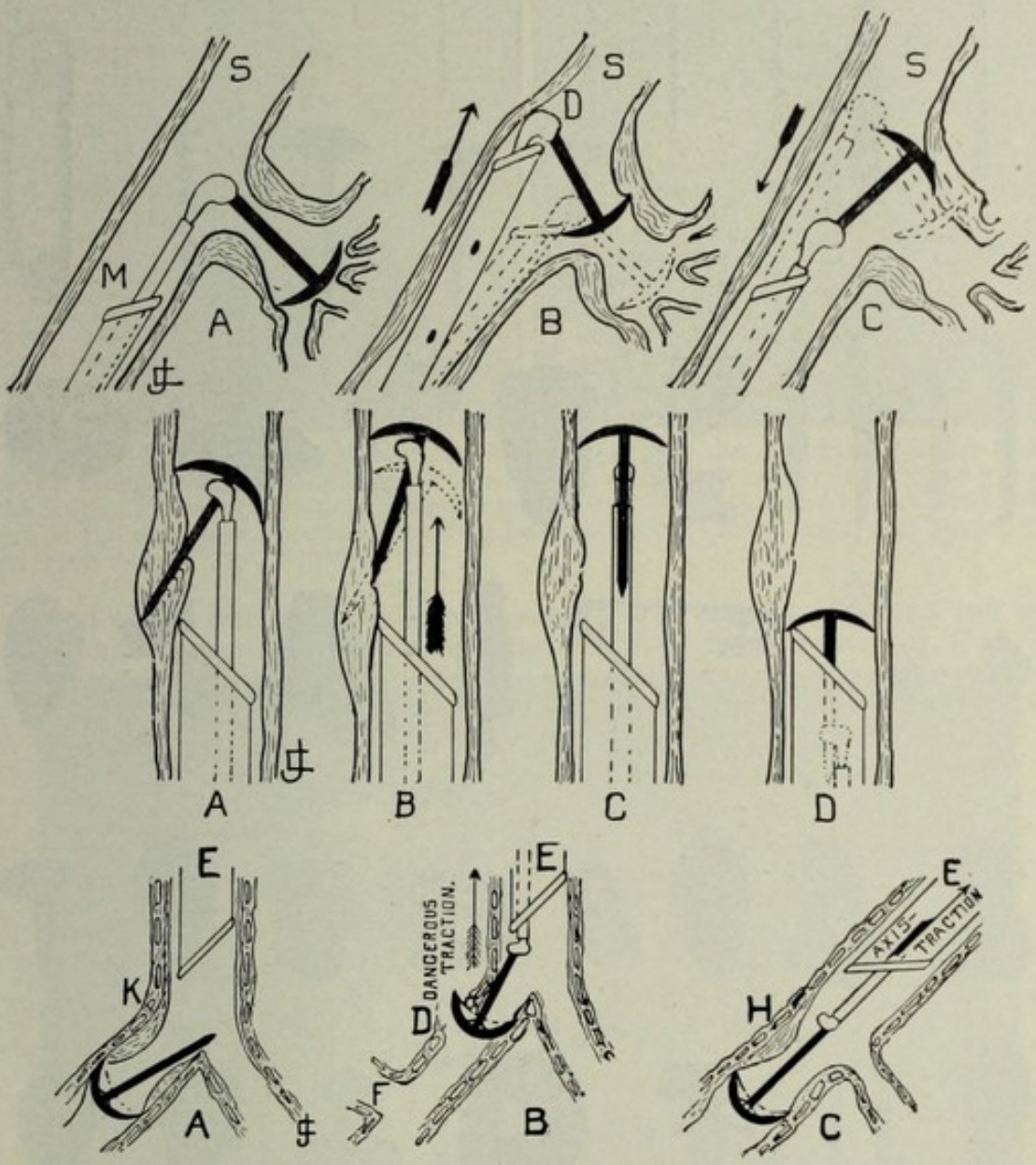


FIG. 698.—Schema showing various manipulations in the disengaging and safe removal of tacks from the bronchi by peroral bronchoscopy without general anesthesia. In 38 cases of this kind of tack all have been successfully removed without anesthesia and without mortality in our clinic (Jackson).

forceps pressure sufficient to hold the foreign body and prevent its being stripped off at the glottis, yet not sufficient to crush it. The latter disaster is usually fatal from scattering the fragments which are promptly aspirated into many minute bronchi. In the removal of any kind of a foreign body that is too large to come through the bronchoscope, the latter is removed along with the forceps and the foreign body. To get through the glottis the intruder must be turned with its greatest plane sagitally. Otherwise it may jam, the forceps slip off, and then prompt work with precision will be required to remove the foreign body before the patient is asphyxiated by impaction of the foreign body in the glottis or its aspiration into the sound lung.



FIG. 699.—Foreign bodies removed from the bronchi by peroral bronchoscopy without general anesthesia and without mortality (Jackson).

Introduction of the esophagoscope is easy of accomplishment in any patient whose mouth can be opened, but, like all technical manual procedures, practice is necessary. Fatal trauma is readily inflicted by the inexperienced, and readily avoided by the facile.

The esophagus has very thin, delicate walls, and is very intolerant of trauma, in addition to its being surrounded by many vital structures. There is no mortality

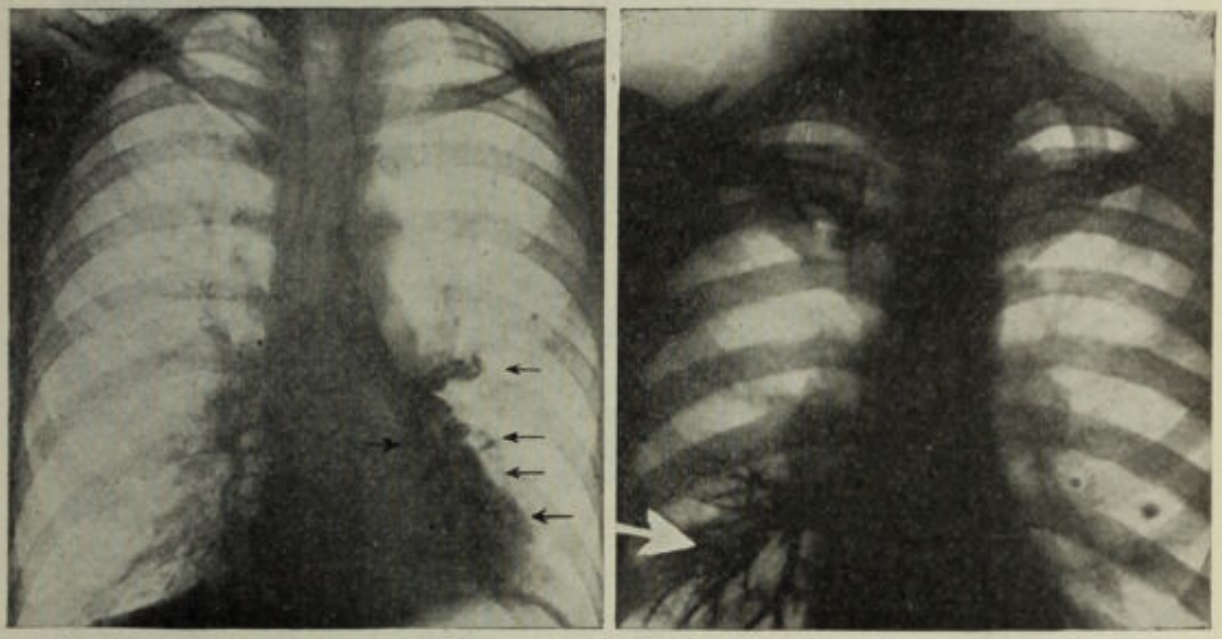


Fig. 699a.—Pneumonograms of living patients showing the value of pneumonography by bronchoscopic insufflation of bismuth subcarbonate in mapping out suppurative foci and other diseases in the lungs. The bronchiectatic condition at the left is in marked contrast to the normal bronchi shown in the right-hand pneumonogram (see Jackson, Tucker, Clerf, Lukens, and Moore, "Jour. Amer. Med. Assoc.," Dec. 27, 1924).

associated with a carefully done esophagoscopy. The position of patient and assistant for esophagoscopy is the same as that described for bronchoscopy (Fig. 700).

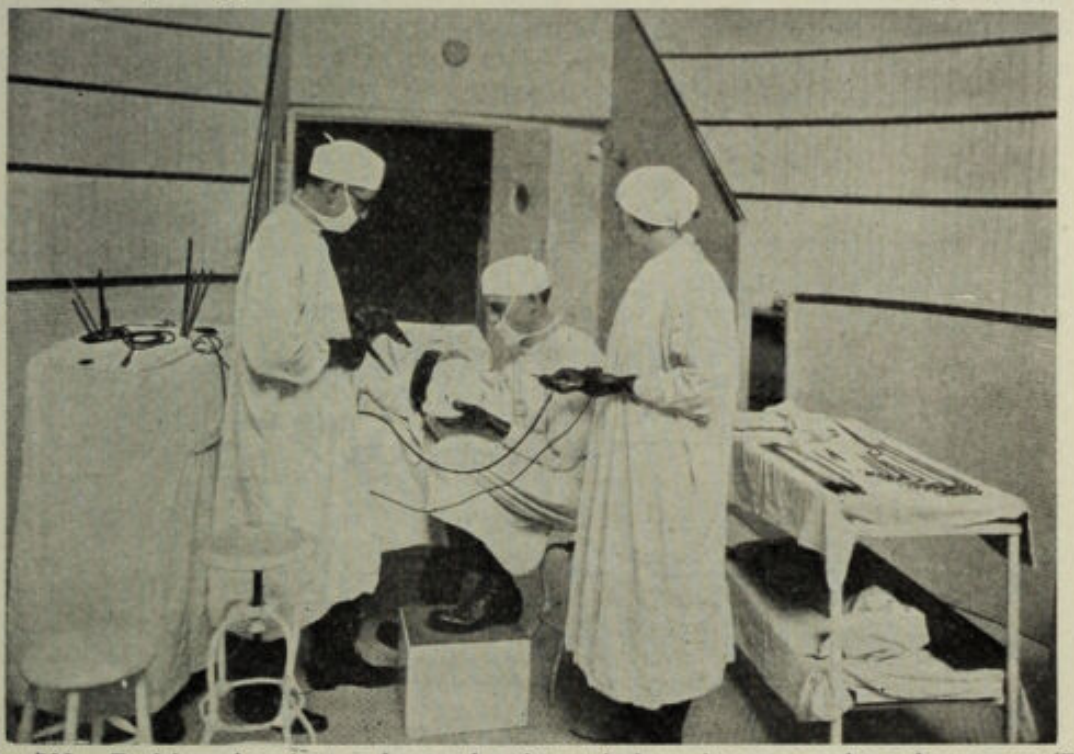


FIG. 700.—Position of patient and second assistant in bronchoscopy and esophagoscopy (Boyce position). The left hand is supported on the left knee, the left foot being elevated on a stool. The right forearm is under the patient's neck, the right index carrying the bite-block. The right forearm carries little weight, most of the extension being done with the left hand (Jackson).

The easiest and most satisfactory way of introducing the esophagoscope is that known as "Chevalier Jackson's high-low method of esophagoscopy" (Fig. 701). The handle

is upward; the thumb and finger of the right hand lightly grasp the proximal end of the tube, while the left hand supports the distal end and at the same time pushes

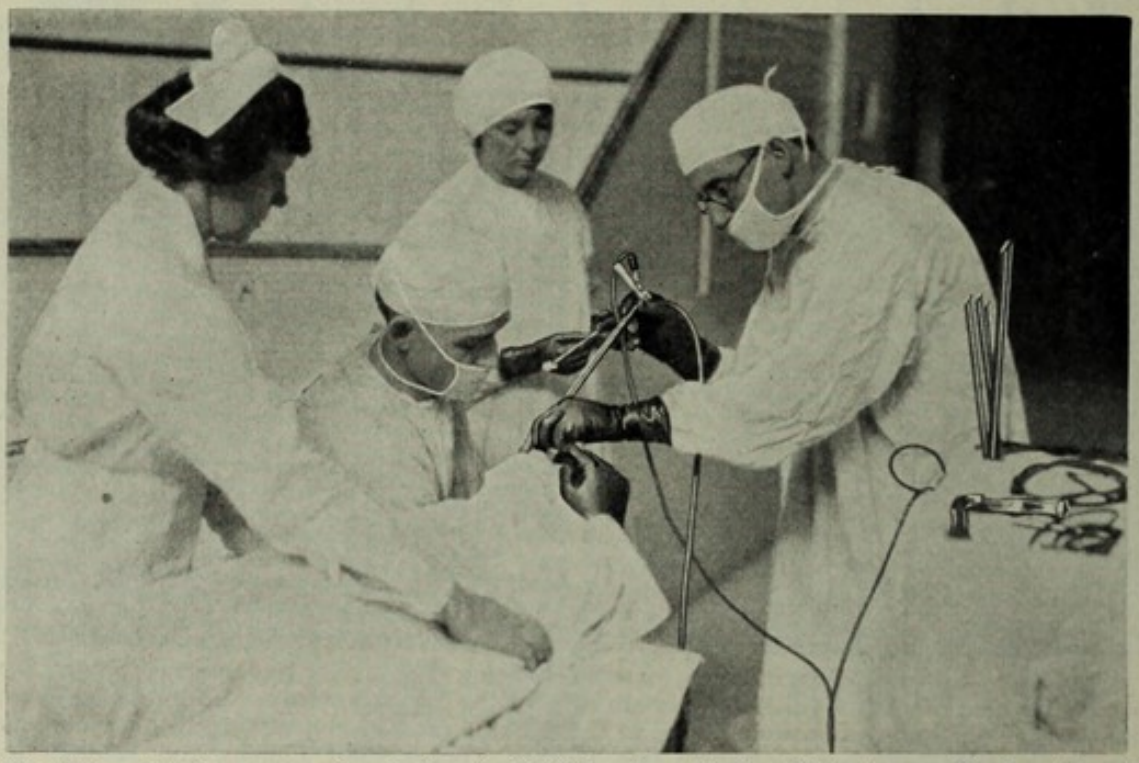


FIG. 701.—Esophagoscopy by Jackson's "high-low" method First stage. Finding the right pyriform sinus. In this and the second stage the patient's vertex is about 15 centimeters above the level of the table with slight extension limited to the occipito-atloid joint (Jackson).

back the patient's upper lip with the thumb, on which the tube-mouth rests. The fingers of the left hand are on the inside of the upper alveolus back of the teeth, steady-

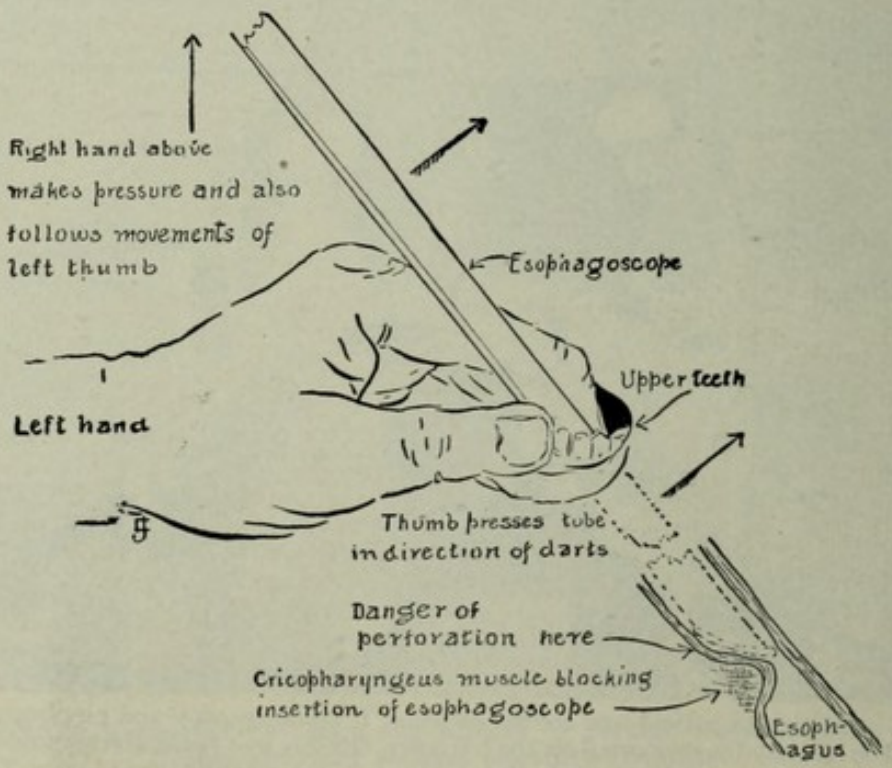


FIG. 702.—Schematic illustration of the technic of passing the cricopharyngeal fold in introducing an esophagoscope (Jackson).

ing the tube. The long axis of the esophagoscope at this, the first stage, is nearly vertical (Fig. 701). The tube-mouth then is passed down along the right side of the

patient's tongue, under guidance of the eye watching the landmarks through the tube, until the bottom of the right pyriform sinus is reached, the proximal end of the esophagoscope being gradually lowered to about 20 degrees above the horizontal. Here firm resistance is encountered, due to contraction of the cricopharyngeus muscle. Though not apparent through the tube, this muscle raises a rigid fold from the pos-

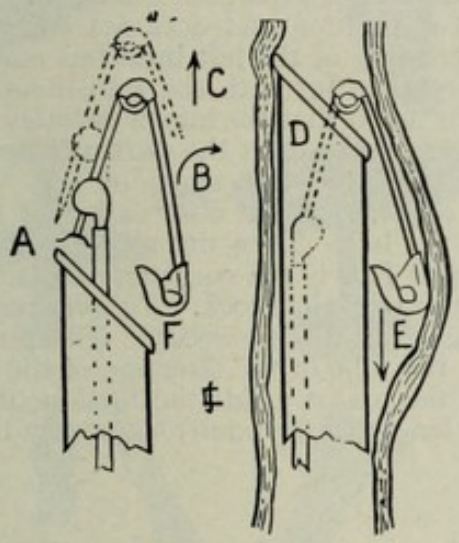


FIG. 703.—One of the many ways of dealing, endoscopically, with the open safety-pin lodged point upward. The point of the pin, *A*, is withdrawn from the mucosa by pushing it downward in the direction of the dart, *C*, at the same time rotating the pointed branch, as indicated by the curved dart, *B*, so that the esophagoscope can be pushed down over the point. With the point thus protected the pin is withdrawn along with the esophagoscope and forceps, the keeper being outside the tube (*E*). The Tucker forceps are better for this maneuver than the side-curved forceps here shown (Jackson).

terior pharyngeal wall, as shown in the schema, Fig. 702. The best way to overcome this obstacle is to raise the tube-mouth forward with the thumb without depressing the proximal end of the tube. At the same time the eye watches through the tube for the opening up of the lumen at the anterior portion of the endoscopic field. Moderate but continuous pressure onward (*i. e.*, toward the deeper esophagus), the long axis

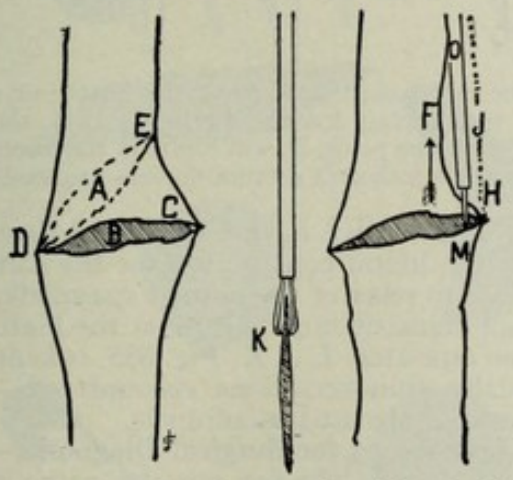


FIG. 704.—The problem of the horizontally transfixed foreign body in the esophagus. The point, *D*, had caught as the bone, *A*, was being swallowed. The end, *E*, was forced down to *C* by food or by blind attempts at pushing the bone downward. The wall, *F*, should be pushed laterally out to *J*, permitting the forceps to grasp the end, *M*, of the bone. Traction in the direction of the dart will disimpact the bone and permit it to rotate. Jackson's rotation forceps are used as at *K* (Jackson).

of the esophagoscope coinciding with the long axis of the esophagus, should be made on the esophagoscope until the cricopharnygeal contraction yields and the lumen opens. Intermittent contraction fails here as it does in using a tongue depressor. The pressure, though continuous, must be very moderate. If anything approaching force be used, the esophagoscope will be forced through the posterior esophageal wall in

the weak place in the support between the circular and the oblique fibers of the cricopharyngeus; that is, in precisely the place where the esophageal hernia, known as pulsion diverticulum, occurs. Fatal perforation with the esophagoscope, and even with the obsolete bougie, has occurred here many times in inexperienced hands. Once the cricopharyngeus yields, usually no further difficulty is encountered until the hiatal region is reached. The thoracic esophagus, unlike the cervical, opens its lumen before the tube-mouth on inspiration and does not completely close on expiration. The ridge formed by the crossing of the left bronchus may be noted on the anterior wall of the esophagus if searched for with the tube-mouth. When the tube-mouth passes back of the heart it is noted that the lumen deviates anteriorly so that to follow the lumen axially it is necessary to drop the patient's head lower and lower. This should be done and constitutes the last stage of the "high-low" method. Just before the hiatal level is reached careful observation of the direction of the lumen will note the deviation to the left. Then the tube-mouth encounters an apparently insurmountable obstruction. This is the constriction made in the esophagus by the contraction of the diaphragmatic pinchcock. To overcome this, moderate but continuous pressure in the right place is necessary. The proper place is a rosette-like slit to be found by aiming the tube in the direction of the left anterior superior spine of the ileum. As soon as the hiatus yields the tube-mouth traverses the abdominal esophagus (about 3 cm. in length in the adult) so quickly that the tube seems at once

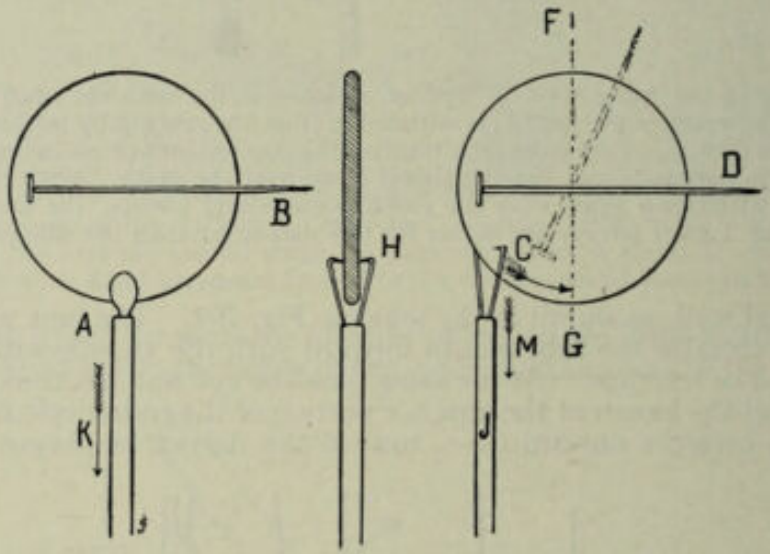


FIG. 705.—Solution of the mechanical problem of the button or other disk-like object with a sharp point. If withdrawn with a plain forceps applied as at *A*, the point, *B*, will rip open the esophageal wall. If grasped at *C*, the point, *D*, will rotate in the direction of *F* and will trail harmlessly behind. To permit rotation Jackson's rotation forceps are used as at *H* (Jackson).

to enter the stomach. So deceptive is this that until demonstrated by the author esophagoscopists mistook the hiatal constriction for the cardia. The so-called "cardiospasm" is really a failure to relax of the normal spasmodic contraction, not at or of the cardia, but of the diaphragmatic musculature at the hiatus esophageus. Throughout an esophagoscopy the aspirator, *I*, *J*, *K*, Fig. 685, is kept going by a nurse. This is efficient with the usually thin secretions encountered. Sponges on carriers, as described under Bronchoscopy, are used as adjuncts.

Esophagoscopy and Gastroscopy for Surgical Diagnosis.—The ease and certainty with which diagnoses can be made in a few minutes without anesthesia and without pain in cases of esophageal disease have resulted from development of a perfected technic. Endo-esophageal lues, tuberculosis, and malignancy are readily diagnosticated by clinical appearances and by the taking of specimens for biopsy. With the forceps, *E*, Fig. 685, a specimen of tissue is very readily taken, and it is safe to do so in case of fungating, ulcerating or projecting growths, or any process involving the esophageal wall itself. In the case of peri-esophageal growths compressing the esophagus, and covered with normal mucosa, it doubtless involves risks and may prove disappointing because the disease lies beyond reach and the specimen will include only the intervening normal covering. Growths in the left half of the stomach can be found with the esophagoscope, and specimens taken, constituting gastroscopy; but doubtless this procedure will be most frequently of use in cases that refuse exploratory opera-



FIG. 706.—Foreign bodies removed from the esophagus by peroral esophagoscopy without anesthesia and without mortality (Jackson).

tion. In cases of pulsion diverticulum the diagnosis is made by the discovery of a blind pouch which seems like a continuation of the pharynx, and in the upper anterior part of which the opening into the subdiverticular esophagus is found.

Retrograde pyloroscopy and *duodenoscopy* are valuable procedures in patients with a gastrostomic fistula (Tucker, "Surgical Clinics of North America," Feb., 1924).

Cicatricial stenosis of the esophagus is treated with all the safety afforded by ocular inspection. The filiform bougies (*B*, Fig. 685) in increasing sizes are inserted into the lumen of the stricture under guidance of the eye.

Atresia of the esophagus can be cured by the combined peroral and retrograde esophagoscopic method, by which a lumen is made and a string placed. The string is used to pull up the Tucker retrograde bougies (see Clerf and Tucker, "Surgical Clinics of North America," Feb., 1924, W. B. Saunders Co.).

Esophagoscopy for foreign bodies has reached such a high state of development that the exceedingly dangerous blind methods with bougie, probang, Graefe's basket, Bond's forceps, and the like are relegated to districts remote from medical centers. It usually requires but a few minutes without anesthesia and without pain or serious

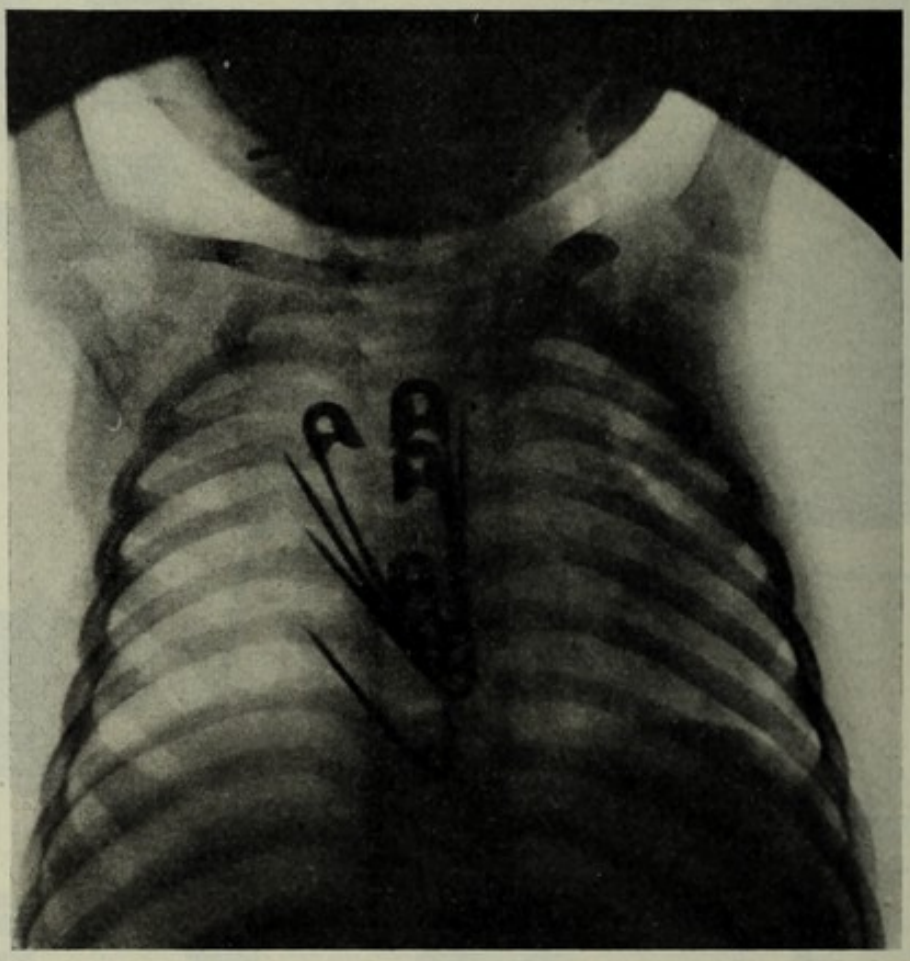


FIG. 707.—Four interlocked safety-pins, open and point upward, impacted in the esophagus of a child aged nine months. Successfully dealt with by peroral esophagoscopy. Any sort of blind method is certain to prove fatal in safety-pin cases (Jackson).

risk to remove a foreign body by esophagoscopy in practised hands. Any foreign body that has gone down the natural passages can be brought back the same way, provided it be turned so as to present the same way relatively to the upward direction that it previously presented relatively to its downward course. This can be done by an experienced esophagoscopist in probably every case. Foreign bodies without points or projections may be seized and withdrawn with the forceps, *D*, Fig. 685. If the foreign body is too large to come through the tube, as is usually the case, the forceps holds the foreign body close up against the distal tube-mouth while forceps, foreign body, and esophagoscope are all withdrawn together.

In cases of pointed objects, such as safety-pins lodged point upward, if the intruder be grasped and pulled upon by the presenting part, the point or points will catch, the intruder will become transfixed and cannot be removed at all, or fatal trauma will be inflicted. A radiograph should be taken and the position of the intruder should be studied esophagoscopically and a safe method of seizure, and version if necessary, be

devised before any traction is made. Too much emphasis cannot be placed upon the necessity of care in esophagoscopy for foreign bodies. Various methods of working out mechanical problems are shown in Figs. 704–705. In cases of bones, which are

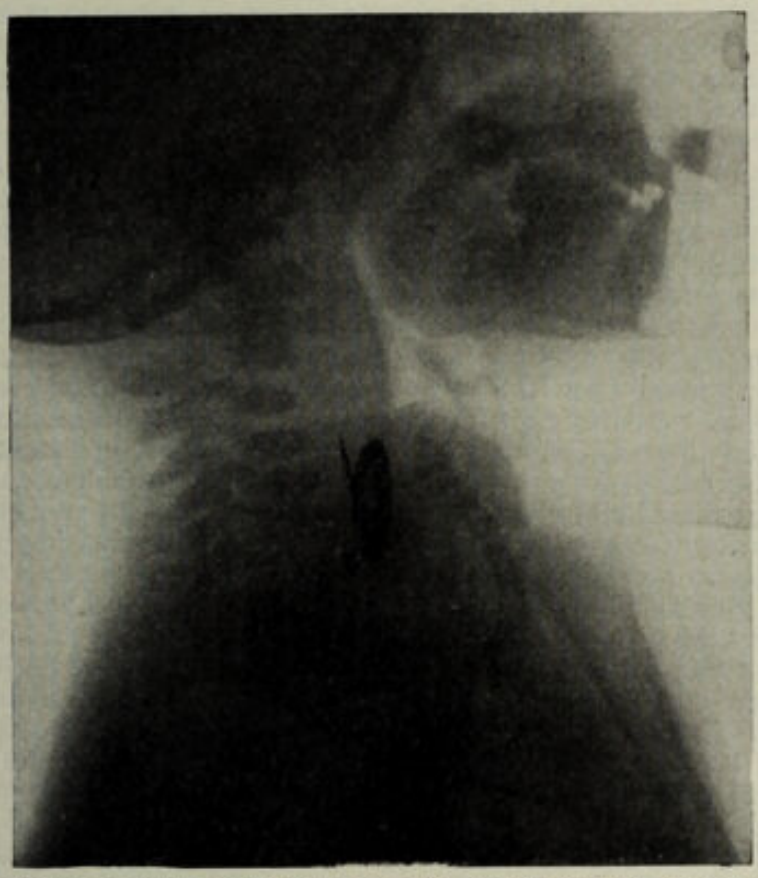


FIG. 708.—Pin button in the esophagus of a child, aged two and one-half months. Turned and removed by peroral esophagoscopy in two minutes without anesthesia, general or local. Case of Dr. Ellen J. Patterson. Any sort of blind method is certain to prove fatal in such a case (Jackson).

very frequent intruders, the foreign body should be manipulated so as to bring its greatest diameter into the long axis of the esophagus. The next-to-the-greatest diameter must be transverse to get the intruder past the cricoid cartilage.

DISEASES AND INJURIES OF THE CHEST, PLEURA, AND LUNGS

Traumatic Asphyxia (*Pressure Stasis; the Ecchymotic Mask*).—This is a condition that occasionally arises when the chest, abdomen, or both are subjected to sudden and violent compression (caught under an elevator, caught under a heavy box, cave in of earth, crush of a crowd in the rush of a panic, etc.). In the majority of reported cases the pressure was very temporary. The discoloration arises almost immediately, and is manifested over the head and neck down to and sometimes below the clavicle. The discoloration usually stops at hair line but may involve the scalp. It may stop at collar line or run to the nipple line, to the deltoid insertions and lower borders of the shoulder-blades, and may be absent under the collar, suspenders, and hat band (George I. Heuer in "Surg., Gynec., and Obstet.," May, 1923). The hue is a violent lividity, blue or bluish black. There are a great many spots in the skin in which the color is much deeper, which have been supposed by some to be ecchymoses and by some to be hemorrhages, and similar spots exist on the labial, buccal, glossal, palatine, and pharyngeal mucous membranes, external auditory meatus, and ear drums.

The color begins to fade in from two to four days and by two weeks disappears. There are no color changes as in a black eye because in the skin the condition is due to venous stasis and not to hemorrhage (Heuer). There is always subconjunctival discoloration, usually bilateral, and that is due to hemorrhage. Often the face swells and may become edematous. There may be bleeding from the nose, mouth, and ears. There is brief

or prolonged unconsciousness, circulatory and respiratory depression, sometimes cough and bleeding from the lungs. Cortical irritation is not very unusual. There may be hemothorax, subcutaneous emphysema, pulmonary edema, exophthalmos, and very rarely ocular palsy, retinal hemorrhage, or intracranial hemorrhage (Heuer, Ibid.). The pupils are variable. There may be grave injury of the body or limbs. There are seldom convulsions, there is no paralysis and no delirium. The lividity may clear up in a few hours. The spots seldom fade for days. The spots do not fade at all from pressure, the livid area fades but slightly from pressure.

If death occurs, it results from pneumonia or associated injuries. The condition in the cases without severe associated injuries soon disappears, and entire recovery follows. The view generally taught is that traumatic asphyxia is the result of compression of the abdominal veins, causing distention of the superior cava and its tributary veins, this region of the body showing the effect more than the limbs because of the comparative feebleness of the valves (Villemin). The blood is forced back along the veins and into the capillaries, and capillary paresis ensues. One thing is sure, and that is, that the condition is particularly apt to arise if the patient struggles violently to free himself from the compression; and many observers have held the opinion that actual vascular rupture takes place. There are certainly some cases, however, in which there is simply great venous and capillary distention in the skin without rupture, because pieces of skin have been excised and microscopic examination has indicated that there had been no blood effused. The selection of the face and neck as the chief regions of discoloration is due, perhaps, to absence or incompetence of valves in the jugular and facial veins. The fluid state of the blood which has been noted occurs in all forms of asphyxia. (See Winslow, "Medical News," Feb. 4, 1906; Birge, "Cleveland Medical Journal," Sept., 1905; Beach and Cobb in "Annals of Surgery," April, 1904; Villemin, "Bull. et mém. de la Soc. Chir. de Paris," No. 9, 1906.) Despard ("Annals of Surgery," June, 1909) has reported 1 case and collected 17 from recent literature. Ettinger in 1907 collected 36 cases and added 1 of his own ("Wein. klin. Wochen.," 1907, vol. xx). I have seen 3 cases. Heuer (Ibid.) collected 127 cases, of which 27 died in a short time. Of the remaining 100, 92 recovered and 8 died.

Pleuritic effusion may arise from the lodgment of foreign bodies, from injury by fragments of a broken rib, from tumors, and from inflammation of the lung, but most usually is due to pleuritis. The commonest cause of primary pleuritis is tuberculosis. Inflammatory effusion is nearly always unilateral (except in tuberculous pleuritis, but even in this form it is often one-sided in origin).

The **signs** of pleuritic effusion are: dulness on percussion over the area of effusion, this dulness, when the patient is erect, being at the lowest part of the chest and ascending higher posteriorly than anteriorly (alteration of position alters the situation of the dulness); the intercostal spaces are widened, the intercostal depressions are obliterated, the intercostal muscles are rigid, and their rigidity lessens the mobility of the ribs (Przewalski). No breath sounds can be detected in the area of percussion flatness when the collection of fluid is large, but in small effusions deeply situated the breath sounds are often audible; the percussion note above the liquid is hyperresonant or tympanitic, and is often associated, at the edge of the liquid, with a friction sound; posteriorly, high up and near the spine, there are bronchial respiration and bronchophony. In cases of pleurisy with effusion pain almost or quite disappears with the advent of effusion, dyspnea comes on, and the patient lies upon the diseased side. Cough always exists if there is pleuritic effusion, and fever is usually present. In serous effusions the diagnosis may be confirmed by the aseptic introduction of a clean aspirating needle. Ramond has pointed out that in serofibrinous pleurisy the iliocostal and longissimus dorsi muscles are always noticeably enlarged on the side of the effusion ("Bull. de la Soc. Méd. des hôp.," 1910, vol. xxvii).

The **treatment** in this stage is to discontinue arterial sedatives and to stimulate if the circulation calls for it. The exudation may be removed by the administration of salines, compound jalap powder, or elaterium. If these means fail, if the effusion is excessive, or if it is producing severe dyspnea, at once aspirate. Aspiration should be performed for an effusion which fills the whole chest, which produces great dyspnea, or which has lasted for three weeks. In tuberculous pleuritis early aspiration is not advisable, but aspiration should be performed if the fluid becomes purulent, if the effusion displaces the heart considerably, and if it adds notably to the dyspnea. If a non-tuberculous effusion becomes purulent, the proper procedure is incision, resection of a portion of a rib, and drainage.

Empyema is a collection of pus in the pleural cavity displacing and compressing the lung. It may begin suddenly, but rarely does so. Among the causes of empyema are those of serous effusion. Empyema is due to infection of the pleura, and in every case a bacteriologic study should be made of the exudate to discover the causative bacterium. The pneumococcus, the streptococcus, the staphylococcus, the organism of influenza, the colon bacillus or the typhoid bacillus may be found. The pneumococcus is the causative micro-organism in many of the cases which follow pneumonia. There may be mixed infection of pneumococci and streptococci, or other mixed infection. Pneumococci live but a short time, and in empyema due to pneumococci these micro-organisms may not be discoverable when the pus is evacuated, only streptococci or staphylococci being found. These micro-organisms may appear in an empyema induced originally by pneumococci (Stephen Paget). In empyema developing during or after typhoid fever typhoid bacilli may be discovered. In putrid empyema various bacteria are found. Bacilli of tuberculosis are present for a time at least in tuberculous empyema, but may disappear, and are particularly apt to after mixed infection with pyogenic bacteria. In adults many cases, in children few cases, are secondary to tuberculosis. In empyema blood-cultures are usually sterile unless taken from the moribund. If an organism is found it is usually a hemolytic streptococcus, though occasionally pneumococci are demonstrated. Empyema may be due to a wound or contusion, an attack of pneumonia, bronchopneumonia, bronchitis, tonsillitis, pharyngitis, tuberculous pleuritis, phthisis, influenza, pyogenic infection of a serous effusion, caries of a rib, specific fevers (especially measles, typhoid), peritonitis, abscess of the liver, suppurating hydatid cyst of the liver, subphrenic abscess, malignant disease of the pleura, gangrene of the lung, and pneumothorax. Pneumonia is the common cause in children. In them we find streptococci in only 15 per cent. of the cases and sterile fluid in 20 per cent. In 65 per cent. of the cases we find pneumococci. In adults the pus is often thin and very putrid. In children the pus is nearly always thick. Pneumococcic pus is fairly thick, contains some clots, and is white or greenish white. In our military camps during the winter of 1917–18 almost 20 per cent. of pneumonia victims developed empyema. (See the study of various reports by Evarts A. Graham, M. R. C., from the office of the Surgeon-general, U. S. A.)

Acute Empyema.—The physical *signs* are, in reality, those of pleuritis with effusion—viz., dulness on percussion, absent breath sounds over the purulent matter, bulging of the intercostal spaces, and sometimes edema of the skin of the chest. The intercostal muscles are rigid. The effusion may be large and in some cases it forms very quickly. It may be thick or thin. In some cases there is very little effusion and adhesions form. In such cases thick pus is liable to pocket. The *symptoms* of acute empyema are pain, dyspnea, pallor, cough, sweats, chills, and usually irregular fever, but fever may be absent. There is marked leukocytosis. The fingers may become clubbed (Fig. 709). The *x*-rays aid in diagnosis. Puncture by means of an aspirating syringe obtains pus. Pericarditis, endocarditis, peritonitis, synovitis, or empyema of the other side may arise. Streptococcic empyema is an acute, violent, and very fatal malady in which there are evidences of grave systemic infection and in which there is a strong tendency to involvement of other serous membranes (the other pleura, the pericardium, the synovial membranes, the peritoneum, the endocardium). Many cases begin with a chill and in twenty-four to forty-eight hours the pleural sac contains a very large effusion. The effusion swarms with streptococci which can usually be demonstrated by smears. Sometimes blood-cultures are positive. The effusion is usually serofibrinous and devoid of odor. There is a decided tendency to the development of peritonitis and other dangerous complications.

Streptococcic empyema may arise after pneumonia, bronchopneumonia, tonsillitis, or pharyngitis. A peculiarly fatal form is seen after measles. A pneumococcus empyema seldom arises, or at least is seldom recognized, until after the pneumonia subsides. In streptococcic empyema the pneumonia and the empyema exist together. Streptococci may attack the pleura even when the lung is free, the empyema being primary. If thick pus forms it may be wide-spread, more or less limited, pocketed between the lobes (*interlobar empyema*) or between the upper lobe and pericardium back of the sternum. If peritonitis arises adhesions form and pus gathers in pockets. An empyema may pulsate, particularly an empyema of the left side. The cause of *pulsating empyema* has been much debated. The most probable explanation is that of W. J. Calvert ("Amer. Jour. Med. Sciences," Nov., 1905). He says the requirements for such a condition are : "A firmly fixed, pulsating organ; distention of the pleural sac with fluid or air or solid material; and a collapsed condition of the lung."

In all probability the thoracic aorta is the "fixed pulsating organ." The left parietal pleura is in close relation with the aorta, and most pulsating empyemas are left sided. The right parietal pleura may be "pushed against the aorta." If a lung contains air, it is elastic and compressible to a degree that enables it to absorb the aortic impulse; if it is collapsed and solid it cannot, and aortic pulsations are transmitted to fluid in the pleural cavity and the thoracic wall pulsates. A neglected empyema may break into a bronchus (*bronchial fistula*), the esophagus, or pericardium, through an intercostal space, or may point in the lumbar region. When an empyema is pointing externally, the condition is called *empyema necessitatus*. A *total empyema* is a condition involving the entire pleural sac. In a *partial* or *localized empyema* the purulent matter is encapsulated. A *closed empyema* is one in which no opening has been made by the surgeon and no opening has formed spontaneously. In a closed empyema the pus is rarely putrid; in an *open empyema* the pus is often putrid. After an empyema ruptures spontaneously it rarely heals without surgical interference, a *pleural fistula*, as a rule, persisting. A pulmonary or a *subphrenic abscess* may follow an empyema. When an empyema ruptures into a bronchus, pneumothorax arises as a rule. An acute empyema may cause death, a complication may arise, or chronic empyema may result. Empyema may cause death by compression of the heart and lung, pulmonary embolism, pericarditis, peritonitis, cerebral embolism, cerebral abscess, mastoiditis, meningitis, septicemia, exhaustion, or rupture into a bronchus. Empyema is a very



FIG. 709.—Clubbed fingers in a cured case of lung gangrene (from Captain Spear, U. S. N., U. S. Naval Hospital at League Island).

dangerous disease and is particularly fatal in childhood. In empyema of the early months of life nearly all the victims die. In those under one year of age 54 per cent. of the affected died formerly, but under modern treatment the mortality has greatly lessened. It was estimated that the mortality among older children was 30 per cent.

Graham ("Surg., Gynec., Obstet.," April, 1924) reports the mortality of the St. Louis Children's Hospital as 11 per cent. In our military camps the mortality of empyema was from 30 to 40 per cent. In one camp it was over 53 per cent., in another over 84 per cent. In civil practice the mortality of pneumonic empyema is from 12 to 20 per cent. The mortality of streptococcic empyema is much higher than of pneumococcal empyema. Empyema following measles or the pneumonia or bronchopneumonia of measles has a dreadful mortality.

A small empyema due to pneumococci occasionally, though very rarely, undergoes spontaneous cure, the pus being absorbed (Stephen Paget).

A small empyema is occasionally cured by encapsulation by fibrous tissue.

Under exceptional circumstances even a large empyema may be cured by breaking externally or into a bronchus.

Empyema is so rarely cured spontaneously that it does not do to trust to nature at all, and practically almost all cases die without surgical treatment.

Double empyema is an extremely fatal condition. In civil practice I have seldom seen it. In our military camps 8.7 per cent. of the cases of empyema have been

bilateral (Graham, Ibid.). Exploratory puncture is of great value in diagnosis. If there is massive fibrinous deposit it may lead to a dry tap below and a tap higher up may obtain fluid. If a needle is caught in an adhesion there will be a dry tap. So there may be in a case with pocketed pus. Any matter obtained should be studied bacteriologically. The *x*-rays are of decided value in diagnosis.

In acute empyema if there is bacteremia we must consider the use of antistreptococcic serum (page 129) and mercurochrome (page 129).

Nourishment and stimulation are of high importance.

Chronic empyema may follow acute empyema, or the condition may be chronic from the beginning. It is more common in adults than in children. In chronic empyema the lung is compressed, shrunken, does not expand and is strongly adherent, and the layers of the pleura are covered with granulations and thickened. In very chronic cases the pleura may be 1 inch in thickness. Such thickening is due to delayed healing and formation of masses of scar tissue. There may or may not be a bronchial fistula. Chronic empyema may result from delay in discerning an acute case, or from insufficient, ill-placed, or badly managed drainage. It may be maintained by persisting infection of the pleura in spite of free drainage, bronchial fistula, necrosis of a rib, or by a tube having slipped into the cavity and having been retained. Tuberculosis is not unusually responsible. In chronic empyema the shrunken, fibrous, and adherent lung cannot expand.

Treatment of Acute Empyema.—The treatment is purely surgical, and the earlier it is applied the better. To delay allows the pleura to thicken and permits adhesions to form, conditions which prevent lung expansion and retard or even prevent cure. The surgical methods for empyema comprise aspiration, incision, and rib resection.

I do not believe in any of the appliances to drain with a small tube and maintain negative pressure in the chest to favor lung expansion. The Thiersch method consists in introducing a trocar into the cavity, passing a Nélaton catheter through the trocar, and removing the trocar. The external end of the catheter is attached to an easily collapsible rubber tube, the other end of which is in a bottle of water. The catheter is fixed to the side by rubber tissue and rubber plaster. "The theory is, that when the patient expires, the pus runs out through the tube, and on inspiration the collapsible walls of the tube are sucked together and prevent the entrance of air, and cause negative pressure in the chest, favoring expansion of the lung" (Lund, "Jour. Amer. Med. Assoc.," Aug. 26, 1911). In any method of suction so far devised the tube is so small that it blocks up, and though the drainage-tube may at first make an air-tight joint with the chest, it always loosens sooner or later and leaks air.

Aspiration is to be regarded only as a diagnostic or a palliative procedure, although occasionally it may cure an encysted empyema or a pneumococcal empyema in a child. In tuberculous empyema occurring in a young person and associated with a rapidly progressive phthisis it is the only surgical treatment. In such a case, as Lockwood showed, incision and draining will be soon followed by death. In a very extensive total empyema it is wise to aspirate and withdraw part of the effusion a short time before operating. This enables the patient to take an anesthetic with greater safety and obviates the danger attending the rapid evacuation of a large amount of pus. While pneumonia exists it is very dangerous to open and drain, the open pneumothorax thus created tending to cause asphyxia because of the low vital capacity (Graham and Bell in "Amer. Jour. Med. Sciences," 1918, clvi). Hence, if empyema exists with active pneumonia, make repeated aspirations until the pneumonia subsides and then drain, if pus is thick.

External draining from the pus cavity may be by intercostal incision or by rib resection. The latter gives better drainage and is not more dangerous (page 895). Real pus calls for external drainage. Serous effusions and serofibrinous exudates do not and are treated by repeated aspirations (Graham in "Surg., Gynec., and Obstet.," April, 1924). I do not believe in irrigations after incising an acute empyema unless great fibrinous masses are noted or there is sloughing. Dakin's fluid will not cause permanent healing, but may be of some aid. It lessens putridity, but does not seem to me to shorten the duration of the case notably. The same may be said of Dakin's oil. Occasionally a convulsive seizure known as pleuritic epilepsy occurs (page 897). Dr. Toland, U. S. N. R. F., had 4 cases of pleuritic epilepsy following irrigation with Dakin's fluid, but no fatality.

Treatment of Chronic Empyema.—If an empyema continues to drain and refuses to heal the walls may, perhaps, be sterilized by Dakin's fluid and the cavity will then heal. It may heal, but not permanently from such treatment. We know that we can

sterilize cavities. The drainage opening may heal, perhaps for weeks or months, but it is liable to break open.

An acute empyema heals by expansion of the lung, ascent of the diaphragm, and fusion of the granulations upon the visceral pleura with those upon the parietal pleura. These healing granulations contract and pull the pleural surfaces together and hence pull out the lung (Phemister in "Surg., Gynec., and Obstet.," April, 1924). Two factors in the expansion of the lung are positive pressure caused in the collapsed lung by air from the other lung driven by forced expiration, and negative pressure in the cavity of the empyema during inspiration when the drainage opening is smaller than that of the main bronchus of the diseased side (Phemister, Ibid.). Contracting granulations are the most important factor in healing. In acute empyema we operate to save life, to prevent complications, and to oppose the development of chronic empyema. A chronic closed empyema is drained in the same manner as an acute empyema, and if the lung will not fully expand and remains stationary for one year, and all efforts to sterilize the cavity fail, a radical operation is required. An open chronic empyema, in which the lung will not expand, requires a radical operation (see pages 898, 899, 900). The results of operation for chronic cases are best in children almost in the teens. Extensive decortication is sometimes impossible, and then Ransohoff's operation may be done. He calls it *discission of the pulmonary pleura* (see page 900). When there is an external opening which persists and which joins a long, narrow cavity, the condition is spoken of as *pleural fistula*, and pleural fistula may be produced by the prolonged use of a drainage-tube and sometimes by caries of a rib.

A pleural fistula may be amended by dilatation, cauterization, or rib resection.

A *bronchial fistula* is a troublesome affair. There may or may not be a surface opening. It may be single or multiple. In these cases there is pulmonary suppuration (single abscess, multiple abscess, or bronchiectasis). Don't be in a hurry to operate. It may act as a safety valve. They usually heal spontaneously after many months when pleural or pulmonary infection ceases. Closure may be followed by fatal complications. If it is finally decided that operation is necessary, expose the lung surface and cauterize or use purse-string inversion sutures. If these procedures fail, mobilize the fistula and fix a muscle graft over it, or use pedunculated, skin-covered muscle flap (Keller in "Jour. Amer. Med. Assoc.," Sept. 22, 1923).

A bronchial fistula is a contraindication to the employment of Dakin's fluid which will cause cough or suffocative attacks, but bismuth paste can be used. Bismuth paste has warm friends, but I have not had any great success following its use.

We owe this method to Dr. Emil Beck. This plan will sometimes succeed. Ochsner has strongly commended it ("Annals of Surgery," July, 1909). The injection is made by a glass syringe and the material should fill but not stretch the cavity. After injecting the paste the external opening of the fistula is plugged with gauze. The treatment is begun with solution No. 1 (1 part of subnitrate of bismuth devoid of arsenic and 2 parts of yellow vaselin).

This is used every second day until pus has practically disappeared. Then solution No. 2 (30 parts of bismuth, 60 parts of yellow vaselin, and 10 parts of paraffin) is substituted for it. The injections are made often enough to keep the sinus and pocket full. They are made at first every day, then every other day, and so on until, finally, every eighth or tenth day is often enough. If poisoning should arise from these injections Beck advises the injection of olive oil at a temperature of 110° F. to dissolve the paste and favor its evacuation. McKelvey Bell recommends a paste which is more stimulating than Beck's. He takes 1 oz. of subnitrate of bismuth and 2 oz. of white petrolatum, dissolves over a hot-water bath, and stirs until cool. Then, while stirring, he adds 72 gr. of iodoform (5 per cent.). This must be kept in a dark place to prevent decomposition of the iododorm ("New York Med. Jour.," May 4, 1912). (See page 584.)

Treatment of Empyema in Army Camps (from report by Graham, Ibid.).—Empyema was very common in our training camps. The Surgeon-general of the Army directed a thorough study of it. Various plans of treatment were tried and the greatest differences of opinion were manifested. The high mortality shows that treatment, on the whole, was not satisfactory. The reason is that no treatment has been devised to combat the multiple lesions of streptococcic empyema, such an empyema being often but part of a generalized trouble (Graham, Ibid.). Some surgeons maintained that early repeated aspirations were better than immediate operation. Some operated at once unless the pneumonia was still active. Some surgeons would not

operate while the fluid was thin and serofibrinous, preferring to wait until it became distinctly purulent. Some drained as soon as the diagnosis was made. Most surgeons operated by rib resection. Some made intercostal drainage. Most operations were done with the aid of a local anesthetic.

Some used antistreptococcic serum. If given in considerable doses intravenously it may be of service.

In only one camp was postoperative negative pressure used at all extensively. The surgeons of that camp praised it. Other surgeons abandoned it because it caused pain and bleeding.

In several camps blowing bottles met with approval. In a number of camps irrigation was not employed. Some used Dakin's fluid, some dichloramin-T, others 2 per cent. formalin and glycerin, others tincture of iodin, others normal salt solution, others peroxid of hydrogen, others boric acid. A number of surgeons did not approve of Dakin's fluid and claimed that it brought no benefit except the diminution of the odor of the pus. Some surgeons recommended it strongly.

Non-traumatic Pneumothorax.—By the term "pneumothorax" is meant the presence of air in the pleural cavity. As a rule, besides air there is serous fluid or pus. It may be due to the rupture of an empyema into a bronchus; to the rupture into the pleural sac of a tuberculous area, an area of gangrene, an abscess of the lung, an air-cell in a state of emphysema, or of pulmonary tissue softened because of hemorrhagic infarction. The condition is by no means uncommon in phthisis. In 473 autopsies held in the Henry Phipps Institute of Philadelphia upon persons dying of pulmonary tuberculosis there were 41 cases of pneumothorax, or in 8.6 per cent. of the autopsies this lesion was found (J. M. Cruice, "Med. Record," Sept. 23, 1911). In 60 per cent. of the cases the lesion is on the left side. It is inaugurated by cough, straining at stool, vomiting, or lifting. It is more frequent in men than in women and is most common between the ages of thirty and forty. The immediate effect of the entrance of air into the pleural sac is to compress the lung, the degree of compression being in proportion to the amount of air present. In severe cases the lung is squeezed against the vertebral column, and the heart and diaphragm are displaced. In a right-sided case the liver may be displaced. In some cases, when the admission of air does not continue, the amount set free in the pleural sac is absorbed. In most cases pyopneumothorax (empyema) follows.

The **symptoms** usually arise suddenly (in three-fourths of the cases), and consist of distressing dyspnea, pain in the chest, lividity, and rapidity and weakness of the pulse. In some cases of phthisis the symptoms are gradual and not very severe. There may be pain and dyspnea or only dyspnea. In the latter case, if dyspnea existed before, the accident may be unrecognized. It has been pointed out that occasionally in phthisis pneumothorax seems actually to benefit the tuberculous area in the lung. There is nothing characteristic in the attitude. The patient usually lies on the opposite side, but may lie on the side of the trouble or on the back. He may sit erect or semi-erect. He may place himself in a knee-chest position. The physical signs of pneumothorax are as follows: The affected side of the chest is often bulged, movements are lessened or absent, and the heart is displaced, especially if the condition affects the left side. Palpation discovers that vocal fremitus is lessened or absent. On auscultation it is found that the breath sounds are very feeble or absent in 70 per cent. of cases. Occasionally they are amphoric, bronchovesicular, or cavernous. The voice may be transmitted as a metallic sound (this is present in about half the cases), râles may sound metallic, and on coughing there may be metallic tinkling. The percussion note is hyperresonant or tympanitic in 95 per cent. of cases. Very seldom it is normal. In some rare cases the percussion note is dull. When fluid gathers, there is a positively dull note on percussion over the fluid.

Treatment.—Osler says the treatment should be the same as that for pleurisy with effusion. In many cases it is wise to perform paracentesis without suction to remove air and serous effusion. If pus forms, a rib should be resected and a tube inserted (see Empyema). In pneumothorax occurring during chronic phthisis operation is of service. In cases with rapidly progressive phthisis it is practically useless.

If the opening into a bronchus or air-cell remains patent, aspiration will not get rid of air; the air will enter into the pleura as rapidly as the aspirator removes it. Incision has dangers of its own: the diaphragm is flapping during respiration and may be injured (Fowler), and when the pleura is opened there is a great alteration produced in the air-pressure in the chest, and the patient may "drown in his own

secretions." After incision irrigation is not justifiable because the fluid may enter a bronchus and produce suffocation (Fowler).

West's rules[1] are those which I follow. West says early incision is dangerous. In an early stage use paracentesis without suction. This will often relieve the patient. If paracentesis does relieve him, wait a while and perhaps repeat the operation if the symptoms again become severe. If paracentesis does not relieve, incise, resect a portion of a rib, and drain. If pus forms, an incision must be made and a portion of a rib be resected to afford exit to the fluid.

Fowler pointed out that even if the lung is bound down by adhesions, incision, though dangerous, is justifiable. Operation at the proper time often prevents the lung being bound down by adhesions.

Acute or Open Traumatic Pneumothorax.—This is produced by the sudden admission of a quantity of air into the pleural cavity as a result of a wound of the chest wall, the result being complete and immediate collapse of the lung. A small quantity of air, or the gradual introduction of considerable air, does not, as a rule, produce very serious symptoms. The sudden admission of a quantity of air may cause very dangerous symptoms and even death. A quantity of air may be admitted rather suddenly as a result of an accident or during the performance of a surgical operation which opens the pleura. It sometimes arises during the removal of tumors from the chest wall, during operations upon the lung, and during empyema operations. A wound of the pleura which allows air to be sucked into the pleural sac (*a sucking wound*) causes a progressively increasing pneumothorax. As a rule, when pulmonary adhesions exist, dangerous symptoms do not arise, even when the pleura is widely opened, and adhesions exist in 25 per cent. of empyema cases seen by the surgeon.[2]

It was formerly taught that whenever the pleura is opened there is a strong tendency to the development of pneumothorax, but West has shown that the surfaces of the pleura often cohere with a force superior to pulmonary elasticity, and in such cases pneumothorax does not arise. When the non-adherent pleura is widely opened, respiration is embarrassed, violent respiratory efforts are made, and the mediastinum flaps tumultuously. Hence the partial asphyxia, the back pressure on the heart, and the grave collapse (*traumatopnea*).

In surgical operations in which it is necessary to open the pleura widely (as in operation for sarcoma of the chest wall) the surgeon endeavors to prevent acute pneumothorax, which may prove fatal. This may be done as indicated on page 892.

Symptoms.—When the pleura is opened during an operation or by an injury the symptoms may be trivial and transitory, may be tolerably severe, may be extremely grave, and the patient may quickly die (Quénu and Longuet). Rudolph Matas[3] sets forth the symptoms as presented by the French observers.

The mild symptoms are weak, slow pulse and irregular, noisy respiration.

The severe symptoms are slow pulse, slow and irregular respiration, and dyspnea, continuing after the anesthetic has been withdrawn.

The grave symptoms are cyanosis; collapse; small, weak pulse; shallow and noisy respiration, and spells of syncope. Death may occur suddenly from inhibition, or later from mechanical asphyxia (Matas).

Treatment.—Various plans have been adopted; suturing the opening in the pleura; plugging the opening; pulling the diaphragm into the wound in the chest wall and suturing it; and grasping the lung and suturing it to the wound. None of these is satisfactory except as an expedient in an accident case. If the pleura is to be opened the best plan is to operate while giving the patient ether by the intratracheal method (page 894), or nitrous oxid and oxygen under positive pressure. Either method will prevent pulmonary collapse. At the termination of the operation the wound is sutured. Some operate in the Sauerbruch chambers, others by aid of a positive pressure apparatus (page 892).

Contusions and Wounds of the Chest.—Contusions.—A contusion may be trivial and limited to the superficial parts of the chest wall; it may involve the muscles; it may be associated with fracture of the ribs or sternum or with visceral injury.

Symptoms.—In an ordinary contusion without visceral injury there are considerable pain, discoloration, and often much swelling. The patient prefers to lie upon the back and the respiration is abdominal. After a severe blow upon the chest there is great shock and may even be instant death. The condition of shock so produced

[1] "British Medical Journal," Nov. 27, 1897.
[2] Rudolph Matas, "Annals of Surgery," April, 1899.
[3] Ibid.

is called *concussion of the chest.* After a severe blow upon the chest a limited area of inflammation may arise in the pleura (*traumatic pleuritis*). Severe visceral injury is announced by positive symptoms. A *contusion of the lung* causes extravasation of blood and leads to pain, cough, expectoration of bloody mucus, dyspnea, and possibly distinct hemophthisis. Over the contused region the percussion note is dull and on auscultation crepitus is audible. It may be mistaken for phthisis, but complete and early recovery soon dispels this fear. *Traumatic pneumonia* always follows. This usually involves a limited area of lung tissue, but genuine croupous pneumonia may arise after injury of the chest even when no rib has been broken. The physical signs and symptoms are not evident until two or three days after the accident (Sir Thomas Oliver in "Brit. Med. Jour.," April 30, 1910). Traumatic pneumonia may be caused by other things than external violence, viz., inhalation of illuminating gas, of dust, or of a foreign body.

In **rupture of the lung** the physical signs are dependent on the extent and situation of damage. A minute rupture would not produce definite physical signs. If the lung is ruptured and the pulmonary pleura is not, there will not be pneumothorax, but there may be cellular emphysema first becoming evident at the root of the neck. If the pleura is torn as well as the lung, there will be pneumothorax and hemothorax, the amount of hemorrhage depending upon the situation and extent of the injury.

Robt. G. Le Conte ("Annals of Surgery," March, 1908) points out five ways in which rupture may be caused: (1) *Bruising* (simply causes subpleural ecchymosis); (2) *bursting* (violent force—a lung unable to empty itself of air is broken as an inflated paper bag is broken by a sharp blow); the question as to whether the glottis must be closed for such an injury to occur is not settled; (3) *penetration* by a greenstick fracture of a rib; (4) *compression* of the lung against some resistant structure; (5) *tearing* (when the lung has previously been adherent to the wall of the chest).

These five causes might be sententiously designated as bruising, bursting, puncturing, squeezing, and tearing.

The *symptoms* are shock, dyspnea, cough with or without bloody expectoration, rapid and irregular pulse, cyanosis, emphysema (appearing first over the region of injury if a broken rib penetrated the lung; at the root of the neck if there is ruptured lung but intact pleura), and in some cases pneumothorax and hemothorax (Le Conte, Ibid.).

Rupture of the diaphragm causes pain, dyspnea, and often vomiting. The stomach or intestine may pass into the pleural sac. If this happens, there will be a tympanitic percussion note over the displaced viscus and symptoms will vary with the viscus involved. Such a diaphragmatic hernia may become strangulated (see pages 1147–1152). In a case in the Jefferson Medical College Hospital, in which the stomach passed into the left pleural sac, there were persistent vomiting, violent pain in the chest and upper abdomen, intense dyspnea, great thirst, and displacement of the apex-beat. The condition may be confused with pulmonary rupture causing pneumothorax, but in rupture of the diaphragm persistent nausea and vomiting are prominent features; whereas, in pulmonary rupture, if they exist at all, they are early and temporary; further, in rupture of the diaphragm the tympanitic percussion note is not found over the pleural apex, but in pulmonary rupture with pneumothorax a tympanitic note is found over the entire pleural cavity (Le Conte, Ibid.).

Treatment of Contusions of the Chest.—A contusion of the chest wall is treated as directed in the section on Contusions (see page 188), and the chest is strapped with adhesive plaster, as in the treatment of fractured ribs. In concussion of the chest the treatment for shock is applied. It may be necessary to employ artificial respiration for a time. If a diaphragmatic hernia is diagnosticated, the abdomen should be opened, the displaced viscera restored to their proper abode, and the diaphragm sutured, or the diaphragm should be reached by resecting several ribs and opening the pleural sac. In contusion of the lung cold is applied to the chest early in the case, and any inflammation which arises is treated according to general rules. In rupture of the lung the case may be treated expectantly, but dangerous and continued bleeding or pneumothorax may render surgical interference necessary. For pneumothorax paracentesis without suction is employed. If this fails, it may be repeated. If it fails again, resect a portion of a rib and put in a tube. If bleeding is dangerously profuse resect a portion of a rib and insert a drainage-tube into the pleural cavity. Pulmonary collapse usually arrests bleeding.

Wounds of the Chest in Civil Life.—Non-penetrating wounds are not particularly grave, and are treated according to general principles, the chest being immobilized.

Penetrating wounds are extremely grave, as viscera are apt to be injured. In such a wound an intercostal artery may be severed or the internal mammary artery may be divided. An intercostal artery is rarely divided unless a rib is broken. The surgeon should always examine carefully in order to determine whether an intercostal artery or the internal mammary artery has been divided, and, in doing so, should bear in mind the admonition of Matas—that is, the bleeding from these vessels may be internal, the blood collecting in the pleural sac. The pericardium or heart may be injured (see page 349). A wound of the pleura is usually, but not always, associated with a wound of the lung. If the lung is injured there are usually great shock, pain in the chest, dyspnea, and cough. In a large wound damage to the lung will be indicated if air is sucked into the wound during inspiration and expelled during expiration, and if blood is forced out of the wound by coughing. The lung may be visible or may protrude (*protrusion of the lung*). In a small wound it is often difficult and sometimes impossible to determine if the lung has been injured. Pneumothorax with pulmonary collapse proves it has. Severe hemothorax strongly suggests it. Spitting blood does not prove it. In some severe wounds there is no hemoptysis; in some slight bruises the amount of blood coughed up is large. Emphysema about the wound does not prove lung injury. An incised wound of the lung is apt to produce rapid death from hemorrhage, especially if the wound is at the root of the lung. A revolver bullet or a sporting-rifle bullet may not be productive of great primary hemorrhage; but infection will probably follow, and secondary hemorrhage will be apt to occur. The modern military rifle ball, if it strikes exactly point on, passes through, rarely lodges, and is practically aseptic if it has not struck the ground in its course and if the victim's skin and clothing have not been seriously soiled. It often produces astonishingly little trouble. If the bullet enters side on it produces dreadful laceration. A revolver bullet and an old-time rifle bullet may lodge or may perforate. A bullet lodged in the lung seldom causes much pain. If it is in contact with the pleura or pericardium it causes severe pain. Pain from pericardial irritation is felt in the side of the chest or in the shoulder (either side or both sides).

Treatment.—Bring about reaction as previously directed (see page 194).

An incised wound of the chest, if large, should be carefully inspected. If the wound is small, cut down layer by layer until the depths of the wound are reached. Disinfect the wound and arrest hemorrhage. If the pleura is not open, proceed according to general rules. If the pleura is found to have been opened, suture it with catgut, close the superficial wound, dress with gauze, and immobilize the chest wall.

The above proceeding should be carried out whether it is or is not believed that the lung has been damaged, provided there is no pneumothorax and no violent hemorrhage. What course should be pursued if the lung has been injured by a stab? If hemorrhage does not threaten life and there is no pneumothorax, the patient is kept at rest and observed. If pneumothorax occurs, the pleural sac must be drained by means of a tube, because clots must be evacuated and infection should be anticipated. If hemorrhage into the pleural sac persists, active measures become necessary. The use of ice-bags and drugs is but waste of time. Some surgeons believe that the mere closure of the external wound leads to arrest of hemorrhage, blood accumulating and making pressure. It is true that hemorrhage often ceases after suturing or plugging a wound and strapping the chest, but it is not probable that it ceases because of these measures. It has long been taught that blood in the pleura usually remains unclotted for several or many days. Elliot and Henry ("Lancet," 1917, ii) as a result of experience in this war assert that clotting occurs quickly because of ferment liberated from the wounded tissues, though complete clotting may be hindered by the respiratory movements. Further, as Le Conte[1] shows, as the blood is forced against the root of the lung the right heart is engorged, the blood-pressure is raised, and the bleeding continues.

Bleeding from the lung can sometimes be arrested by aspiration of blood and injection of the pleural sac with nitrogen gas. It may often be arrested by inserting the end of a drainage-tube into the pleural sac. The surgeon does this because gradual pulmonary collapse will ensue and will probably arrest bleeding, and gradual pulmonary collapse is not so dangerous as violent hemorrhage. In cases in which a drainage-tube is inserted into the pleural cavity and free drainage is established the pleural sac becomes filled with air, and the muscles of respiration are kept from acting on the lung. The lung contracts by its own elastic tissue, pressure is also exerted

[1] "Annals of Surgery," April, 1899.

by the pneumothorax, and at the same time the presence of the air favors clotting in the severed vessels.[1] Baudet maintains that all grave wounds of the lung should be operated upon. If the insertion of a tube fails, or if the bleeding is rapid and obviously threatens life seriously, several ribs must be rapidly resected and the bleeding part explored. In some cases the bleeding may be arrested by ligation, in some cases by packing a small wound with gauze, in some cases by the suture ligature. Two cases of lung suture have been recorded by Philadelphia colleagues (Jopson in "Annals of Surgery," 1906, vol. xliii; Kelly in "Annals of Surgery," 1910, vol. li). In a violent secondary hemorrhage following a gunshot wound of the lung I packed the entire pleural cavity with sterile gauze to obtain a base of support, and arrested the bleeding by carrying iodoform gauze directly against the oozing surface. The man[2] recovered. I did the same thing on a Chinaman suffering from a gunshot wound of the lung. The hemorrhage was arrested and he lived three weeks, dying finally from pericarditis. After directly arresting hemorrhage from the lung, turn clots out of the pleural sac and insert a drainage-tube. In a perforating wound inflicted by a bullet reaction must be brought about, the wound dressed antiseptically, the chest strapped, and the patient kept quiet. If pneumothorax occurs, the pleura should be drained with a tube. If hemorrhage occurs, it should be met as directed above. In a wound in which the bullet has lodged, an examination should be made to see if the bullet is under the skin, and if it is, it is removed after the patient has reacted. It should always be borne in mind that a pistol bullet may be deflected by a rib or may pass from the front to the back part of the chest by making a burrow under the skin (*a contour wound*). If a bullet is lodged, no attempt should be made to remove it unless an operation must be done for bleeding, unless the bullet causes trouble, or unless it is felt under the skin. Under no circumstances conduct a long search for a bullet. If emphysema of the chest walls is moderate, strapping or a bandage will control it; if it is great, make multiple punctures and then apply pressure. In protrusion of a portion of the lung try to restore the protrusion; but if restoration is impossible or if gangrene seems likely to occur, ligate the base of the protrusion with silk and cut away the mass. In pulmonary operations the anesthetic should be ether given by the intratracheal method or nitrous oxid and oxygen with a mask and under positive pressure.

Moller ("Archiv. f. klin. Chirurgie," 1909–10, vol. lvi) collected 26 cases of gunshot wounds in civil life, which were operated upon, and 11 died (42 per cent.). In 20 suturing was done, with 7 deaths. In 2 the wound was sutured to the pleural opening, with 1 death. In 2 lung resection was followed by death. One, in which pleural packing was used, recovered. He collected 10 stab wounds: 7 were sutured, with 1 death. In 3 the pleura was packed and all recovered.

Wounds of the Chest Involving the Diaphragm.—In such a case abdominal viscera may pass through the wound in the diaphragm and appear in the wound of the chest. If there is no indication of a wound of the abdominal viscera some surgeons would suture the wound of the diaphragm by way of the thorax. If there are indications of injury of abdominal viscera the abdomen must be opened. Personally, I prefer to open the abdomen in every chest wound implicating the diaphragm, even when symptoms of injury to abdominal viscera are not as yet manifest.

Chest Wounds in War.—In many engagements during the World War chest wounds represent 1 in 40 of the wounded. Our knowledge of these wounds is gathered from the immense experience of many military surgeons (Moynihan, Hull, Gray, Anderson, Duval, Depage, Rouvihois, Henry, Elliot, and many others). A missile may perforate the chest, making a wound of entrance and a wound of exit (perforating wound). It may penetrate the chest and lodge, in which case there is a wound of entrance, but no wound of exit (penetrating wound). A tangential wound may do as much damage as though the missile entered the chest, the damage being caused by bone fragments. H. M. W. Gray ("N. Y. Med. Jour.," June 8, 1918) divides chest wounds clinically in the following useful manner:

1. No operation required.
2. Operation required at the earliest possible moment.
3. Question as to immediate operation doubtful.
4. Moribund and useless to operate.

We consider here wounds of the lungs and pleura. For heart wounds see page 349.

[1] Le Conte in "Annals of Surgery," April, 1899.
[2] The Author in "Annals of Surgery," Jan., 1898.

Sir Berkeley Moynihan ("American Addresses") discusses the mortality of chest wounds and shows that it differs greatly "at various parts of the line of communication." At the first-aid stations it is from 25 to 30 per cent. At the casualty clearing stations it is 18 to 20 per cent. In the base hospitals it is 10 per cent. "At the aid post, where the mortality is 25 per cent., there will remain alive, of 100 patients, 75. At the ambulance, of these 75, 20 per cent. will die and there will remain 60 patients. At the base, of these 60, 10 per cent. will die, so that finally 54 cases will survive."

Moynihan (Ibid.) points out that the mortality is influenced by the nature of the projectile. A rifle bullet makes a very dangerous wound if it divides a large vessel. It makes a comparatively benign wound if the lung is wounded, but no large vessel is damaged. Wounds from shell fragments are torn and irregular and bits of skin and portions of clothing are apt to be carried in. Such wounds are very grave because of the great probability of infection. It is well known that many cases of perforating bullet wounds recover easily. A rifle bullet lodged in the lung may cause no symptoms and become encapsuled. Large shell fragments are very dangerous and should always be removed.

Little or nothing can be done for chest wounds at the first-aid station. When such cases reach the evacuation hospital station they are usually gravely shocked. They require stimulants and if there is an open wound which sucks air it should be sutured or plugged to make it air-tight. Usually in a couple of hours alarming symptoms have largely subsided (Gray, Ibid.). It is desirable, if circumstances admit, to perform any urgently necessary operation in the evacuation hospital. Some cases are kept for several days and then sent to the base. There may be a lodged bullet. A rifle ball may have perforated. A rib or ribs may be broken. So may the scapula. A shell fragment may have broken ribs and driven them in, may have crushed the chest in, or may have torn away a part of the wall of the thorax. A hail of bone fragments may have been driven into the lung or pleura.

The bronchi usually escape injury. It is seldom that fissures or tears radiate in the lung from the track of the missile (Moynihan, Ibid.). Distant parts of the lung or pleura may be damaged due to the force of the impact or by the alteration in air pressure produced by the explosion of the shell. "There may be hemorrhages by 'contrecoup' in the upper lobe if the lower is wounded, or in the lower if the upper is injured, or in both if the projectile has passed near the base of the lung." There may be hemorrhage in the other lung or beneath its pleura, bronchopneumonia may arise in it, or septic matter may be inhaled from the trachea ("American Addresses," by Sir Berkeley Moynihan). In some cases hemothorax is slight, in some a quart or more of blood gathers. Inflammation soon arises and exudate is added to the blood. As hemothorax increases the lung collapses and collapse lessens and perhaps arrests bleeding. It was formerly taught that blood in the pleural sac did not tend to clot. We now know that it does clot. Hemothorax, if infection does not occur, will seldom be fatal, but infection will occur in two-fifths of the cases (Moynihan, Ibid.). Moynihan points out the important fact that the upper portion of the fluid may be uninfected when the lower is infected, hence a tap may give deluding results.

Duval points out that in nearly half of all infections the infecting agents are anaërobic bacteria. Such infection arises from the wound (bacillus of gas gangrene, *Bacillus sporogenes*). Aërobic infection may come from the respiratory tract (pneumococci, staphylococci, etc.) or from the wound (streptococci or colon bacilli).

Treatment.—We have spoken previously of the reactive treatment necessary when the patient is brought into the evacuation hospital. Immediate operation is necessary when there is great dyspnea due to hemothorax or hemopericardium; if there is a foreign body in the diaphragm or rapidly increasing infection especially by bacteria which form gas; if there is severe and lasting pain (due probably to irritation of pleura or pericardium by a sharp edged foreign body or a rib fragment) (H. M. W. Gray, Ibid.). Many cases with a wound of entrance and a wound of exit have very little hemothorax and soon recover from shock. "If the hemothorax does not reach higher than the nipple line, shows no sign of increasing, and if there is no evidence of infection, such cases may be sent to the base without danger in the course of three to six days" (H. M. W. Gray, Ibid.). In non-infected, closed hemothorax the pulse, respiration, and temperature should become practically normal in twenty-four hours; if they do not do so an exploratory puncture should be made and the fluid obtained should be subjected to a bacteriologic study. If the fluid has a foul odor, and if the froth in the syringe has a "crimson purple color," no further proof of anaërobic infection is necessary (H. M. W. Gray, Ibid.). This test should be made every day until the situation has

become clear. "The test is by no means infallible. Sepsis may develop in islands or areas of the clot or fluid which were not tapped by the needle. Increase of pneumothorax or development of resonant patches in previously dull areas should make one suspicious of gas infection. If, then, other symptoms pointing to infection are sufficiently prominent operation should be undertaken without waiting for bacteriologic confirmation" (H. M. W. Gray, Ibid.).

A small, non-infected hemothorax does not require aspiration; usually the fluid will be absorbed rapidly, but if it lingers, diagnostic puncture and a bacteriologic examination of the fluid are called for. Gray (Ibid.) says that a mild infection may be cured by repeated aspiration.

If a hemothorax is large it will not do to send the patient to a base sooner than from three to six days. If during the wait respiration becomes difficult a slow aspiration is indicated, and the withdrawal of fluid is to cease as soon as respiration is relieved. Rapid aspiration may cause the hemorrhage to start again (Gray, Ibid.). If after relief by aspiration urgent symptoms arise again, operate. The operation consists in evacuating blood, clots and exudate, arresting the bleeding, and closing the wound in the chest wall. In many chest wounds we are in doubt what to do. If we do not operate sepsis may arise. The operation is dangerous. On one hand is a danger which is problematic. On the other is an operation which might give relief and save from sepsis, but which is dangerous. Gray (Ibid.) says that in many of these cases operations followed by complete closure of the chest wound have been highly successful, and that the use of blood transfusion in early stages would secure better results and give strength for a radical operation. If there is a severe open wound and the patient is not moribund, operate at once. If the wound is large and lacerated and a shell fragment is lodged, clothing and other infected matter has, in all probability, been carried in. There may be a sucking wound or a tangential wound. Take an *x*-ray picture. Give nitrous oxid and oxygen in preference to ether. Excise the damaged tissue. In some cases use this wound as the door of entrance for our work. In others close it at once and remove the fifth rib to permit of necessary procedures. Liquid blood is to be drawn off or poured out, clot is to be spooned and mopped out, the lung is grasped and drawn out of the wound. The missile is located, cut down upon, and removed. The lung wound is excised, is sutured with catgut, the lung is wiped off with ether, sutured with catgut, and restored to place. The wound in the chest wall is sutured and sealed hermetically. The pleural sac is aspirated. As air is withdrawn the lung expands.

Cancer of the Lung.—This very rare condition, which is sometimes complicated with tuberculosis, is seldom diagnosticated. It may arise in the alveolar epithelium, in the bronchial epithelium, or in the mucous glands of a bronchial tube. The patient has cough, respiratory embarrassment, and sputum free from tubercle bacilli (in an uncomplicated case) and sometimes containing carcinoma cells. The symptoms early in the case are, as a rule, intermittent. Pain occurs when the pleura is attacked. Hemorrhage is rare until late in the cases. Prune juice sputum is significant. As the tubes block, physical signs of pulmonary collapse become evident. Cavities may form and pleural effusion may occur. The *x*-rays and bronchoscopy are valuable in diagnosis. Metastasis is early.

Treatment.—Unfortunately, in a large majority of cases, the cancer is near the root of the lung.

In some cases lobectomy is possible. In 1919 Davies reported a successful case ("The Surgery of the Lung and Pleura"). Lenhartz removed almost the whole lung piecemeal. The wound was kept open and the *x*-rays were used. The patient lived two and a half years (see Kenneth Playfair and Cecil P. G. Wakeley in "Brit. Jour. of Surg.," Oct., 1923. This article contains a full bibliography).

Occluding Pulmonary Embolism.—By this term we mean an embolism which completely blocks the pulmonary artery or some of its chief branches. Such cases occasionally follow a surgical operation, especially an abdominal operation. They are more frequent than used to be thought. The clot is derived from a vein. The calamity is most apt to occur between the second and fourth weeks after an operation (Bartlett and Thompson in "Annals of Surgery," May, 1908). Pulmonary embolism may arise from fractures, inflamed veins anywhere, and during or after pneumonia, erysipelas, typhoid fever, and any acute infection. In malignant endocarditis and valvular stenosis small emboli are common. If the pulmonary artery proper is completely blocked, death occurs at once. If one branch only is blocked, the patient may recover if the heart is sound and strong. If the artery proper is partly blocked, the patient

has a period of suffering and dyspnea before death, but death is sure to occur from subsequent complete blocking.

Bartlett and Thompson (Ibid.) report 22 cases of occlusive pulmonary embolism, 20 of which were fatal. The greatest cause in a surgical operation seems to be varicose veins, especially about an abdominal or pelvic tumor. I am convinced that most sudden deaths in infected cases are due to pulmonary embolism. I have seen pulmonary embolism after an operation for varicocele, for hydrocele, for duodenal ulcer, and for appendicitis.

I am inclined to believe that more care in hemostasis might lessen the liability to the accident. If vessels ooze and a clot gathers, the clot projects into the lumen of open vessels and muscular effort or even slight infection may loosen it (see page 116).

The **symptoms** of a mild case of embolism are rapid pulse, dyspnea, after some hours percussion dulness and impaired breath sounds over the base of the lung, and, perhaps later, spitting of blood. In a real occluding embolism there are sudden collapse, cyanosis or pallor with livid lips, the pulse at the wrist is absent or very rapid, and irregular. There are pain in the chest, intense dyspnea, dilated pupils, and early unconsciousness. The right side of the heart distends greatly and the second sound is accentuated in the pulmonary area.

Schumacher in discussing these cases says there are three classes of them: Those in which almost immediate death occurs; those in which death occurs in a few minutes, and those which last much longer. In the last mentioned cases a main branch becomes blocked and total obstruction is gradual (Willy Meyer in "Annals of Surgery," Aug., 1913). These cases only are suitable for operation. The surgeon must bear in mind the danger of embolism and endeavor to prevent it in operations by handling and exposing viscera as little as possible, by applying ligatures above all clots in veins and all varicosities, and removing the affected structures. Quénu proposed to lessen the danger of postoperative thrombosis by administering citric acid before operation. This agent lessens the coagulability of the blood. Tuffier fears this remedy, believing that it makes an existing thrombus more apt to break up and form emboli ("Presse Médicale," April 20, 1910).

Treatment.—For small, non-occluding emboli, in which condition the only symptoms are dyspnea, pain, rapidity of pulse, and, after some hours, dulness at the base and impaired breath sounds, give stimulants, dry cup the chest, and administer morphin if there is no cyanosis. In a very severe case death is rapid and there is nothing to do medically.

Trendelenburg, of Leipzig, suggests surgical treatment (German Congress of Surgery, 1908). He points out that death is not always sudden (in 7 cases out of 9 the victim lived from ten minutes to one hour), and advises opening of the pulmonary artery and removal of the embolus. The first patient operated on died before the completion of the operation. "Since then it was done, twelve times in all, at the Leipzig clinic, without one permanent recovery" (Willy Meyer in "Annals of Surgery," Aug., 1913). One patient lived four days; 1 died on the table; 1 died in fifteen hours from cardiac failure; 1 lived for thirty-seven hours and died of reactionary bleeding from the internal mammary artery. Kruger did one operation for embolism. The early result was apparently successful, but the patient died of infection on the eighteenth day ("Zentral. für Chir.," May 22, 1909). In Sauerbruch's clinic at Zurich the operation has been performed four times without a recovery (Willy Meyer, Loc. cit.). Of 15 recorded cases not one recovered, though one lived until the fourth day.

Trendelenburg thinks that the surgeon has about fifteen minutes in which to work. The operation is done under differential pressure. The pleura is opened, then the pericardium. A rubber tube is passed through the transverse sinus of the pericardium and the aorta and pulmonary artery are constricted. This constriction must be released within forty-five seconds. The artery is opened, the clot removed, the arterial wound clamped, and the elastic constriction released. The arterial wound is then sutured.

Abscess of the lung may be due to a foreign body, influenza, or pneumonia (especially aspiration pneumonia). Tonsillectomy performed with the patient under ether seems to have been particularly dangerous. Wessler states that 28 per cent. of all cases of lung suppuration examined in the *x*-ray department of Mt. Sinai Hospital, N. Y., arose after operation upon the mouth, tonsils or pharynx (Lilienthal in "Annals of Surgery," 1916, lxiv). Abscess must be differentiated from other forms of lung suppuration (drowned lung, purulent bronchitis, and bronchiectasis). It is usually caused by streptococci or staphylococci, but it may result from pneumococci or colon

bacilli. These germs may reach the pulmonary tissue by direct entrance from adjacent organs, by way of the blood, or by way of the bronchi and alveoli. Sir William Osler[1] tells us that pulmonary abscess may result from the aspiration of septic particles after "wounds of the neck, operations upon the throat," and suppurative lesions of the nose, larynx, or ear. Aspiration-pneumonia may develop when there is difficulty in swallowing from any cause, when there is profound exhaustion, and when there is palsy or inco-ordination of any of the muscles of deglutition. Cancer of the esophagus may be a cause; so may perforation of the lung by an empyema, wound of the lung, impaction of a foreign body in the lung, suppuration about a focus of tuberculosis, or a metastatic abscess. An abscess is first acute and may become chronic. A pulmonary abscess may be of trivial size or it may be very large, involving an entire lobe. There may be one abscess, several, or many. When suppuration results from aspiration-pneumonia or blood infection there are usually multiple abscesses. An acute abscess is often single. The wall of an acute abscess is granulation tissue and it is surrounded by a zone of edematous lung. A case becomes chronic in from four to eight weeks. In a chronic abscess the wall is fibrous and there are pus pockets partially or completely blocked off from the bronchi by fibrous tissue. The pockets and bronchi contain masses of bleeding granulations. Some of the bronchi are dilated and fibrous and a large area of the lung may be in a state of fibrosis. The visceral pleura becomes adherent to the parietal pleura. An abscess may break into a bronchial tube (*bronchopulmonary fistula*), into the pleural cavity (*pleuropulmonary fistula*). The latter accident causes secondary empyema. A bronchial tube may communicate with the pleural cavity and also with a cutaneous opening.

Symptoms.—In an acute case, which has opened a bronchus, the expectoration is not frequent, but is profuse, and during a paroxysm mouthfuls are coughed up in rapid succession. The expectorated matter is sour or very offensive in odor and contains fragments or shreds of pulmonary tissue, which can be identified as such by the microscope. The patient lies upon the diseased side in order to keep the pus from running into the bronchi and causing cough. When the cavity fills and pus reaches the bronchi, violent cough and expectoration begin, continue until the cavity is partly or entirely emptied, and then subside, perhaps for several hours. If the abscess cavity is large and full of pus, an area of dulness on percussion can be mapped out. When the pus is coughed out and the air enters, physical signs of a cavity are clear. The *x*-rays often show the situation of such a cavity.

There are attacks of fever of the hectic type, rapid loss of weight, weakness and rapidity of circulation, dyspnea, pallor, sleeplessness, and great weakness. The breath is foul, attacks of hemorrhage may occur, and empyema may develop. Gangrene may arise and pyopneumothorax may develop; very rarely the abscess breaks through the chest wall; recovery may follow spontaneous evacuation or drainage by coughing up pus; death may result from hemorrhage, exhaustion, or secondary septic lesions (brain abscess, meningitis, or pyemia). Many acute cases get well. Others settle down into a chronic condition with exacerbations due to blocking or spread. The *x*-rays (page 1449) and the bronchoscope (page 859) are of the greatest value in diagnosis. In every case the surgeon should have the aid of an internist and a bronchoscopist.

Treatment.—Acute abscess usually recovers. If there is a bronchopulmonary fistula, recovery is aided by postural drainage and bronchoscopy with or without antiseptic applications.

In some like cases the lung has also been collapsed by inducing artificial pneumothorax. I do not believe that the latter plan is safe. I know of 2 deaths due to it. It cannot be used in the presence of pleural adhesions. No operation through the chest wall is proper until the abscess is chronic (four weeks or more) and until there are pleural adhesions. If conservative plans fail, one or two ribs are resected, the pleura is opened, the lung and visceral pleura are sutured to the parietal pleura, the abscess is opened by means of the actual cautery, and drainage is established. This plan may cure a solitary abscess, but will fail in multiple abscesses. In any case it gives relief and a safety valve. If external drainage after simple pneumotomy fails to cure, if there are multiple abscesses or bronchial fistulæ consider lobectomy with the knife or the cautery. The former operation has a mortality of over 50 per cent., the latter appears to have a lower death-rate (see page 901).

The direct mortality of pneumotomy with drainage is from 15 to 20 per cent.

If suppuration persists, use antiseptics in the cavity, and if they fail, employ fulguration or the actual cautery.

[1] "Practice of Medicine."

Roentgenographic localization with dry bismuth subcarbonate insufflated with the bronchoscope is often of aid. In cases with bronchopleural fistula the bronchoscope may be inserted through the mouth into the cavity and thus serve as a sound upon which to cut down with the cautery. At the Bronchoscopic Clinic of Jefferson Hospital biweekly peroral bronchoscopic drainage and medication have cured many cases of pulmonary abscess. The bronchoscopic treatment is carried out without general anesthesia and in most cases without hospitalization. There has been neither mortality nor untoward effect in over 200 cases (see Lukens, Moore, and Funk, "Medical Clinics of North America," Jan., 1923, W. B. Saunders Co.; also same authors, "Atlantic Medical Monthly," 1924; also Jackson, Clerf, Tucker, Lukens, and Moore, "Surgical Clinics of North America," Feb., 1924, and "Jour. Amer. Med. Assoc.," 1924).

Gangrene of the Lung.—This term means the putrefaction of a devitalized portion of pulmonary tissue. The tissue is devitalized by the action of pyogenic microorganisms. Gangrene may follow abscess, bronchitis, or pneumonia, or may be due to diabetes, to embolism of a branch of the pulmonary artery, bronchiectasis, tuberculosis, malignant disease, wounds, or the lodgment of a foreign body. Gangrene may be circumscribed or diffused. There may be one cavity, small or large, or multiple cavities may form. The gangrenous area putrefies, softens, and the softened matter may be expectorated, a gangrenous cavity being formed. In the rare cases which undergo spontaneous cure the cavity is, after a time, surrounded by fibrous tissue and obliterated by granulations. The mortality from operation is about 30 per cent.

Symptoms.—Expectoration occurs only now and then, but at each seizure a great quantity of matter is brought up and this matter is horribly offensive. Occasionally there is no expectoration. The patient, as in lung abscess, lies upon the diseased side. The expectorated matter is mucopurulent, contains particles or shreds of pulmonary tissue, bacteria, and altered blood. The fetor of the pus is much greater than is the fetor of the pus of an abscess. The breath is very foul. Physical signs may indicate either consolidation or a cavity. There are hectic fever, great exhaustion, deathly pallor, and diarrhea. Pulmonary hemorrhage is not unusual, and complications spoken of in the article upon Abscess may occur (see page 889). Recovery sometimes ensues, the cavity closing by granulation. Death may take place in a few days. Often the patient lives for weeks, being sometimes better and sometimes worse, dying finally from exhaustion or from the effects of a complication.

The **treatment** is to operate as for pulmonary abscess. Sloughs are to be removed.

Bronchiectasis.—This term means dilatation of the bronchial tubes. The dilatation may be fusiform, saccular, or trabecular. The first form, or true bronchiectasis, is great dilatation of a tube caused by strain. It is most common in children and in them is a result of coughing. The other two forms occur in adults and result from chronic inflammation. There may be one or more cavities. Not only are the bronchi dilated, but fibrous tissue has formed about them. The condition may result from bronchial inflammation, from pulmonary sclerosis, or from the presence of a foreign body. Surgeons sometimes see bronchiectasis following tonsillectomy or operation for adenoids (Lilienthal in "Annals of Surgery," 1916, lxiv). In bronchiectasis there are paroxysms of violent cough with intervals of hours between them. The expectoration is profuse, mucopurulent, and fetid. If very purulent it is like the matter coughed up by a victim of pulmonary abscess. Hemoptysis may occur. The physical signs are uncertain. Fever is seldom present unless purulent matter is long retained. The *x*-rays and the bronchoscope are very useful in diagnosis. The fingers may become clubbed (Fig. 709). Most cases are treated medically. Drugs may be directly introduced through the bronchoscope. If medical and local treatment fail, surgery must be considered. Pneumotomy and drainage may cure. If it fails, consider radical operation. Radical operation is only to be considered in a unilateral lesion which is not very extensive and in which in spite of medical and local treatment the patient grows progressively worse. Radical operation consists in extirpation of the diseased lobe. Lilienthal (Ibid.) cured 4 cases out of 7.

The operation of lobar resection has a mortality of about 50 per cent. Samuel Robinson reports five complete resections of the lower lobe of a lung, with one death ("Surgery, Gynecology, and Obstetrics," Feb., 1917). I believe that operation by the cautery is safer than by the knife.

In bronchiectasis and large abscess in a tuberculous lung rib resection and drainage should be considered.

Surgical Treatment of Pulmonary Tuberculosis.—For a number of years past surgical thought has been actively directed toward placing on a scientific footing operations for pulmonary phthisis. The matter is still in a transition stage, and operations at present have a very limited field of application, although Sonnenberg and others have reported cures. Baglivi in 1643 endeavored to tap and inject tuberculous cavities. Hastings and Stuckè did the same thing in the eighteenth century. Mosler, a number of years ago, attempted to treat cavities by introducing a trocar into the cavity and injecting permanganate of potassium solution through the cannula. Patients were not benefited by this procedure. The plan was revived by Pepper in 1874. The results are bad and the operation is dangerous. Hillier tried injection of corrosive sublimate into the lung parenchyma, but the effect of the injections was disastrous. Vidal advocates counterirritation by the actual cautery and maintains that congestion improves nutrition. When the strength of the patient is well preserved and the pulmonary lesion is circumscribed and slowly progressive, it may, in some few cases, be justifiable to perform an operation, open the cavity, and treat it directly (*pneumotomy*). That pneumotomy might be performed successfully was suggested to surgeons by observing that some patients recovered after sword thrusts into the lung. Fowler said it is not justifiable to operate if the disease has come "to a standstill." The same surgeon stated that the only accessible region is bounded above by the clavicle, to the inner side by the manubrium, to the outer side by the lesser pectoral muscle, and below by the second rib.[1] This operation does not cure any one, but it may cause distinct improvement when there is hectic fever from an ill-drained cavity containing the products of a mixed infection. In an advanced case there is usually more than one cavity, and if there is, the operation is contraindicated. Before attempting it, be sure the case is advanced and not incipient and that the cavity is single. Locate the cavity by auscultation, percussion, and the *x*-rays. Tuffier collected 45 cases, and only 1 was a success.

Mauclaise[2] says that pneumotomy is justifiable only in circumscribed tuberculous cavities without peripheral infiltration and in pulmonary abscesses. Bronchiectatic cavities are usually multiple; they are exceedingly difficult to locate, and treatment by pneumotomy has been very unsatisfactory. In the treatment of pulmonary tuberculosis resection of the diseased area was proposed by Ruggi (*pneumectomy*). Tuffier successfully performed this operation. Surgeons, as a rule, do not believe in pneumectomy. Reclus[3] voices the general opinion when he says the operation is not required if the area of disease is very limited, as such a condition is frequently curable by medicinal means, and it does no good if the area of disease is extensive.

Only two methods of surgical treatment seem to have won a distinct place: one is the artificial production of pneumothorax; the other, some form of plastic operation upon the thorax to collapse and immobilize the lung.

Artificial Pneumothorax.—It has long been known that pneumothorax might benefit a tuberculous lung. Carson of Edinburgh, in 1843, tried to create artificial pneumothorax by making a puncture in the visceral pleura to allow the passage of air into the pleural sac. Farlanini suggested the introduction of a gas into the pleural sac and reported a successful case in 1894. In 1898 Murphy began the use of nitrogen. In 1912 there were on record about 400 cases (Mary E. Lapham in "Amer. Jour. Med. Sciences," April, 1912). Since then many cases have been recorded. The method should only be used in unilateral cases which are not far advanced. It is used when the patient continues to grow worse in spite of medical treatment. The method is useless if there are adhesions, and is contraindicated if diabetes exists or if there is uncompensated valvular disease of the heart (Lapham, Ibid.). Adhesions forbid because they prevent pulmonary collapse. If adhesions exist the surgeon may consider an operation to permit pulmonary collapse (page 892). It is maintained that the operation occludes the lymph-channels, lessens the absorption of toxins (shown by the abatement of fever), prevents bleeding, compresses the lung, arrests its mobility, approximates the walls of cavities, squeezes masses of bacteria out of the tubes, favors the development of fibrous tissue, and leads to healing of cavities.

Certainly it seems that the once widely condemned therapeutic pneumothorax is of real value in proper cases and causes not only improvement, but sometimes cure (Burnand in "Rev. méd. de la Suisse Rom.," 1915, xxv). Nitrogen is the best gas

[1] See the very full and thoughtful article by George Ryerson Fowler on "The Surgery of Intrathoracic Tuberculosis," "Annals of Surgery," Nov., 1896.

[2] "La Tribune médicale," Sept. 21, 1893.

[3] "Revue de Chirurgie," Nov. 11, 1895.

to use. It is non-irritant and remains long in the pleural cavity. Our aim is to keep the lung compressed for one year. The nitrogen is introduced by means of a special apparatus. At first injections are made daily, then every other day, then twice a week, then twice a month. The injection is made "over an area where the breath sounds and resonance are best" (Lapham, Ibid.). There is little danger in the method, but trouble may follow. There may be shock, dyspnea, or spasm of the glottis from pleural reflex. Other dangers are: gas embolism, convulsions, edema of the lung, empyema, pulmonary abscess (if the lung is stuck), cerebral embolism, and emphysema of the chest wall. A danger is an unfavorable influence on the other lung. In 18 cases out of 46 subjected by Mayer to the formation of an artificial pneumothorax exudate formed. In 8 of the cases the exudate contained tubercle bacilli, in 2 staphylococci, and in 1 pneumococci (Boit, in "Beitr. z. klin. Chir.," 1914, xciii).

Plastic Operations on the Chest Wall (Mobilization of the Thorax).—Freund and others asserted that a rigid thorax is a cause of phthisis. Allis[1] suggested that in extensive unilateral tuberculosis of the lung resection of a number of ribs would favor cure by permitting retraction of the chest wall. This operation is founded on the belief that the chief element in effecting a cure is the formation and contraction of fibrous tissue. Pulmonary collapse and abolition of movements favor the formation of fibrous tissue and the emptying of an abscess cavity. It is only in advanced tuberculosis with abscess that we should use the operation. The operation is justifiable if several attempts to collapse by means of artificial pneumothorax have failed, and also in cases in which firm and wide-spread adhesions forbid the use of nitrogen gas. The suitable cases "are those with large, rigid-walled abscess cavities in the upper or middle lobes of one side with a comparatively sound lung on the opposite side" (Charles D. Lockwood in "Internat. Clinics," vol. iii, Series 32). The pus is squeezed out of the cavity. Lockwood (Ibid.) thinks the operation should often be done in two stages. In this operation the pleura is not opened. Quincke, Landerer, and others remove portions of ribs with periosteum along the axillary line. Some surgeons remove portions of ribs and periosteum from directly over the lesion. In tuberculosis of the apex in a person with a narrow and rigid chest the followers of Freund remove the first rib. Freeman removes portions of ribs without periosteum and applies a truss to push in the chest wall ("Annals of Surgery," July, 1909). Friedrich, of Marburg, removes all the ribs from the second to the tenth inclusive and mobilizes the first rib (*thoracicoplastic pleuropneumolysis* with *subcostal apicolysis*). The pleura is not opened. He used to remove the periosteum, but does so no longer. He now leaves the periosteum so that after a time enough bone will re-form to prevent lung bulging on coughing. Sauerbruch, Wilms, and others have individual operations. When the induction of pneumothorax would be indicated were it not for adhesions Torek performs what he calls *interpleural pneumolysis*.

A long incision is made in the sixth or seventh intercostal space, the pleura is opened, the head is lowered, the ribs are held apart, the adhesions are separated by the fingers, and later the hand is carried into the pleural cavity. When adhesions have been well separated the lung collapses. The wound is then closed ("Surgery, Gynecology, and Obstetrics," 1914, xix). The results of none of the above operations seem very encouraging.

Operations on Pleura and Lungs

Intrathoracic Operations Under Positive or Negative Air-pressure.—(This subject has been fully and judicially discussed by Jopson in "Annals of Surgery," May, 1911.) When under ordinary conditions the chest wall is widely opened the lung often rapidly collapses and the patient is placed in deadly peril (see Acute Traumatic Pneumothorax on page 882). The reality of the danger has to a great extent retarded progress in the surgery of the heart, lungs, and lower portion of the esophagus. Of late, however, methods have been devised for maintaining normal respiratory movements and preventing pulmonary collapse during operations which open the pleura. There are two forms of pressure apparatus and each form finds warm advocates. Negative pressure is the form that is advocated by Sauerbruch. In Sauerbruch's negative pressure chamber the lung is kept from collapse by suction exerted upon its exposed surface. Positive pressure is advocated by Brauer. Positive pressure keeps the lung from collapsing by distending it from within. The two methods act similarly in many respects. Clinical observations and numerous experiments seem to prove that "emphysema, persistent pneumothorax, difficulty of narcosis, and in-

[1] To State Med. Soc. of Penna. in 1891.

fection of the pleura are not dangers associated with the use of positive pressure as such" (Samuel Robinson and George Adams Leland in "Surg., Gynec., and Obstet.," March, 1909).

The Sauerbruch Chamber (Fig. 710).—This is an air-tight cabinet. The sides are of boards covered with tin, the corners being soldered. The roof is of glass. The sides contain air-tight windows. There is one air-tight door.

The room is lighted by electricity and contains a telephone. The larger chambers have a communicating room. Instruments which are wanted can be placed in this room so that the surgeon may reach them. The patient's head projects outside of the cabinet and a tightly fitting rubber collar is placed around the neck. The body and legs are surrounded by a canvas-covered rubber sac the interior of which is in communication with the external air.

The chamber is sufficiently large to hold the patient, the surgeon, and the assistant. By means of an electric suction air pump, the valve of which is in the wall, negative pressure is obtained and is continuously maintained in the cabinet. The patient's thorax is exposed to the suction of negative pressure, but the bronchioles are subjected to ordinary atmospheric pressure, hence, even when a wide opening is made in the chest wall, the lung does not collapse. The operator does not suffer from the negative pressure.

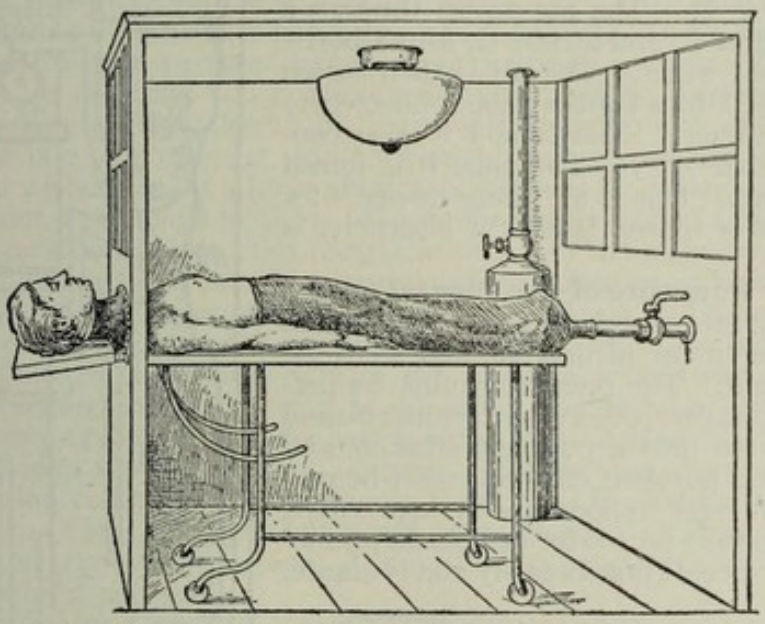


FIG. 710.—Sauerbruch's cabinet: Position of patient in chamber ready for operation under negative pressure.

Willy Meyer is the great American advocate of the negative pressure chamber in cases of open pneumothorax (see paper read before the "Amer. Assoc. for Thoracic Surg.," June 6, 1921). He believes that any form of positive pressure compresses the capillary vessels in the walls of the alveoli and makes the patient liable to acute cardiac dilatation.

The Positive Pressure Apparatus.—Numerous apparatuses have been devised. Positive pressure used to be obtained by the Fell-O'Dwyer apparatus. The larynx was intubated and the bellows was used. It can be obtained with this, but the apparatus is uncertain and difficult to use. Positive pressure can be obtained by intubation anesthesia, by the pulmotor, and by the lungmotor.

Brauer advocated the following plan: When the patient has been anesthetised and the surgeon is ready to open the pleura, a glass case is placed over the patient's face and the air in the case is condensed by means of an apparatus.

Bauer subsequently modified the head chamber so that the hands and wrists of the anesthetist are admitted within it. Some surgeons have given compressed air by the nose, the mouth being sealed. Some give it by intubation from the mouth. The trouble with this method in man is that no completely satisfactory tube has yet been made. As a general thing the best way to give it is by a well-fitting face mask. A small motor runs a rotary air pump and thus we dispense with the trouble and uncertainty of clumsy reservoirs. Robinson and Leland (Ibid.) state that any positive

pressure apparatus consists of four elements: (1) A supply of compressed air; (2) an anesthetizing segment; (3) a device for introducing air and ether into the respiratory tract; (4) a means of varying the resistance of exhaled air (Figs. 711, 712).

Intratracheal Insufflation (Method of Meltzer and Auer).—This method is highly valuable. It can be used to maintain respiration and, at the same time, to give ether. The patient is first anesthetized by the ordinary method. A flexible and elastic tube is then carried through the larynx well into the trachea. In order to get it into the larynx use a tube director (Cotton and Boothby), or use Chevalier Jackson's direct laryngoscope, as do Elsberg, Peck, and the author. The tube usually enters the right bronchus before it blocks. When it blocks it should be drawn back 5 or 6 cm. (Meltzer in "Keen's Surgery," vol. vi). The tube is an English catheter or, as Elsberg prefers, a woven silk catheter. The eye should be at the end. It is always decidedly less in diameter than the trachea. Meltzer says the largest size used should not exceed 8 mm. in diameter. The tube is attached to the insufflation apparatus. This forces the air, the air and ether, or the oxygen and ether into the lungs, and the vapor returns between the tube and the tracheal wall.

Elsberg's apparatus is shown in Fig. 712. An electric current is turned on at the switch A. It is carried by wire to the motor C. This motor drives the blower D. The air passes through a tube E, an oil filter F, and a tube G, into a bottle H, containing hot water. The air is then forced through the tube I to a rubber tube connected to the tracheal catheter. The tube I is also connected to the ether jar J. The tube P is joined to a foot bellows. This is a "safety device," for use if the motor or blower fails or if electricity is not available.

Exploratory Puncture of the Pleural Sac.—Puncture often gives valuable information as to the existence of fluid in the pleural sac and as to the nature of the fluid. The operation must be performed with aseptic care, otherwise a serous effusion might be converted into a purulent effusion, and either a serous or a purulent effusion might be rendered putrid. A large hypodermic syringe with a long and strong needle is used for exploratory puncture. A slender needle breaks easily and is unsafe.

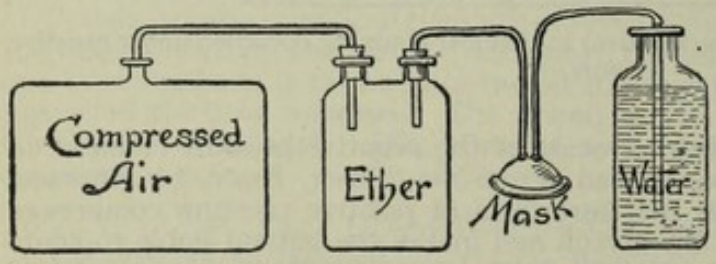


FIG. 711.—Scheme of apparatus for the maintenance of distention of the lung by positive pressure (Robinson and Leland).

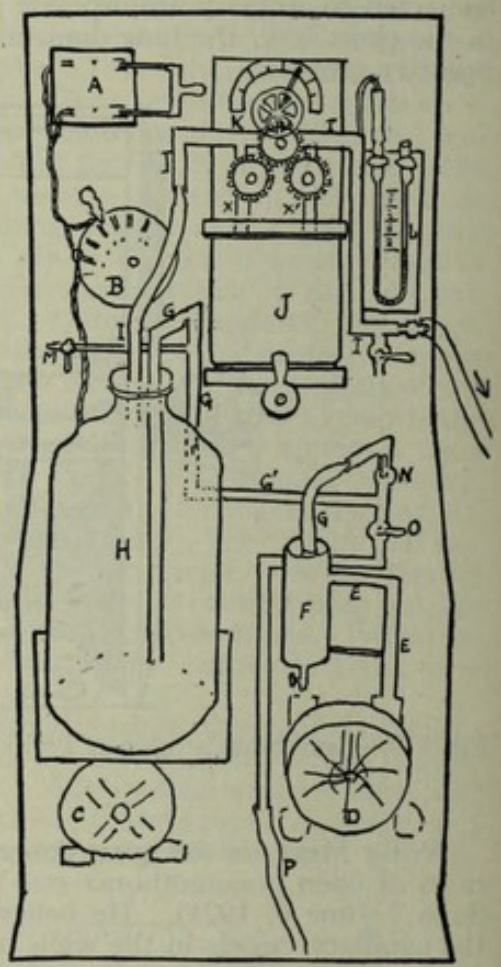


FIG. 712.—Diagram of Elsberg's apparatus showing essential parts.

In order to prevent breaking the needle, impress upon the patient the absolute necessity of keeping quiet and avoiding any violent respiratory or general movement during the operation. It is not desirable to stick the lung, although harm seldom results from such an accident. If no fluid is found in the pleura on one trial, several other punctures should be made. What is known as a dry tap may be due to the entire absence of fluid, to encapsulation of fluid in a region not invaded by the needle, to the lodgment of the point of the needle in thickened pleura or in an adhesion, or to blocking of the lumen of the needle with coagula. Fowler[1] points out that if a person has been recumbent for a long time the upper layer of fluid may be clear, while the lower layer is purulent. The fluid should be collected in a sterile glass tube and subjected to a careful bacteriologic study.

[1] "Annals of Surgery," Nov., 1896.

Paracentesis Thoracis.—The operation of tapping with a trocar and allowing the fluid to flow out through the cannula is no longer practised except in an emergency, when an aspirator cannot be obtained, or in an early stage of non-traumatic pneumothorax. An aspirator is a much better instrument for most cases.

Aspiration consists in the introduction into the pleural sac of the tip of a hollow needle, the other end of which is attached by means of a rubber tube to a bottle from which the air has been exhausted. The fluid does not run out, but is sucked out, air is excluded, and bacteria do not enter the pleural sac. Figure 525 shows a pneumatic aspirator. No anesthetic is required. The patient's skin, the instruments, and the surgeon's hands must be thoroughly asepticized. The patient is given a little whisky, and, unless he is very weak, he assumes a semi-erect attitude, with the arm hanging by the side. The trocar is introduced in the fifth interspace, just in front of the angle of the scapula. The surgeon marks the upper border of the sixth rib with the index-finger, and plunges in the trocar just above the finger, thus avoiding the intercostal artery, which lies along the lower border of the rib above. He guards the needle with the index-finger to prevent its going in too far. The fluid is withdrawn rather slowly in order that the patient may escape syncope and violent cough. If the patient becomes very faint the operation should be abandoned. All the fluid present should not be removed at one sitting—complete removal of a large effusion is not safe. The operation can be repeated if necessary. After withdrawing the cannula place iodoform collodion over the opening in the chest. In an early stage of non-traumatic pneumothorax perform paracentesis without suction. In non-purulent pleuritic effusion, if the lung will not expand after tappings, perform thoracotomy. In some cases aspiration is followed by pulmonary embolism or embolism at a distance. Syncope is a not unusual result. Convulsions occasionally occur. In rare cases the sudden withdrawal of a large effusion is followed by *albuminous expectoration*, as was pointed out by Pinault in 1853. It usually begins from a few minutes to half an hour after aspiration. When this complication arises the pulse is very weak, there are severe dyspnea, cyanosis, cough, and the expectoration of quantities of a yellow, frothy fluid. Riesman ("Amer. Jour. Med. Sciences," April, 1902) demonstrates that the condition is due to pulmonary edema and not to puncture of the lung. The sudden withdrawal of fluid by aspiration relieves the pressure which was compressing the lung, the lung becomes congested with blood (*congestion by recoil*, Riesman calls it), the blood distends weakened vessels, and profuse transudation takes place into the air-cells. Most cases recover in a few hours or a day or two. Severe cases die from asphyxia. Terrilon collected 23 cases, with 2 deaths. If albuminous expectoration arises, dry cup the chest and counterirritate with mustard plasters. Perform venesection. Give oxygen by inhalation. Administer atropin hypodermically. Employ artificial respiration if necessary.

The Operation for Creating Artificial Pneumothorax.—Murphy's apparatus as modified by Brauer is shown in Fig. 713. The manometer is on the left-hand side of the figure. The jar for nitrogen (*A*) contains a solution of corrosive sublimate through which the gas flows. The water jar (*B*) is lowered and the nitrogen tube is opened, and as the stream of nitrogen passes along the glass tube it goes through a filter of sterile cotton. The tube from the jar of nitrogen joins a three-way stop-cock (*C*). The nitrogen may be made to flow through the needle (*H*), or to deliver the intrapleural pressure to a water manometer and a mercury manometer. After determining that the functional capacity of the other lung is sufficient to sustain the demands about to be put upon it, proceed with the operation. Follow Brauer's plan because it is the safest. Select a spot where the healthy sounds and resonance are best heard (Mary E. Lapham, "Amer. Jour. Med. Sciences," April, 1912). Expose the pleura by an incision. If adhesions are absent, puncture by a blunt instrument and explore by a catheter to be sure there is a pleural cavity. If a cavity exists attach the needle to the apparatus and inject the nitrogen. After injection suture the wound. Subsequent injections are made by the needle alone, no incision being required.

Thoracotomy is an incision into the cavity of the pleura. It may be merely an intercostal incision, or may be an opening into the chest after resecting a portion of a rib. Often in a child with empyema good drainage can be obtained by an intercostal incision, but in most children and in all adults a rib should be resected.

If there is very little dyspnea, ether may be given. If there is considerable dyspnea, chloroform should be given. If there is severe dyspnea, no general anesthetic is admissible. In severe dyspnea the patient is using certain voluntary muscles to

aid him in obtaining air. A general anesthetic abolishes the activity of the voluntary muscles of respiration, and so may cause suffocation. In such cases the operation can be done with satisfaction after the injection of novocain. Preliminary aspiration will permit of the subsequent administration of a general anesthetic. The patient on whom thoracotomy is to be performed in the posterior axillary line is placed supine, the diseased side being at or over the edge of the table. He must never be placed on the sound side, because he breathes with that side only, and pressure on it may be dangerous. In cases of encapsuled empyema in which posterior incision is necessary, place the patient on the belly, each shoulder resting on a sand-bag.

The arm of the diseased side should be elevated to a right angle with the body. If the surgeon desires to obtain intercostal drainage only, he should make a longitudinal incision about 3 inches in length at the upper border of the rib, and the middle of this incision should correspond to the postaxillary line. This incision is carried, layer by layer, to the pleura. If, as will usually be the case, he wishes to remove a portion of a rib, he will make an incision about 3 inches in length directly upon the outer surface of the rib he wishes to remove. In operating for encapsuled empyema the incision should be made over the purulent collection. For interlobar empyema the incision is to be posterior to permit of exploration and satisfactory drainage. In general empyema expose the eighth rib in the posterior axillary line. Some surgeons

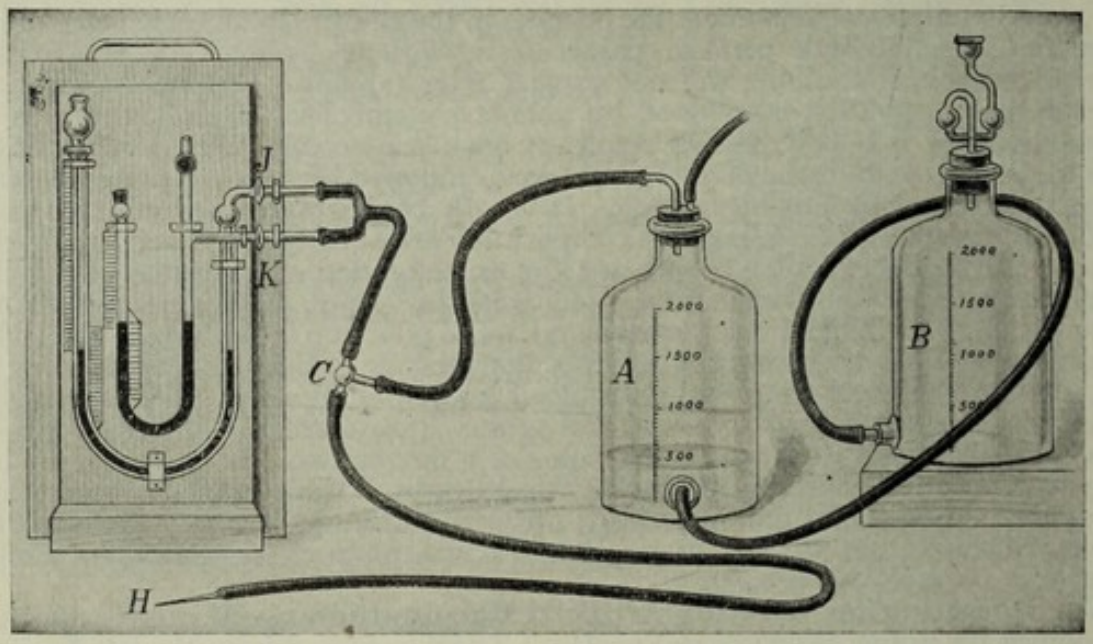


FIG. 713.—Brauer and Spengler's modification of Murphy's apparatus for nitrogen injections.

resect a portion of the fifth rib. Most remove a bit of the eighth rib, and Munro[1] shows that at the level of the eighth rib there is no danger of injuring the diaphragm. By many operators a portion of the eighth or ninth rib is removed posterior to the line of the posterior axillary fold.

I believe the middle of the incision should correspond to the posterior axillary line and that a portion of the eighth rib should be removed. Hutton believes that a portion of the sixth rib in the midaxillary line should be removed.[2] The reasons given by Hutton for the selection of this rib are: (1) It is over the portion of the lung which expands last. An empyema is drained only partly by gravity, and most of the fluid is really forced out and the cavity is obliterated by lung expansion. If an incision is made anterior or posterior to this point the expanding lung will block the drainage opening, and a pus cavity without drainage will remain in the midaxillary line. (2) Such an incision permits a patient to lie on his back without making pressure on the drainage-tube. Formerly I agreed with Hutton, but the writings of Sir John O'Connor convinced me of my error ("Brit. Med. Jour.," May 5, 1923). He shows that posterior gravity drainage is highly efficient and advises the removal of a portion of the ninth rib posteriorly.

The periosteum of the outer surface of the rib must be divided in the same direc-

[1] "Medical News," Sept. 2, 1899.

[2] See W. Menzies Hutton on "Empyema," in "Brit. Med. Jour.," Oct. 29, 1898.

tion as the superficial incision. The exposed rib is stripped of periosteum front and back by means of a periosteal separator, and with the periosteum at the lower border of the rib the intercostal artery is lifted out of harm's way. The rib can be divided by means of cutting forceps or a Gigli saw. The usual method is to push a periosteal separator under the rib and saw the bone in two places by means of a metacarpal saw (Fig. 714). I prefer a costotome, as it accomplishes the section most rapidly. Two inches of the rib should be removed and the raw bone surfaces are covered with antiseptic wax. The intercostal artery is ligated at each end of the incision, the periosteum is removed, and the pleura is opened. The object of removing the periosteum is to prevent the rapid formation of bone which might narrow the opening and interfere with drainage. The actual opening of the pleura is carried out in the same way in intercostal incision and after rib resection. A grooved director is pushed into the pleural sac, and the opening is enlarged by means of the forceps and the finger.

The finger removes all masses of tuberculous material or aplastic lymph within reach. If the finger finds the lung firmly bound down by dense adhesions so that it cannot expand, simple rib resection will not cure the patient. If the adhesions between the parietal and visceral pleura can be separated easily by the finger the lung may expand. In order to accomplish this separation a piece of more than one rib must be removed, because it is necessary to insert more than two fingers (Samuel Lloyd quoted by Lund in "Jour. Amer. Med. Assoc.," Aug. 26, 1911). If adhesions cannot be separated easily so that the lung can expand, a radical operation should be done. Some surgeons advocate immediate irrigation after opening an acute empyema, but this procedure has long been thought unsafe. It is true that in most cases flushing does no harm, but in no case will a single flushing sterilize the cavity, and in some cases it is very dangerous. The pleura is very susceptible to the action of irritants. This is especially true of young children. It happens occasionally that the injection of the blandest fluid is followed by intense dyspnea, great shock, disturbances of respiration and circulation, convulsions, and even death (Quénu). The convulsions which occasionally follow pleural irrigation were called by de Cerenville *pleural epilepsy*. In putrid empyema I have always irrigated, but not in ordinary acute empyema. Irrigation will remove part of the actively poisonous putrid matter, and the retention of putrid matter is a greater danger than irrigation. Many surgeons irrigate all empyemata gently every two hours with Dakin's fluid. This combats foulness, fever and suppuration, and favors healing. It is much safer than flushing by means of a large and forcible stream, but even this process sometimes produces pleural epilepsy (see page 879).

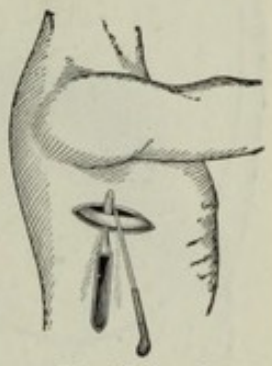


FIG. 714.—Resection of a rib (Esmarch and Kowalzig).

Some believe that pleural epilepsy is a reflex phenomenon. Others, especially Breuer, maintain that it is due to embolism. In favor of the reflex theory is the fact that a preliminary injection of morphin prevents it. I regard irrigation as of value in many cases especially if the pus is putrid. It saves lives in spite of its occasional danger. The balance is in its favor. It was formerly a common custom to make a counteropening by cutting down upon a long probe pushed against the chest wall after being introduced through the incision, but a counteropening is of no particular use. A drainage-tube about 2 inches in length is introduced and stitched in place. The tube must not be long enough to touch the lung. A safety-pin is clamped upon the tube to keep it from slipping into the chest. A tape should be fastened to each side of the pin and tied about the chest to prevent the tube from slipping out or in. Arrest bleeding, suture the skin, dress with gauze and a binder, and have the dressings changed as soon as they become soaked at one point. If we purpose irrigating, a Carrel tube is fastened to the drainage-tube and introduced with it. The Carrel tube is kept blocked except when we irrigate. Then the drainage-tube is blocked and the fluid is permitted to flow in. When sufficient has entered the Carrel tube is blocked and the drainage-tube is opened. This process is repeated until the fluid runs out clear. As soon as is safe after operation put the patient semi-erect or erect (if the position does not depress the heart or cause cough). Several times a day change the patient's position. At each change of dressings direct him to lie on the diseased side with the foot of the bed raised for half an hour. Healing takes place by granulations. Granulations from the visceral pleura fuse with those of the parietal pleura. The lung expands because of positive pressure within, negative pressure in the empyema cavity and pulling out of the lung by growth and contraction of granulations. Ascent of the diaphragm

aids healing. Expansion of the lung is favored by expiratory acts; hence cause the patient several times a day to blow through a rubber tube into a 1-gallon Wolff bottle filled with water. The water is blown into another bottle attached to the first by a tube. Before starting the blowing exercises follow the plan of Bunts, of Cleveland, and strap the other side as for fractured ribs. This may prevent emphysema of the sound side. Remove the drainage-tube when the discharge becomes thin and scanty (about the eighth or tenth day, as a rule). If an empyema ceases to improve and remain stationary for months after it has been drained, firm adhesions exist. If after one year has passed a cavity still exists and there is a flow of pus, the surgeon must perform the operation of Schede, Estlander, Fowler, Ransohoff, Keller, or some other radical procedure.

Thoracoplasty (Estlander's operation) was first proposed by Warren Stone, an American surgeon, but was set forth in detail by Estlander, of Helsingfors, in 1879. It is employed in old cases of empyema in which drainage has failed and in cases with retracted chest wall, collapsed lung, thickened pleura, and cavities whose rigid walls will not collapse. The procedure recognizes the fact that after pus has been evacuated, if the lung is adherent, it cannot expand readily to fill the space once occupied by fluid, and that the rigid chest wall cannot fall in as a substitute for the lung. It seeks to destroy the rigidity of the chest wall and to permit it to collapse and thus obliterate the cavity of the empyema. In this operation a piece is removed from every rib which overlies the cavity. When the surgeon resects a rib and finds a cavity with uncollapsible walls, or a lung bound down with firm adhesions, he should perform thoracoplasty. This operation causes the obliteration of the cavity by collapsing that portion of the chest wall overlying it. The cavity is usually in the upper or central part of the pleural space. The instruments required are the same as those for resection of a rib. The position is the same as that for rib resection. The length of the incision depends on the size of the cavity. The surgeon usually removes portions of the second, third, fourth, fifth, sixth, and seventh ribs. Make a transverse incision along the center of an intercostal space, and through this incision remove the ribs above and below by the method set forth on page 896 (the removal of parts of six ribs will require three incisions). Instead of this incision, we can make a vertical incision or a U-shaped flap. Always take away the periosteum in order to prevent reproduction of the ribs. In cavities which are surrounded by firm adhesions, and in old cases in which the pleura is greatly thickened, irrigation is safe. The cavity is sterilized by Dakin's fluid.

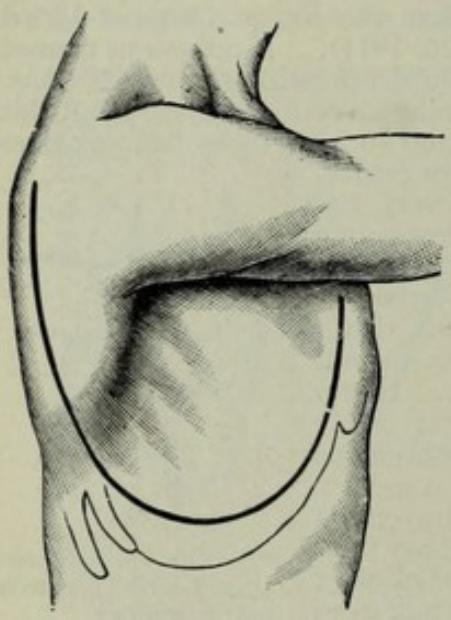


FIG. 715.—Incision for Schede's operation of thoracoplasty (Esmarch and Kowalzig).

Schede's Operation.—Schede, of Hamburg, showed that when the pleura is much thickened, even Estlander's operation will not permit the chest wall to collapse and fill the cavity once occupied by the fluid. The instruments used are the same as for Estlander's operation. A U-shaped flap is made from the level of the axilla in front to the level of the second rib and between the scapula and spine behind. The lowest level of this incision corresponds to the lowest limit of the pleura (Fig. 715). The flap is loosened and raised and the scapula is lifted with it. The ribs from the second rib down and from the costal cartilages to the tubercles are removed, along with the intercostal muscles and the parietal pleura. This is accomplished by cutting with bone-shears and scissors. Hemorrhage is arrested. The remaining pleura is curetted. Carrel's tubes are introduced and the raw flap is laid against the visceral layer of the pleura. The superficial incision is sutured, except at the point wheer the tubes emerge. The cavity is sterilized by Dakin irrigations. The average mortality from Schede's operation is from 15 to 20 per cent. The operation is far more often necessary in adults, but the results are much better in children who are not very young.

Total Pleurectomy or Pulmonary Decortication (Fowler's Operation).—In the spring of 1893 Delorme, of the Val de Grace, performed some experiments on dogs looking to the development of the operation. In October, 1893, the late George Ryerson Fowler, of Brooklyn, having no knowledge of Delorme's investigation, oper-

ated on a man and cured a chronic empyema. The French surgeon's first operation was months later. Delorme sought to do away with the great mutilation of the Schede operation. His idea was to make an opening in the chest wall large enough to work through (but not nearly so large as that caused by Schede's operation), incise the dense fibrous membrane which binds down the lung, and allow the lung to expand and fill the cavity. Delorme makes a trap-door incision. Fowler resected ribs extensively to obtain room. The thickened fibrous membrane is removed from the chest wall, lung, pericardium, and diaphragm, any sinus is extirpated, and all granulation tissue is taken away. The shrunken lung expands to fill the cavity.

Lund describes the operation as follows ("Jour. Amer. Med. Assoc.," Aug. 26, 1911): "In regard to the technic of the operation, the method of the resection of $1\frac{1}{2}$ inches of five or six ribs, through an incision running upward and forward from the anterior end of the old drainage incision, has proved, to my mind, very satisfactory. In slitting up the thickened pleura beneath the ribs I have had, in one or two cases, to grab the intercostal artery, but have been very much surprised to find how little trouble there has been from bleeding. The visceral pleura, which is about $\frac{1}{4}$ inch thick and which is more like the sole of an old rubber shoe than anything else, is carefully

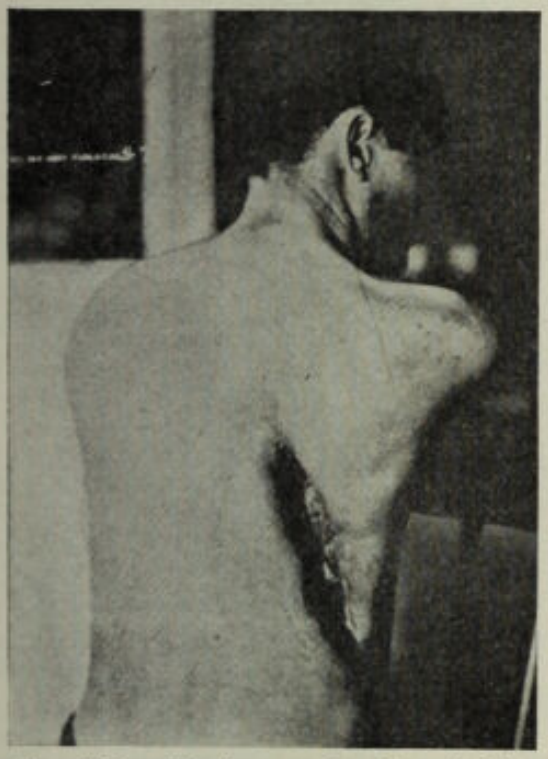


FIG. 716.—Showing turning in of skin to protect wound edges (Col. William L. Keller, U. S. A., in "Annals of Surgery").



FIG. 717.—Regenerated necrosed ribs exposed for removal (Col. William L. Keller, U. S. A., in "Annals of Surgery").

incised with a knife over the lower part of the lung. The finger is inserted through the incision and, as soon as the soft surface of the lung is felt, is swept to and fro with the pulp of the finger toward the pleura and pressing outward so as to cause the least possible damage to the lung. Then a pair of blunt-pointed scissors is inserted and the membrane slit clear up to the top of the chest, and cleared off from the lung with the finger. A wound of one or two of the air-cells resulted in 2 or 3 of my cases, allowing the escape of bubbles of air on exploration, but so small an area of the lung was affected that, apparently, no harm resulted. In regard to the after-treatment, it is probable that after the patient is put to bed the lung does retract to a certain extent, but the occasional coughing keeps up the expansion. The thick, pus-soaked dressing, if tightly applied, to my mind, acts as a more efficient valve than any mechanical valve which one could employ."

Fowler made a report of 30 cases. Eleven cases were completely cured. In 17 cases the empyema was cured, but 6 of them had tuberculosis. There were 3 deaths. The combined statistics of Fowler, de Lorme, and Cestan show 35.7 per cent. cured, 19.7 per cent. improved, 33.9 per cent. not cured, and 10 per cent. died (Kurpjweit in "Beiträge fur klinischen Chirurgie," Bd. xxxiii, H. 3).

Discission of the Pulmonary Pleura (Ransohoff's Operation).—This operation was devised by Ransohoff, of Cincinnati. It can be employed when decortication is impossible, and it may be used as a substitute for decortication in certain cases. It permits the shrunken lung to expand. It is founded on the observation that if the thickened pleura over a shrunken lung is incised the cut widens with each respiration and quickly becomes a groove (Ransohoff in "Annals of Surgery," April, 1906). The pulmonary pleura is divided by numerous parallel incisions ¼ inch apart, and then similar incisions are made to cross these. An incision is also carried through the costal side of the angle of reflection of the pulmonary and costal pleura.

Heuer's Observations ("Proceedings of Amer. Surg. Soc.," 1920).—Heuer and others have proved that many empyema cavities, even when the pleura is very thick, can be sterilized.

Heuer succeeded in several ways:

1. Excision of a single rib, mobilization of parietal pleura to beyond the empyema cavity, excision of parietal pleura over the cavity and to the line of junction with the visceral pleura. This operation leaves a mesial area of pleura. Disinfect by Dakin's fluid.

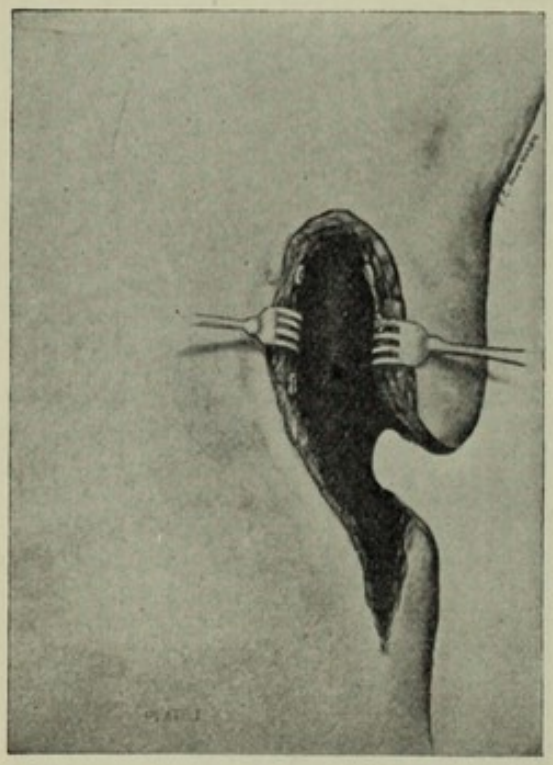


FIG. 718.—Showing defect after resection of necrotic ribs (William L. Keller in "Annals of Surgery").

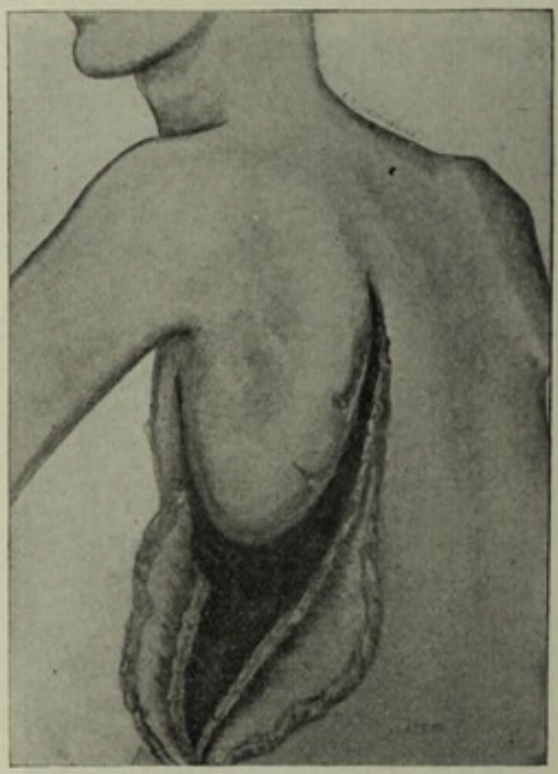


FIG. 719.—Process of plastic closure by muscle implantation (William L. Keller in "Annals of Surgery").

2. Introduction of Carrel tubes through the sinus and sterilization without preliminary operation. The method will fail if the tracts are long and tortuous.

3. Enlarge, disinfect, and close sinus or excise sinus. May disinfect through excised area or may close and make a new point for tubes at a point of election.

4. Immediate sterilization by carbolic acid and closure without drainage.

Col. Keller's Operation.—The trend of surgical thought is to employ a method in which by sterilizing the cavity the surgeon is enabled to do an operation less mutilating than that of Schede. Keller has used it successfully in old cases, in broken health, who have had several or many unsuccessful operations. The operation is broken into as many stages as the condition of the patient demands. Details are of immense importance (see Col. William L. Keller in "Annals of Surg.," Nov., 1922). Keller's plan consists of large incision, extensive rib resection (each rib divided flush with the periosteum in order to prevent necrosis), removal of parietal pleura in cases which have lasted over one year, and judicious chemical decortication of visceral pleura by gentian-violet. Without great care gentian-violet is dangerous and may cause bleeding, rupture, or herniation of lung. Final sterilization by Dakin's fluid, daily cultures being necessary to check off the condition.

This plan enables the surgeon to find and open up diverticulæ, to observe and remove foreign bodies, to treat osteomyelitis of ribs, and to place the Carrel tubes just where they are needed. Later, when the patient has improved greatly, it may be considered wise to treat bronchial fistulæ. The lung expands to a remarkable degree.

Pneumotomy for Abscess and Gangrene of the Lung.—Pneumotomy is employed for abscess, gangrene, and bronchiectasis. Give gas and oxygen or use a local anesthetic. Place the patient recumbent with the shoulders a little raised. Make a U-shaped flap over the seat of disease. Resect a portion of one rib or portions of two ribs. If it is found that adhesions do not exist between the pulmonary and costal layers of the pleura, stitch these layers together with catgut, and either postpone further operation for forty-eight hours or surround the area by gauze and operate at once. If adhesions exist, proceed at once. The anesthetic can be put aside when the pleura is exposed. Fowler called attention to the fact that lung tissue is so insensitive that the administration of an anesthetic can be suspended as soon as the pleura has been opened. Incise the agglutinated layers of the pleura, and pass an aspirating needle into the lung in various directions. When the abscess is located, open it by the cautery. Carry the Paquelin cautery slowly into the lung in the direction of the abscess cavity. The cautery knife should be at a dull-red heat.

When the cautery opens the cavity of the abscess, withdraw the instrument and insert a drainage-tube, and suture the flap of superficial tissue. If the abscess is not found after one or two punctures by the aspirating needle, abandon the attempt.

Tuffier explores for an abscess by what he calls *decollement of the parietal pleura.* He exposes the parietal layer of the pleura, passes his hand between this layer and the chest wall, strips the pleura off over a considerable area, and is able to feel the lung beneath and thus determine its condition.

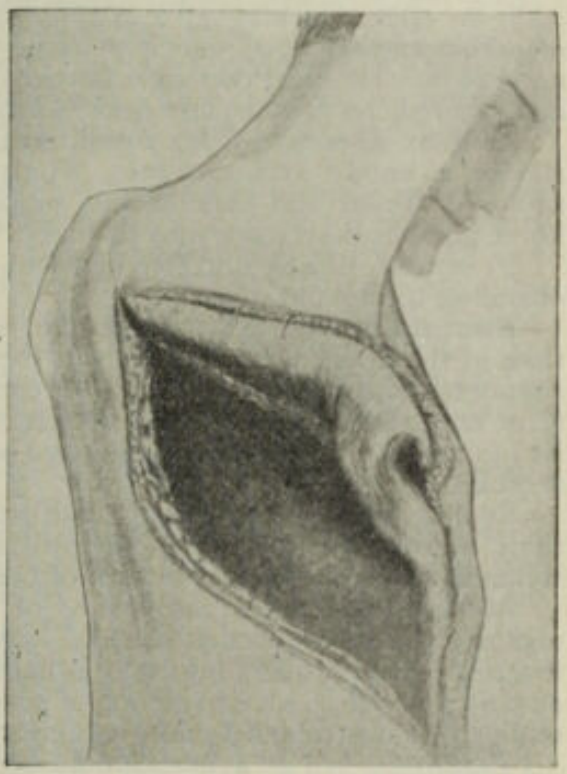


FIG. 720.—Showing closure of upper portion of cavity by muscular transplant (William L. Keller in "Annals of Surgery").

Hartmann ("Presse Médicale," April 27, 1912) states that Garré collected 96 cases of abscess, with 19 deaths, and 122 cases of gangrene, with 42 deaths. In bronchiectasis pneumotomy may be employed. Hartmann (Ibid.) combines the cases of Körte and Sauerbruch, and states that in 149 cases there were 46 cures. In Sauerbruch's 133 cases there were 40 cures, 43 deaths, and 7 were improved.

XXV. DISEASES AND INJURIES OF THE UPPER DIGESTIVE TRACT

Injuries and Diseases of the Face, Nose, Mouth, Salivary Glands, Tongue, Jaws, and Esophagus.—Closure of the Jaws.—This condition may be caused by tetanus, by the irritation of a non-erupted wisdom tooth, carious teeth, by cancer of the mouth, sarcoma of the jaws, alveolar abscess, cicatricial contractions due to burns or noma, and temporomaxillary ankylosis. In many cases of old wounds and scars constriction is due to rapidly developing muscular contracture. It seldom arises if the jaw is fractured. It is a condition of hysteric hypermyotonia, and is analogous to contractures of the limb. The jaws can always be opened widely by the gradual use of a dilator. Treatment of contracture is by repeated gradual dilatation and by suggestion. The condition is curable.

Temporomaxillary Ankylosis.—Ankylosis of the temporomaxillary joint may result from gonorrheal arthritis, rheumatoid arthritis, or fracture of the condyle. Even when one joint is completely ankylosed, the jaws upon the sound side can be somewhat separated because of the elasticity of the mandible. The constriction may be fibrous, the result of peri-arthritis of the articulation. It may be bony.

Treatment.—Gradual dilatation by means of box-wood screws is useless even for fibrous constriction. Violent separation is without value. After either method the condition always recurs rapidly. Esmarch removed a wedge-shaped piece of bone from the angle of the jaw in order to form a false joint. Other operators do a like operation on the ramus. A simple osteotomy is certain to fail because bony union will occur. That is the trouble with Swain's operation (sawing the body at the angle). Bony union may be prevented by resecting the zygoma and putting a flap of temporal muscle between the fragments (Helferich). The masseter may be used. Removal of the condyle and a portion of the neck is usually efficient. In double ankylosis both condyles should be resected. Verneuil in 1860 suggested mobilizing the joint and interposing an attached flap of temporal muscle between the condyle and the socket. Such an operation may give a gratifying result. Murphy divided the neck of the mandible and removed sufficient tissue to permit of the interposition of a flap of fat and fascia. He fixed the lower border of the flap to the upper border of the zygoma and sutured the flap in place between the bones.

Alveolar Abscess.—This condition is caused by a decayed tooth. A superficial abscess is known as a *gum-boil.* The process may spread to the jaw bone, causing necrosis. From the maxilla the suppuration may enter the antrum. From the lower jaw pus may track into the neck.

Treatment.—Early and free incision; usually, but not always, the extraction of the offending tooth, and drainage.

Necrosis of the Jaw.—Extensive necrosis is much more common in the lower than in the upper jaw. Necrosis of the alveolar process of either jaw may be due to suppurative periostitis, the result of carious teeth. In suppurative periostitis of this form an alveolar abscess arises which is followed perhaps by circumscribed necrosis. In rare cases wide-spread suppurative periostitis occurs which may result in extensive necrosis.

Syphilis produces periostitis and osteomyelitis, but more commonly causes caries than necrosis. Tuberculous periostitis may result in limited necrosis. Its most common site is the orbital margin of the maxilla.

Actinomycosis is a rare cause of necrosis. In mercurial salivation extensive necrosis is prone to occur. A child suffering during dentition from an exanthematous fever or other virulent infection is liable to a violently acute suppurative periostitis and osteomyelitis with evidence of severe general infection. In the lower jaw particularly extensive and usually symmetric necrosis follows.

Treatment.—In an acute suppurative periostitis, if there is a carious tooth, extract it, and incise the gum to the bone; if osteomyelitis exists open the outer plate of the bone, and order frequent cleansing of the mouth by antiseptic washes. In syphilitic caries place the patient on antisyphilitic treatment and use a curet to remove carious bone. In tuberculous caries use a curet and employ antituberculous treatment.

When necrosis occurs it is usual to wait until the sequestrum loosens before removing it, but early sequestrectomy is a better plan. The sequestrum is usually removed through the mouth or nose. If there is profuse suppuration, remove the dead bone by subperiosteal resection (Tillmanns's "Text-book of Surgery").

Phosphorus Necrosis.—This condition was first observed by Lorinser, of Vienna, in 1838 and was fully described by Bibra and Geist in 1847. It is seen among those who mix, box, and dip in factories in which matches are made from yellow phosphorus. Recent legislation against the use of yellow phosphorus is wiping out the affliction. The condition is most common in the lower jaw, but it may occur in either jaw, or in both jaws. Most sufferers have decayed teeth, but Lewin, of Berlin, claims that decayed teeth do not exist in all cases.

It is supposed that the fumes dissolve in saliva and the fluid enters the cavities in the diseased teeth. We know that fumes are not the sole cause. If a worker eats food without washing his hands he may come to trouble. In some cases the condition does not manifest itself for a year or even two years after a man has ceased working in a match factory. There may be serious impairment of the general health when the necrosis begins (albuminuria, pallor, and dyspnea).

Oliver points out that in phosphorus workers there is a decided tendency to fracture of the long bones.

The first lesion is periostitis. The gums and jaw swell and become painful, salivation occurs, pus forms eventually even if there is ossifying periostitis. In that case the pus gathers between the periosteum and new bone or between the new bone and old bone. The jaw enlarges enormously and the bone is slowly destroyed. Eventually

extensive necrosis takes place, sinuses form, and the patient may become toxic from swallowing quantities of foul pus. Dead bone may be cast off. The entire lower jaw may be lost. The bones of the base of the skull may be destroyed and meningitis may arise.

Most of the victims of phosphorus necrosis get many teeth pulled, but even wholesale extraction does not cure the pain.

Tillmanns (quoting Maas, Binz, and others) states that arsenic and pyrogallic acid act like phosphorus, and tend to produce ossifying periostitis.

If yellow phosphorus is used, the paste should be mixed in closed vessels by a machine. Dipping and boxing are sources of danger from fumes and should be done only in very well-ventilated places.

Phosphorus workers should always wash their hands before eating, should never eat in the factory, and should take the best of care of the teeth. The treatment of necrosis consists in the removal of the victim from the fumes, making him live in the open air and frequently using antiseptic mouth-washes. If pus forms, incisions are required. Early subperiosteal sequestrectomy by means of a chisel and mallet is indicated.

Wounds of the Salivary Glands.—An aseptic wound usually heals and rarely results in a salivary fistula, although after healing it is not unusual for an encysted collection of saliva to gather under the skin. Such a collection of saliva, if it does not disappear spontaneously, can usually be caused to disappear by continued pressure. When a wound of a salivary gland is infected a single fistula or multiple fistula may be left as a legacy. A salivary fistula is very annoying, because the saliva flows constantly. A fistula of a gland usually heals spontaneously after a long time, but healing may be quickly brought about by touching the orifice with the Paquelin cautery.

Steno is the Latin form and Stenson is the German form of the name of the Copenhagen anatomist who in 1661 described the duct of the parotid gland.

Wound of Stenson's or Steno's duct is apt to cause a fistula, and the condition is often difficult to cure. In this condition, if the duct has been cut across, the central end grows fast to the cutaneous surface. Fistula of Steno's duct may also be caused by obstruction and rupture of the duct and by suppurative or gangrenous processes.

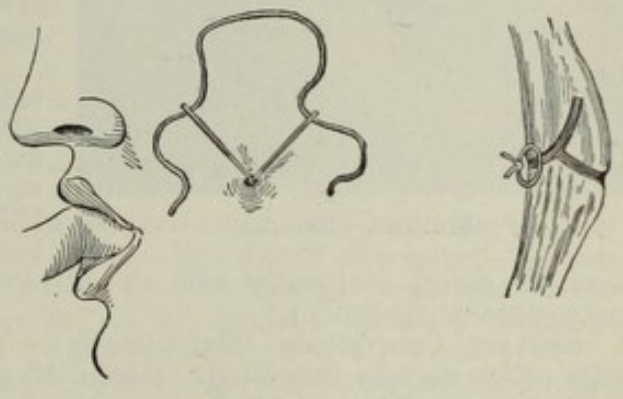


Fig. 721.—De Guise's operation for salivary fistula (Esmarch and Kowalzig).

In wounds of the duct the ends should be brought as near together as possible by catgut sutures which do not enter the lumen of the duct. If the oral mucous membrane has not been already opened an incision should be made through it to permit drainage of saliva into the mouth, and the skin should be sutured. In some cases the central end of the duct may be carried into the mouth and sutured to the mucous membrane. If, after any injury of Steno's duct, saliva gathers under the skin, make an incision through the mucous membrane to give a route for the saliva to enter the mouth, and apply pressure externally. When an external fistula forms, it may perhaps be cured by the cautery and pressure, but, if the peripheral portion of the duct is obliterated (which can be determined by a sound), a cutting operation must be performed. Tillmanns advocates cutting out the external portion of the fistula by two elliptic incisions. A trocar is passed through the bottom of the wound in two places about ½ cm. apart; a piece of stout silk is drawn through the holes and tied tightly and the superficial incision is closed. The silk cuts through and makes an internal fistula. Another method is to make an incision, find and isolate the central end of the duct, open the mucous membrane, suture the duct to it, and close the superficial wound.

De Guise's operation is shown in Fig. 721. He threads a piece of silk through two needles and carries the needles into the mouth so that the silk will embrace a bit of tissue ½ cm. in length. The silk is tied tightly within the mouth, the ends are cut off, and the margins of the fistula at the surface are freshened and sutured. I prefer silver wire to silk. Some advocate treating fistula of the duct by tying the duct

near the gland in two places and cutting between the ligatures. The gland, if not infected, should undergo atrophy (Hupp in "Annals of Surg.," Sept., 1921).

Parotitis.—Mumps, or epidemic parotitis, is treated by the physician. In this condition the submaxillary and sublingual glands are usually involved, as well as the parotid. In pyemia metastatic abscesses may form in the parotid gland. If such abscesses form, great swelling arises, respiration is often embarrassed, and early incision is necessary. Parotid inflammation other than mumps is usually due to the passage of bacteria up Steno's duct, the source of the microbes being a foul condition of the mouth, particularly from noma or stomatitis. Hence such inflammation is most common during the existence of acute infectious diseases and sepsis. Suppuration or even gangrene may occur. As a rule, only one gland is attacked, but both may be. It is a well-known fact that occasionally, though very rarely, after an abdominal operation inflammation of the parotid gland occurs (*sympathetic parotitis*). The condition is more common in adults than in children. This form of parotitis may, of course, be due to septic metastasis and may be produced by trauma, but I am satisfied that most cases result from foul mouths, the infection ascending from the mouth along the duct. Oral cleanliness tends strongly to prevent the so-called sympathetic parotitis. In about one-third of the cases the condition is not to be distinguished from mumps and is recovered from in seven to eight days. Mild cases seldom suppurate, and if they do, the pus may flow down the duct into the mouth. In nearly one-half of the cases, according to Marchetti ("Epitome of Surgery" in "Brit. Med. Jour.," March 6, 1909), there is phlegmonous inflammation with necrosis and suppuration of the tissues and formation of a salivary fistula. In non-suppurative parotitis there are pain, tenderness, obvious swelling and hyperemia of the skin, and it is difficult to open the mouth or swallow. When suppuration occurs, all of the above symptoms are intensified, the discoloration becomes dusky, the skin becomes shiny and edematous, the constitutional symptoms of pus formation exist, and there may be delirium.



FIG. 722.—Ranula.

Treatment.—In the non-suppurative form apply heat. Wash the mouth out frequently with an antiseptic wash and apply ichthyol and lanolin to the swollen region. In the suppurative form make several openings by Hilton's method, seeking for points of softening; apply hot antiseptic fomentations, wash the mouth frequently with an antiseptic fluid, and combat sepsis by appropriate constitutional treatment.

Salivary Concretions (Sialolithiasis).—The saliva contains in solution certain salts which may be deposited. Deposited on the teeth they constitute tartar. Deposited in a salivary duct or the acini of a gland they constitute a calculus. The salts deposited are carbonate and phosphate of lime. A calculus may consist purely of these two salts or there may be a foreign-body nucleus. A calculus is a possible result of an inflammation which blocks, constricts, or roughens a duct or acinus and decomposes saliva. Inflammation of a duct is known as *sialodochitis*. Small concretions are often passed. Concretions the size of a bean are retained. A concretion may attain the size of an English walnut. A concretion does not block a duct continuously, but does so now and then, causing swelling and tenderness of the gland. A retained calculus can be palpated by a finger in the mouth and a finger externally. Whenever a salivary gland enlarges an attempt should be made to probe the duct. In some cases the stone can be touched. In others the duct is found to be blocked. The *x*-rays demonstrate the stone. Salivary calculus is more common in adults than in children, but is not very rare in children. The duct of the parotid, of the sublingual, or of the submaxillary may contain a calculus, but it is unusual to find a stone in Wharton's duct.

Treatment.—A calculus in a duct is extracted by making an incision through the mucous membrane. If a very large calculus forms in the submaxillary gland, the gland should be removed through an external incision.

Ranula is a retention cyst of the duct of the submaxillary or the duct of the sub-

lingual gland. A ranula when first formed contains saliva, but after a time the saliva undergoes a change, and then resembles mucus. *Mucous cysts* occur in the floor of the mouth, resulting from obstruction of the ducts of the *mucous glands of Nuhn and Blandin*. These glands lie on each side of the frenum of the tongue. Such a cyst is often spoken of as a ranula. A *cyst of the incisive gland* forms just back of the lower jaw and lifts up the frenum. A true ranula appears upon the floor of the mouth on one side and pushes the tongue toward the opposite side (Fig. 722). The *treatment* of a mucous cyst is by excision of a portion of the cyst wall and cauterization of the interior with pure carbolic acid; or by cutting a flap from the cyst wall and stitching it aside so as to keep a permanent opening. Such an operation may cure a genuine ranula, but will often fail. In true ranula it is usually advisable to make an external incision, and through this remove both the cyst and the gland. This plan is recommended by Mintz.[1]

Lymphomata of the Salivary and Lachrymal Glands (Mikulicz's Disease).—Mikulicz, of Breslau, described this condition in 1888 (see Billroth's Festschrift for 1892). It is a chronic brawny and non-inflammatory swelling, painless, though sometimes tender, perhaps fluctuating in size and unconnected with any known systemic condition. In Mikulicz's early cases the lachrymal gland, the parotid, and submaxillary salivary glands of both sides were enlarged, hence he regarded it as symmetric. We now know that non-symmetric cases occur; in fact, only one gland may be enlarged, although, of course, such cases may eventually develop growths on the other side. In some cases the sublinguals have been involved, in some the accessory lachrymals, in some the glands of Nuhn and Blandin. In a case of Osler's there was enlargement of the spleen, tonsils, and cervical lymph-glands. In a typical case the cheeks are much broader than natural, and the eyelids droop on the temporal side like "those of a bloodhound" (Zeigler in "New York Med. Jour.," Dec. 11, 1909). The mouth is very dry because of deficiency of salivary secretion. The conjunctiva is dry for want of enough tears. Chronic inflammation in the nasopharynx is not unusual. In some cases the blood findings resemble those of lymphatic leukemia (Paton in "Proc. Roy. Soc. Med.," 1915, viii); in others they are normal. The lumps may fluctuate in size.

The condition may occur at practically any age after three or four. A case four years of age has been reported. The glands may undergo regression during pneumonia, appendicitis, or some other infection. The cause is doubtful. Some think it is due to bacteria, but the tissue is not inflammatory, being merely hyperplastic lymph tissue. Others regard it as due to a toxic material in the blood. Ziegler believes that the causal toxic material comes from the nasal sinuses. The condition is lymphomatosis of lymphatic elements and microscopically the tissue resembles that of Hodgkin's disease.

Treatment.—Arsenic internally will perhaps produce cure. The iodids are used by some and pilocarpin has been recommended. The *x*-rays should be applied. Operative removal is practised only to relieve pressure. All diseased conditions of the nasopharynx should be corrected, if possible. (See Ziegler's thorough study in "New York Med. Jour.," Dec. 11, 1909.)

Harelip and Cleft-palate.—(Dr. Warren B. Davis, who has charge of these cases in my clinic, did me the favor to revise this section on harelip and cleft-palate.) Harelip and cleft-palate are congenital deformities, either or both of which may be unilateral or bilateral, partial or complete. They are often associated, but either may occur without the other. They are due to varying degrees of deficiency in union between the frontonasal, the lateral nasal and the maxillary processes, and between the palatal shelves of the maxillæ. Hereditary tendencies play an important part in the etiology of the majority of cases. Carefully investigated family histories in our series showed other cases of some degree in over 50 per cent. of the families. Some of the preceding deformities were in parents, several in grandparents, and others in uncles, aunts, or cousins. Some cases of complete harelip and cleft-palate deformities had one or more relatives with very slight deformities, such as a bifid uvula or a congenitally absent lateral incisor tooth without any deformity of the alveolar process.

Embryologic studies show that the processes entering into the formation of the lip and palate normally cause closure by the sixtieth or sixty-fifth day of embryonic life. We have not seen any cases supporting the theory of maternal impression as an etiologic factor. Several mothers have volunteered their belief in such a cause, but in every instance the fright or other cause to which they attributed the condition occurred long after the above-named known time of normal union of the parts.

[1] "Zeitschrift für Chirurgie," March, 1899.

It was long taught that operations for the correction of these deformities should not be done until the child is several years old. In 1868 Dr. Thomas Smith insisted that the operations should be done some time before the child learned to talk. The truth of his opinion has steadily become more generally recognized and accepted, so that at the present time cases of harelip in children otherwise in good health are usually operated upon some time between the first week and the third month. Cases of complete cleft-palate, unilateral or bilateral, and the incomplete clefts of the palate involving the alveolar process and associated with harelip, we believe should have the premaxilla placed in proper position and the lip repaired some time before the fourth month, if the child's general condition permits operative procedures. The remaining cleft in the palate should be repaired some time between the ninth and the eighteenth months. Cases properly operated upon at that age unquestionably have less deformity and less impairment of speech than those operated upon at later periods. If the child is in poor health postpone operation until the general condition is such as to render operative procedures relatively safe. These cases are seldom able to nurse from the breast, but must be fed with a medicine-dropper or a small spoon, or a nipple with the opening somewhat enlarged.



FIG. 723.—Showing unilateral harelip, deviation of nasal septum to the right, and moderate flattening of left nostril. Aged twelve months (Warren B. Davis).

Unilateral Harelip.—Single simple harelip deformities (Fig. 723), complete or incomplete, usually require the same general plan of treatment, since in the majority of cases in which the cleft extends only partially through the lip there is little or no muscle tissue between the upper angle of the cleft and the floor of the nostril. To correct this condition it is necessary to convert such an incomplete cleft into a complete one in order to secure approximation of the muscles and to properly correct the flattening of the ala nasi and the associated widening of the nostril.

Operation: Select the most careful anesthetist. Ether or chloroform may be given. Use light anesthesia. The use of a suction apparatus facilitates the removal of blood and secretions from the pharynx. In outlining incisions for the correction of harelip (Fig. 724) the method devised by J. E. Thompson has been in our cases by far the most satisfactory both at the time of operation and in the end-results. Before approximating the margins it is essential to free the superolateral portions of the lip from the anterior surfaces of the maxillæ through incisions made above the alveolar process in the canine areas. This relieves tension and permits the ala nasi to be brought into approximately normal contour. The deviation of the nasal septum should be corrected at this time by forcible pressure with a nasal dilator. This is usually sufficient in infants. Catgut or silk sutures should be used on the mucous membrane surfaces. Fine silk, horsehair, or equisetene sutures are used on the skin surface. The vermilion borders must be accurately approximated. If the cleft is a wide one, a stay suture may be necessary to avoid tension on the suture line.

Median harelip is very rare and is due to agenesis of the philtrum. It is usually associated with failure of development of the premaxilla and the structures having their origin from the median frontonasal process (Fig. 725). The measurements for outlining incisions for the repair are made as for unilateral harelip (Fig. 724), only taking the superior angle of the cleft for the upper measuring point instead of the point at the floor of the nostril.

Double Harelip.—Incisions are outlined as shown and described in Fig. 724.

Unilateral Harelip and Cleft-palate.—This type (Fig. 726) shows wider separation of the lip margins than in simple harelip, more marked flattening of the ala nasi, greater deflection of the nasal septum to the opposite side, and varying degrees of anterosuperior rotation of the margin of the premaxilla. The treatment is preferably by a two-stage operation, the operative treatment being completed before the child

is two years old. We believe best results are obtained by closing the cleft in the alveolar process and repairing the harelip at the first operation, which should be done as soon as the child is in good condition, and it is known that the formula used in feeding is a suitable one. A time somewhere between the tenth day and the third month is usually selected for the first operation. The margins of the alveolar cleft can usually be approximated in infants by digital pressure on the premaxilla, combined with intranasal pressure on the lower portion of the nasal septum and the nasal floor with a small nasal dilator. In wider clefts and in the case of an older child the alveolar cleft is repaired by partially dividing with a thin chisel the buccal side of the alveolar process just posterior to the canine region on the side opposite the cleft. Pressure

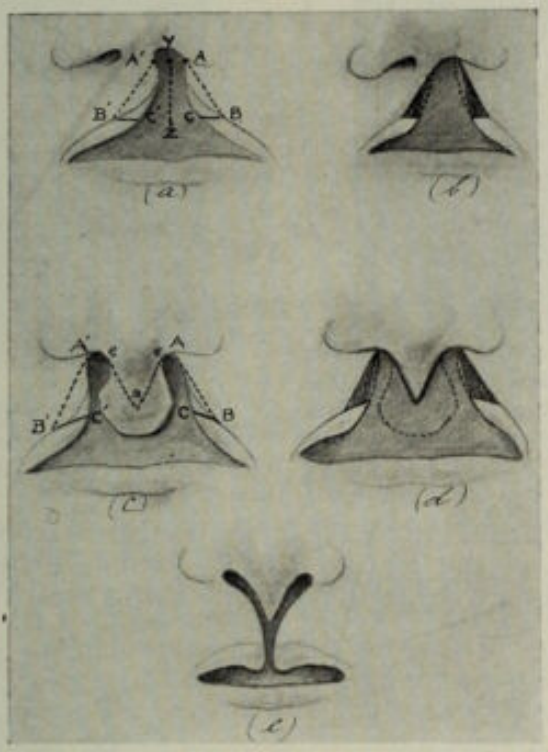


FIG. 724.—Semidiagrammatic sketches, showing lines of incisions used for the correction of single and double harelip. (After methods of J. E. Thompson.) In single clefts (*a*) sharp-pointed calipers are used in measuring the distance (*YZ*) from the midpoint of the floor of the nostril to the point in the same sagittal plane to which the free margin of the lip would come if it were of normal contour. Fixing the distance on the calipers and keeping the superior point at *Y*, the inferior point of the calipers is rotated describing an arc which crosses the vermilion border of the lip on each side of the cleft. These points, *B* and *B'*, are distinctly marked by making a puncture with the point of the calipers or with a small scalpel. Point *C* and *C'* are then located on the free margin of the lip so that the angles *ABC* and *A'B'C'* are between 70 and 80 degrees. Incisions carried through the entire thickness of the lip with a small scalpel at a right angle to the skin surface and following the lines as outlined will give surfaces for approximation which are of equal length and which, when sutured together, will give a lip the length of which is the estimated normal length (*YZ*) plus the distance from the vermilion border to the free edge of lip (*CB*) which is usually just sufficient to allow for subsequent contraction. Sketch *b* shows tissue removed. Lines of incision used in double harelip are shown in sketch *c*. The philtrum is trimmed to a V-shape, leaving as much tissue as is possible with thorough removal of the vermilion borders. The lateral incision lines are outlined as described for single harelip. Sketches *d* and *e* show tissues ready for approximation.

then made as above described produces a greenstick fracture at the point of the partial division of the alveolar process. The margins of the cleft must have the mucous membrane removed so that raw surfaces can be brought into contact. The margins are then held in approximation by a silver wire applied through the upper portion of the alveolar process. This procedure not only closes the alveolar cleft, but by bringing the premaxilla to approximately its normal position, the deviation of the nasal septum is corrected and the width of the cleft in the lip greatly decreased. The lip is then repaired in essentially the same manner as described regarding simple harelip, but requiring greater care in bringing the base of the ala nasi sufficiently medial by the first suture applied at the floor of the nostril. The closure of the remain-

ing cleft in the palate we prefer to do a few months later by a modified Longenbeck mucoperiosteal flap-sliding method as used by Berry (Figs. 727–729).

Bilateral harelip and *cleft-palate* cases present varying degrees of anterosuperior rotation of the premaxilla, elongation of the vomer and nasal cartilage, and shortening of the columella and the philtrum

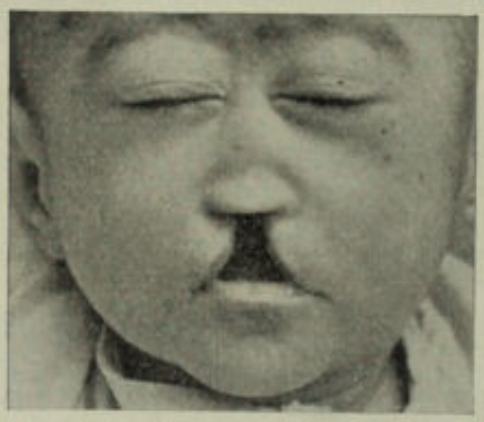


FIG. 725.—Median harelip. Premaxilla, philtrum, and nasal cartilage wholly wanting. Nasal bones, mesethnoid, and vomer are rudimentary. Mongolian idiocy. Aged four months (Warren B. Davis).

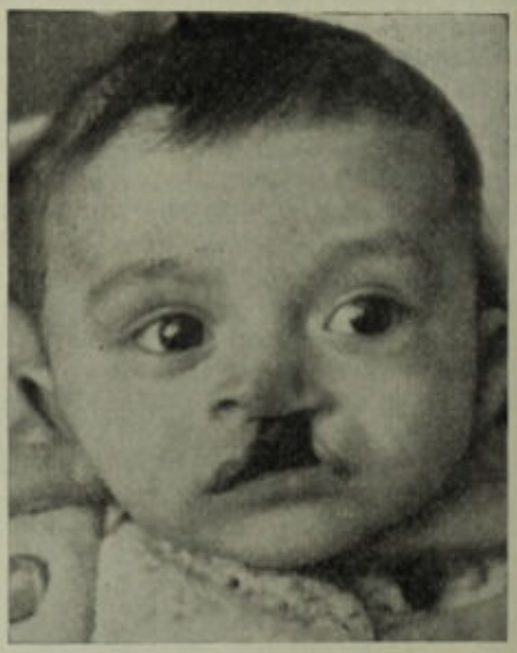


FIG. 726.—Unilateral harelip and complete single cleft-palate. Aged five months (Warren B. Davis).

(Figs. 730, 731). In some instances there is also a lateral rotation of the premaxilla and deviation of the septum. If the anterosuperior rotation of the premaxilla is marked, it is advisable to remove submucously a triangular section of

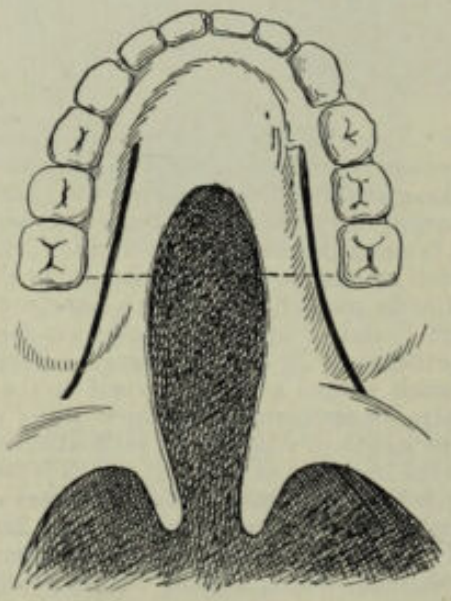


FIG. 727.

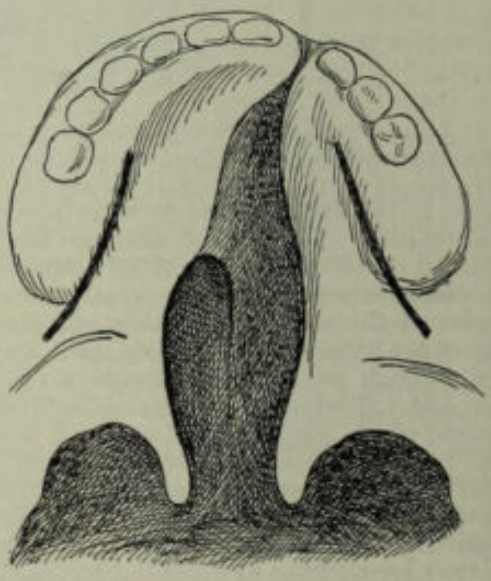


FIG. 728.

FIG. 727.—Cleft of soft and part of hard palate. Shows exact situation in which the lateral incisions should be made (Berry).

FIG. 728.—Semidiagrammatic view of complete left cleft-palate. The septum nasi is attached to the palate on the (patient's) right side. The mucous membrane on the left side of the septum may be detached and brought down if necessary to help in the closure of the anterior half of the cleft. Shows exact situation in which the lateral incisions should be made (Berry).

the antero-inferior portion of the vomer and nasal cartilage of just sufficient size to permit inferoposterior rotation of the premaxilla to its normal position. The base of the triangle removed should be equal to the arc through which the premaxilla is to be rotated. The incision for the submucous removal is made in the mid-

line on the lower border of the vomer just posterior to the premaxilla (Fig. 732). The mucosa is then removed from the sides of the alveolar process on each side so that raw surfaces are brought into a position, and medial pressure is made upon the alveolar processes. A silver wire through the alveolar processes and in front of the premaxilla, as indicated in Fig. 733, holds the surfaces in contact and the premaxilla in position. The philtrum is trimmed to a V shape just within the vermilion borders. Measurements for the incision in the lip are made as shown in Fig. 724. The lip must be freely separated from the anterolateral surfaces of the maxillæ to allow approximation without undue tension and proper formation of the nostrils. The highest sutures must be carefully placed to bring the alæ into proper relation to the septum. To avoid tension on suture lines a stay-suture of silkworm-gut may be passed far lateral on each side and held at desired tension by perforated shot over a button resting on adhesive plaster to give increased surface traction and prevent much cutting of the skin by the suture (G. V. I. Brown method).

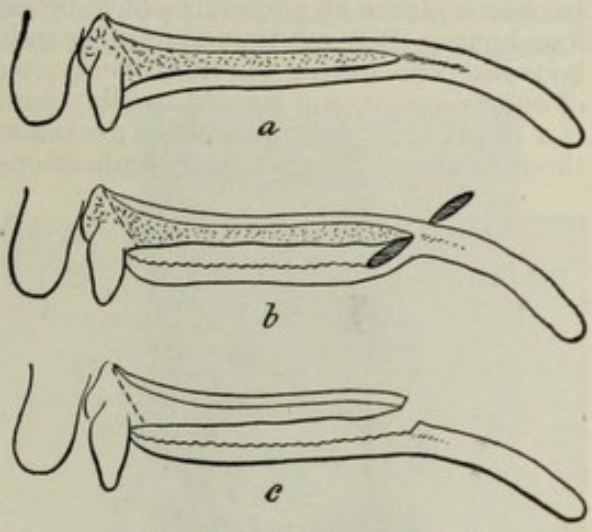


FIG. 729.—Longitudinal vertical section through the hard and soft palates: *a*, Before operation; *b*, palatine mucoperiosteum detached and brought down, blades of scissors introduced to cut attachment of soft palate to the bony palate and to the nasal mucous membrane; *c*, the same after the cut has been made and the soft palate thus brought down (Berry).

Closure of the remaining cleft in the palate we prefer to do by the Langenbeck mucoperiosteal flap-sliding method, as used by Berry. (See Figs. 727–729.) The separation of the mucoperiosteal flaps from the nasal mucosa at the posterior margin of the palate bones is advisable to secure sufficient relaxation at this point. The mucous membrane is carefully removed from the margins of the cleft to secure raw surfaces for coaptation. We prefer to approximate the margins of the flaps with interrupted sutures of 00 silvered wire from the anterior point of the cleft to the junction of the hard and soft palate, at which point *one* on-end silk mattress-suture is used. (The use of multiple mattress-sutures tends to decrease the blood-supply near the suture line and often produces a slough of some of the tissue.) Posterior to the junction of the hard and soft palate we use interrupted black silk sutures. Small iodoform gauze packs placed in the lateral incisions aid in relieving tension and also tend to check any oozing of blood. If the horizontal processes of the maxillæ and the bone are not sufficiently developed to safely hold such a pack, then iodoform gauze tape is passed around both



FIG. 730.—Complete double harelip and double cleft-palate with anterosuperior rotation of premaxilla. Aged three months (Warren B. Davis).



FIG. 731.—Double harelip and cleft-palate with elongation of vomer and anterosuperior rotation of premaxilla, short columella, and philtrum. Aged six weeks (Warren B.Davis).

flaps (Mayo method) and tied at proper tension, using great care that the circulation in the flaps is not restricted by the pressure.

Postoperative Treatment.—In infants water only is given by mouth during the first six or eight hours, then the formula used previous to operation is gradually resumed. In older children an abundance of water only is given by mouth during the first twenty-four hours. Salt solution containing sodium bicarbonate is given by bowel at three-hour intervals during the first twenty-four hours. Small doses of deodorized tincture of opium are given if needed to allay pain and prevent excessive crying. A few drops of a 15 per cent. argyrol solution are placed in the nasal passages with a dropper every three hours. No intraoral applications are made routinely in infants. In older children a warm normal salt solution mouth-wash is *gently* used at three-hour intervals, followed by argyrol application along the suture line and in lateral incis-

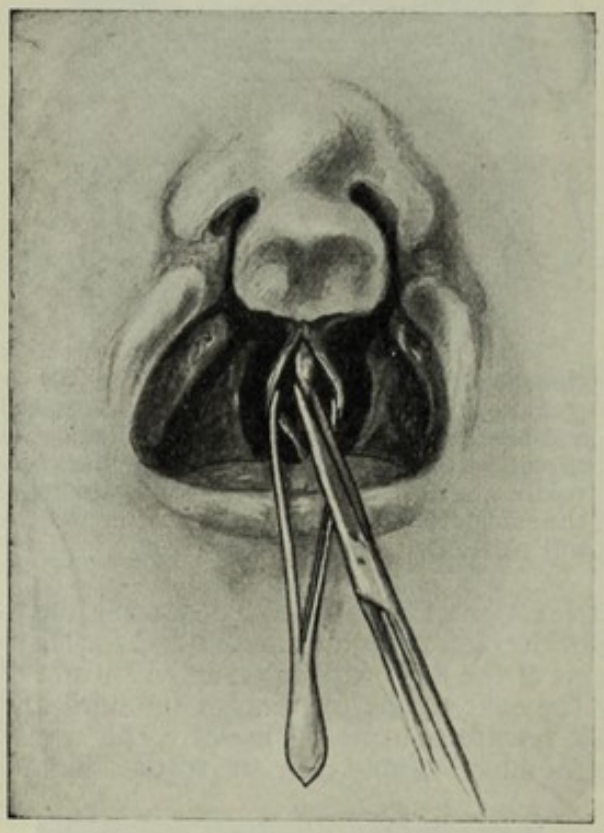


FIG. 732.—Sketch shows position of incision for removal of lower portion of vomer and anterior portion of nasal cartilage by submucous resection. A triangular section of bone and cartilage is removed to allow inferoposterior rotation of premaxilla to its normal position. The length of the base of the triangular piece of bone and cartilage removed is determined by the amount of rotation which the premaxilla requires, and should be such that when the premaxilla comes into proper position the sides of the triangle will be brought together. There will be a bulging of the mucoperiosteum at this point for several days, but the excess tissue soon resorbs.

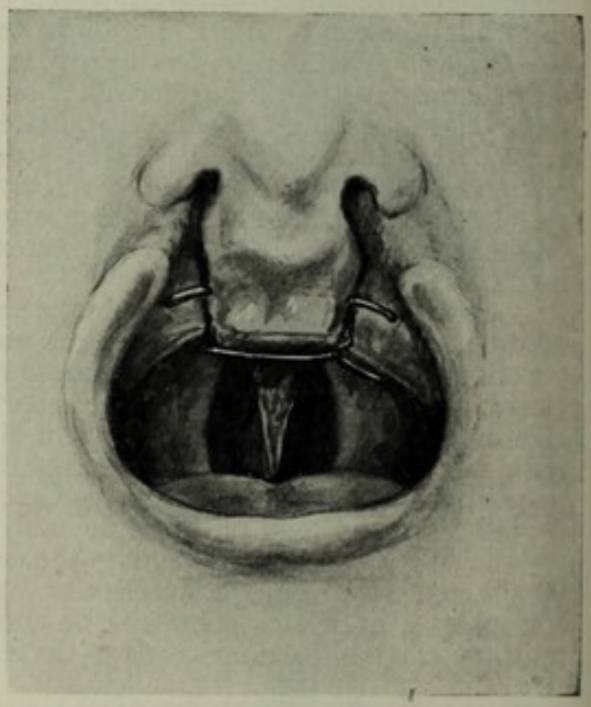


FIG. 733.—After resection of the triangular section of bone and cartilage, as described in Fig. 732, the lateral margins of the premaxilla and the margins of the alveolar process are trimmed to allow accurate approximation of raw surfaces. The silver wire passed through the lateral portion of the alveolar processes, just posterior to the canine area, and carried in front of the premaxilla, passing between the philtrum and the bone, holds the premaxilla in proper position as shown.

ions. In these older cases liquid nourishment is continued for eight days, then semisolid diet is allowed. Solid food is not to be given until after the sixteenth day. Cases having repair of palate properly completed before the twentieth month will have less pronounced speech defects than those done at later periods. Phonation and articulation can usually be improved by instruction from teachers trained in the correction of speech defects.

The teeth of cleft-palate cases require especially good care, since most of them are of poor quality. Many cases require orthodontic care which should begin about the eighth year in order to secure the best functional and cosmetic results.

Carcinoma of the Lower Lip.—Cancer frequently arises in the lower lip, very rarely in the upper lip. Males suffer frequently, but females are not very often

attacked. In some cases it seems to arise in smokers at the point on the lip where the pipe habitually rests. A short-stemmed clay pipe, which grows hot when it is smoked, is particularly apt to lead to the causal irritation. The region of the lip which is most liable to cancer is the junction of the skin and mucous membrane. The growth may begin as a fissure or abrasion, may start in an eczematous area or a wart, but most frequently arises as an indurated area which quickly ulcerates. After a cancer has



FIG. 734.—Squamous cell carcinoma of lip. Man fifty-two (W. L. Clark).



FIG. 735.—Recurrent cancer of lip. Age seventy-five (W. L. Clark).

existed for a variable time the submental, submaxillary, and cervical lymphatic glands become diseased. Some of these glands are usually involved within three months after the beginning of the cancer, but may remain free for seven or eight months. In a case of my own they were found to contain carcinoma cells in less than three months after the origin of the carcinoma of the lip. This involvement cannot be detected by external manipulation in the earliest stages, hence it is not proper to conclude that the glandular involvement is absent simply because it cannot be palpated. In many cases when glands cannot be detected by palpating beneath the jaw they will be discovered by placing one finger in the mouth back of the lower jaw and one finger beneath the chin. It occasionally happens that glands enlarge because of septic absorption, and this enlargement may even precede carcinomatous involvement. From an operative point of view the glands should always be regarded as carcinomatous. If cancer is not operated upon it destroys the lip, extensively involves the glands of the neck, the floor of the mouth, the periosteum and the lower jaw, and produces death in from three to five years. If the jaw is involved the prognosis is bad, and it is almost hopeless if the floor of the mouth is involved.



FIG. 736.—Dr. James A. Kelly's case of epithelioma of lip.

The *treatment* consists in the early and thorough removal of the growth by the knife, and also in the removal of the fatty tissue and glands from the submaxillary triangles, from the submental region, and down to the carotid bifurcation. The growth must be thoroughly removed, that is, the incision must be at least ½ inch wide of the disease. For many years a favorite operation was the V-shaped incision, the skin edges being sutured by silkworm-gut, the sutures being passed almost to the mucous membrane and being inserted so as to compress the vessels when tied, and the mucous membrane being sutured with fine silk or catgut. The V-shaped incision should only be used for a very small and very recent growth. After the removal of the growth from the lip a vertical incision is made from the point of the V over the cricoid cartilage, and, from the origin of this incision, incisions are made in each direc-

tion along the under surface of the body of the jaw. The glandular area is thus exposed, and after the removal of the fat and glands the wound is sutured with silkworm-gut. Far better than the V-shaped incision is the operation devised by W. W. Grant, of Denver.[1] In this operation the growth is removed and cheiloplasty is performed.

Grant's Operation for Cancer of the Lip.—This operation gives a useful mouth and a more natural-looking lip than does the ordinary operation, and there is decidedly

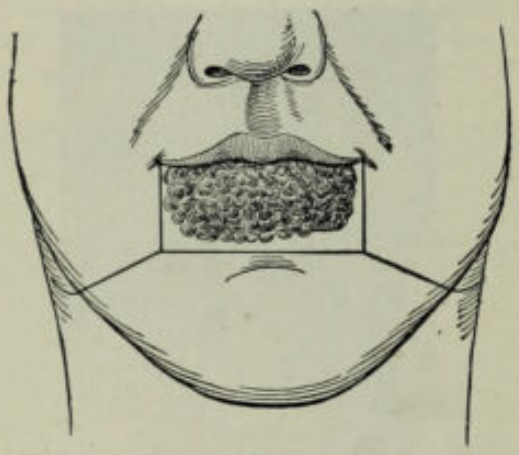


FIG. 737.—Grant's method for removal of carcinoma of the lower lip. The incision.

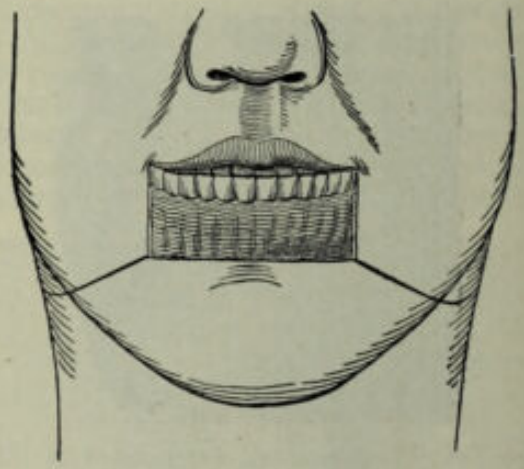


FIG. 738.—Grant's method for removal of carcinoma of the lower lip. Second step. The mass removed.

less tension on the suture line. Furthermore, the suture line in a man is apt to be soon covered with a beard. The procedure has great advantages over the ordinary V-shaped operation, which greatly lessens the size of the mouth, making it what is known as a sucker-mouth, and the new lip is rigid and ugly.

In Grant's operation two vertical incisions are made, one on each side of the growth, and these are connected by a horizontal incision at the base (Figs. 737, 738). Thus, a quadrangular gap is formed, which must be filled by flaps. An incision is

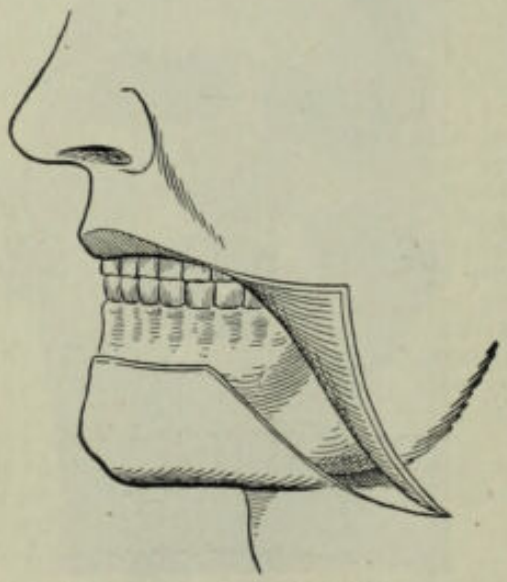


FIG. 739.—Grant's method for removal of carcinoma of the lower lip. Dissection preliminary to suturing.

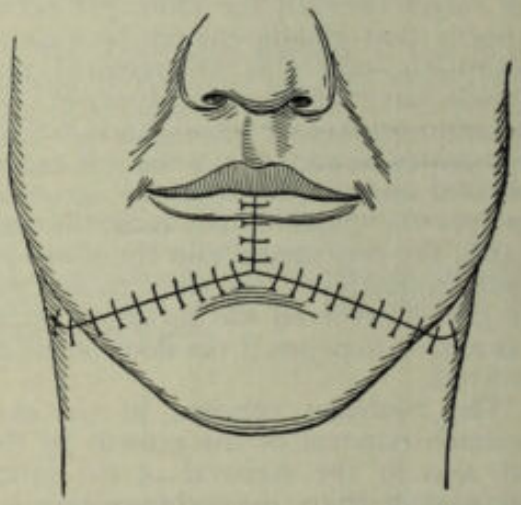


FIG. 740.—Grant's method for removal of carcinoma of the lower lip. The wound sutured.

made on each side from each inferior angle of the wound, obliquely downward and backward beneath the maxilla, on a line about midway between the angle of that bone and the apex of the chin (Fig. 737). Its further extension is determined by the amount of lip removed and by the degree of glandular involvement.

The submaxillary lymph-glands are removed through these incisions. The glands

[1] "Medical Record," May 27, 1899.

in the midline, however, beneath the chin may require a separate incision. If the lip is extensively involved, the cheek ought to be completely separated from the inferior maxillary bone to the middle of the masseter muscle (Fig. 739). When the glands have been removed, the triangular flaps are brought together and united, first of all, in the middle line (Fig. 740). If the tension is marked, owing to the amount of tissue excised, it is wise to insert a traction suture $\frac{3}{4}$ inch from the center line and tie it over pads of gauze covered with muslin. Undue tension upon the sutures in the center of the flap is thus prevented. The stitches that unite the cheek posteriorly are inserted and tied, and the entire thickness of the cheek must be included. Silkworm-gut sutures are used. A drainage-tube is inserted in the posterior angle of the wound on each side. It is very useful to use also a T-drainage-tube as advised by Grant. This tube is about the diameter of a lead pencil and the cross-piece rests behind the incisor teeth or symphysis and beneath the tip of the tongue. It drains away all of the mouth secretions, saves the lines of incision from being constantly bathed in them, and renders very frequent changes of dressing unnecessary.

I have employed this operation repeatedly, and regard it as the most useful method we have for the purpose. Thorough removal of the carcinoma of the lip and of the related glands will cure from 70 to 90 per cent. of cases. After an operation the *x*-rays should be used to antagonize recurrence.

The glands should be removed in all cases operated upon. If the lesions on the lip and the glands are removed and the glands show no metastasis, Bloodgood obtains 95 per cent. of cures, setting the five-year limit as a cure ("Surgery, Gynecology, and Obstetrics," 1914, xviii). Bloodgood shows that when the lip lesion is removed but the glands are left there are 37 per cent. of recurrences in the glands. In this stage not over 20 per cent. of operations will secure a cure.

Operations for recurrence give but 10 per cent. of cures. If the bone is involved, cure is rare; if the floor of the mouth is involved, cure is practically never obtained.

So-called Carbuncle of the Upper Lip.—In contrast to carbuncle in other regions of the body, facial and labial carbuncles are most common in young persons. Carbuncle of the lip is due to staphylococcus infection and begins as a papule, but is not a true carbuncle. Numerous pustules appear, and sloughing usually takes place. There may or may not be serious constitutional involvement. The condition is very dangerous, as thrombophlebitis may arise and track up into the cranium by way of the ophthalmic vein and cavernous sinus. I have known 2 persons to die from carbuncle of the lip.

Treatment.—Excise if possible. If excision is impossible, make a crucial incision, cutting away the skin corners and edges with scissors and dividing the venous connection with the cranium. Scrape out the carbuncle with a sharp and strong curet, swab with pure carbolic acid, pack with iodoform gauze, and dress with antiseptic poultices.

Tongue-tie (*congenital ankyloglossia* or *adherent tongue*) is congenital shortness of the frenum, the tip of the tongue adhering to the floor of the mouth. It is due to the projecting portion of the tongue being incompletely developed from the tuberculum impar. "In many of the slighter cases the development has merely lagged behind and will be completed as the child grows after birth" ("Diseases of the Tongue," by Henry T. Butlin, Second Edition). The tongue cannot be protruded beyond the incisor teeth. Swallowing is interfered with, and later in life articulation is impeded. It is not very unusual in infants, but in the great majority of cases disappears as the child grows older. Persisting tongue-tie, Butlin says, is one of the rarest of conditions, and my experience is in absolute accord with his—in fact, I have never seen a single case. Many unnecessary or even harmful operations are done for a condition which, if let alone, will usually correct itself. Improper operation may result in fatal hemorrhage or in "swallowing of the tongue." The operation usually done is to tear up the frenum with a thumb-nail. This is unsurgical and makes a lacerated wound. A better way is to raise the tip of the tongue to make the bands tense, and then snip with the scissors close to the mucous membrane of the lower jaw. The slit in the handle of the grooved director was placed there to catch the frenum in, but a short frenum will not enter it (Butlin).

Tuberculosis of the Tongue.—This is rather a rare trouble, although Durante was able to collect 250 cases from literature and to report 5 cases ("Annals of Surgery," 1916, lxiii). The tongue, being a muscle, resists tuberculous infection, as does all muscle, and it is not easy for the bacilli to pass through the epithelial covering. The lesion is never found in infancy and is most common between the twentieth and fiftieth

years, and is met with far oftener in men than in women (Durante, Ibid.). It is predisposed to by irritation or injury of the mucous membrane. In the great majority of cases the lesion is secondary to distant tuberculosis, especially the pulmonary form, but primary tuberculosis is occasionally found. Durante (Ibid.) asserts that in a primary case the infection is hematogenous.

In one type of the disease an elevated, gray, uninflamed induration forms in the mucous membrane. There may be multiple lesions (miliary tuberculosis of the tongue). Nodular tuberculosis arises in the tongue parenchyma.

Ulceration may be early or late. The edges of the ulcer are irregular, reddish in color and non-indurated, and the floor is yellowish (Durante, Ibid.). I recently saw an indurated tuberculous ulcer which was thought to be cancer. Any part of the tongue may be attacked, but the tip is most apt to suffer. The glands under the jaw on each side enlarge and become tender. Diagnosis is difficult. To mistake it for cancer is a grave misfortune, as cancer calls usually for amputation of the organ. In very few cases can the bacilli be found. Always take a section and have it studied by the pathologist. In every doubtful case make the therapeutic test for syphilis, which is the administration of salvarsan. Primary cases give a favorable, secondary cases an unfavorable, prognosis. The treatment is destruction by the high-frequency current.

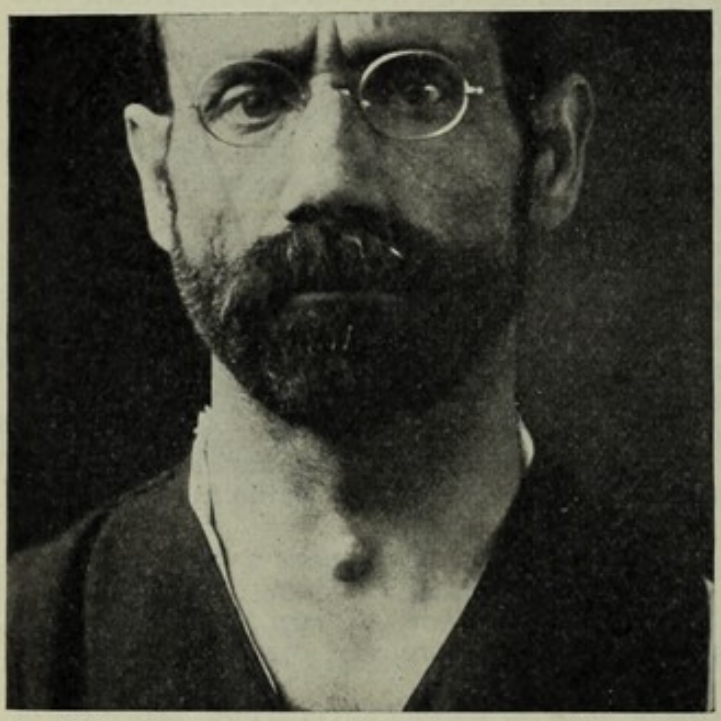


FIG. 741.—Author's case of thyroglossal cyst (three futile operations).

Thyrolingual or Thyroglossal Cysts and Sinuses.—In early embryonal life the thyroid gland has a duct which passes from the thyroid isthmus or a thyroid lobe to the foramen cecum of the dorsum of the tongue. The duct may be lined with one layer, two layers, or several layers of epithelium, and there are mucous glands and lymph-follicles in its walls, these structures being derived from the mucous membrane of the tongue. The wall of the duct presents numerous irregularly placed and irregularly shaped diverticula. It is known as the thyroglossal or thyrolingual duct. The duct runs from the base of the tongue down the midline of the neck. It is connected with the body of the hyoid bone, with the periosteum in front of the bone, and with the thyrohyoid bursa behind the bone. It passes to the upper portion of the front surface of the trachea, where it may bifurcate, each branch passing to a lateral lobe of the thyroid gland. This fetal structure under normal conditions begins to atrophy in the fifth week and closes by the eighth week, the foramen cecum marking its old orifice on the dorsum of the tongue. When the duct is obliterated it becomes a cord of epithelium. In more than 30 per cent. of bodies the remains of this primitive passage can be found (Weglowski in "Zentralb. f. Chir.," 1908, xxxv, 289). The duct may persist between the foramen cecum and the hyoid bone, developing, it may be, into a *sublingual dermoid*. The portion behind and below the hyoid may remain and develop into a *subhyoid cyst*. The part inferior to the hyoid may persist, give origin to a cyst which ruptures, and constitutes an *incomplete cervical fistula*. The duct may remain open from the mouth and make, by bursting an opening into the neck, a *complete cervical fistula*. A patent duct may exist for years and announce its existence by some acute inflammatory process. In a great majority of cases a fistula or a cyst is in the middle line (median cervical fistula). In a few when low down it is a little to the side, usually the left. The small diameter of a cervical fistula renders probing to any depth impossible. Some have told us to determine if a fistula is complete by injecting quassia solution into the lower end. The patient will perhaps experience a bitter taste. If we inject a colored fluid we may see it if it runs from the

mouth. I have never succeeded in doing either. Tumors may spring from the duct.

Treatment.—If a thyroglossal cyst or tumor arises on the dorsum of the tongue, and if it is increasing in size and interferes with swallowing and speech, it must be removed through the mouth. A general anesthetic should be given. In some cases preliminary tracheotomy is necessary.

A cyst, tumor, or fistula about the hyoid bone requires excision, the patient being under the influence of a general anesthetic. A portion of the cyst wall adheres strongly to one of the surfaces of the hyoid bone and must be carefully removed even if it be necessary to split the bone to accomplish it. In treating fistula the surgeon injects the tract with methylene-blue and makes an elliptic incision of the skin about its orifice so as to free the fistula from the subcutaneous tissue. When traction is made upon the cutaneous end of the duct it will stand out clearly and can be dissected out (M. S. Seelig in "Surg., Gynec., and Obstet.," May, 1907). It is useless to try to cure a fistula by cauterization. A fistula requires the complete removal of its epithelial-lined walls. No lesser operation will cure. In 1 case I operated four times before securing success. In another case I divided the hyoid bone, removed the fistula, sutured the bone by chromic gut, and obtained a cure.

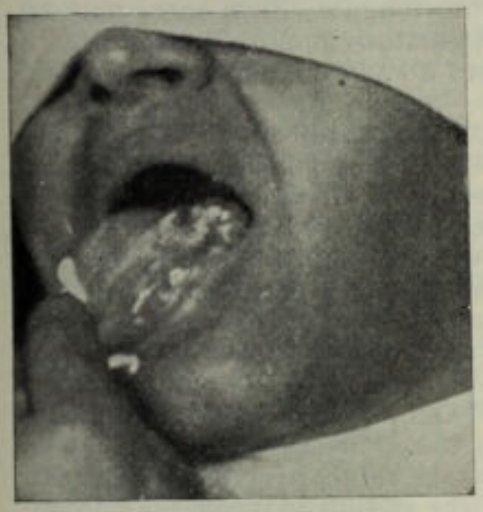


FIG. 742.—Squamous-cell carcinoma of tongue. Man of fifty (Dr. William L. Clark).

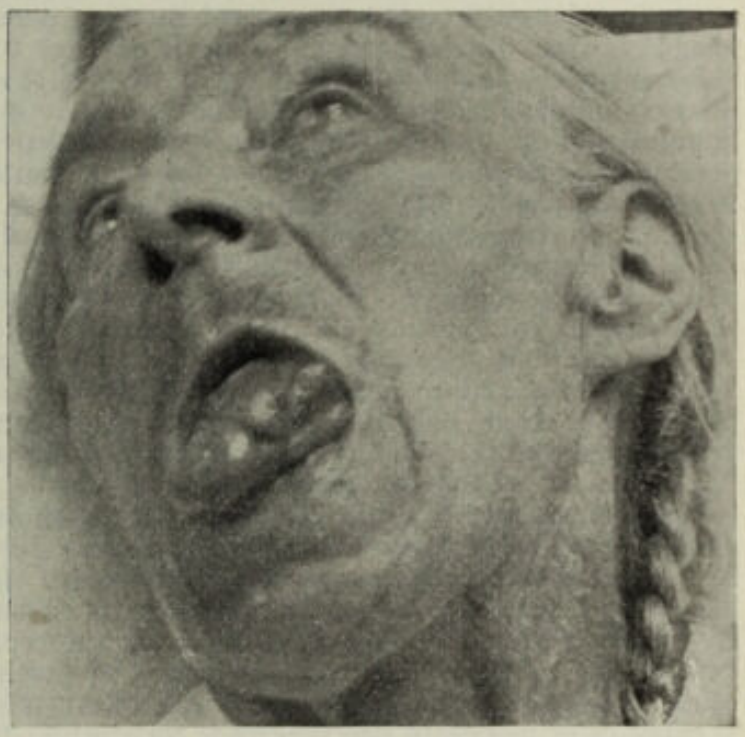


FIG. 743.—Dr. Le Conte's case of epithelioma of the tongue.

Carcinoma of the Tongue.—This is one of the most dreadful forms of cancer. It is quite a common disease. For a time it may grow slowly, but sooner or later it takes on very rapid growth. In most of the cases I see it is far advanced when first brought to the hospital. Almost without exception cancer of the tongue is composed of squamous-cells, but columnar-cell growths have been reported. It is much more common in men than in women. It is a disease of adult life and is very rare before the age of thirty-five. The period of greatest liability is between the ages of forty and sixty. Only 30 cases are recorded in those of less than thirty years of age ("Collective Review in Internat. Abstract of Surgery," Feb., 1916, by Vilray Papin Blair). It begins, as a rule, near the tip, on the side or at the base of the anterior two-thirds of the tongue, as a warty growth, as an ulcer having at first a papillary structure, as a fissure which indurates, or as an indurated area which ulcerates. The cause of the growth may sometimes be traced to the irritation of a jagged tooth or an ill-fitting plate, or to the smoking of a pipe, or to holding nails in the mouth, as is done by those who nail laths. Abbe states the case against tobacco very strongly and claims that 90 per cent. of cases of cancer of the tongue result from the use of tobacco and only 10 per cent. from a jagged tooth ("New York Med. Jour.," July 3, 1915). Cancer may follow a chronic inflammation—leukoplakia, for instance. Chronic ulcers are liable to become cancerous and any indurated ulcer has potentialities of deadly peril

and should be removed promptly. Syphilis predisposes to cancer, especially if leukoplakia arises. It is highly probable that leukoplakia is due to syphilis. Fournier regards syphilis as an influential cause, and states that in 184 cases of cancer of the mouth or tongue 155 had had syphilis. There has been no such proportion of syphilitics in my personal cases. In Whitehead's 104 cases only 7 had had syphilis. In most cases the disease spreads rapidly; produces early and extensive glandular involvement; disease of the floor of the mouth; dribbling of saliva; difficulty in masticating, swallowing, and talking; foulness of the breath; severe pain which is apt to radiate toward the ear and is certain to if the base of the tongue is involved. Fatal septic trouble may arise at any time. Cases not operated upon usually die in much less than two years. Wölfler described a very rare form of carcinoma, which grows very slowly or even remains latent for years.

One reason why cancer of the tongue grows so rapidly has been pointed out by Heidenhain, of Greifswald. The lingual muscles are contracting almost constantly and as a result cancer-cells are forced along the lymph-spaces to healthy areas. In advanced cases the diagnosis is easy. In early cases it may be very difficult. Early cases are the only curable cases and in them correct diagnosis is imperative. The diagnosis from tuberculosis is set forth on page 914. A positive Wassermann test does not prove that the ulcer is syphilitic. It is well known that cancer may arise from syphilitic lesions. It is necessary in every doubtful case to take a section for examination and to apply the therapeutic test (salvarsan or mercury and the iodids).

The superficial ulcer of a broken-down gumma affects the mucous membrane. It is small, indurated, has perpendicular edges, and is covered by a white and adherent slough. It is most common on the edge or tip of the tongue. Such sores may be multiple and are usually at least bilateral. A parenchymatous gumma begins beneath the mucous membrane. When it ruptures it exposes a cavity lined by slough and surrounded by induration.

The results of operation have improved much of late, probably because cases are brought earlier and operations are more thorough. Up to very recent years surgeons were able to obtain only 10 to 15 per cent. of recoveries (cases which passed three years without recurrence). Johns Hopkins Hospital now reports 50 per cent. cured.

Treatment.—A cancer of the tongue should be removed radically at the earliest possible moment. Specific treatment for diagnostic purposes should not be continued beyond a very few weeks. In doubtful cases a Wassermann test is made, and if it is positive, salvarsan is given intravenously. If still in doubt as to the nature of the growth, remove a section and have a pathologist at hand to study it immediately by frozen sections (Warren in "Annals of Surgery," Oct., 1908). Have permission beforehand to proceed at once to radical operation if conditions demand it. The study of a small section is always of somewhat uncertain value, hence, if the growth is small or of moderate size remove it for study. If the growth is larger take a considerable piece for study. This piece must include a part of the floor and the edge of ulcer and of apparently sound tissue beyond the ulcer. An ulcerating, warty, or indurating lesion of the tongue requires removal. If it is not cancer it will be apt to become cancerous. Before any operation is undertaken all stumps of teeth should be extracted and a dentist should clean tartar from the teeth. During several days preceding an operation the teeth should be scrubbed twice a day with a brush and Castile soap and the mouth rinsed with hydrogen peroxid. The nares and nasopharynx should be sprayed with peroxid of hydrogen and then with boric acid solution every second or third hour when the patient is awake.

In some cases the entire tongue is removed; in some, half of it; in some, only a piece of it. Not only the diseased tongue but also the adjacent lymphatic glands must be removed. Cancer of the tip of the tongue, as a rule, involves the submental and sublingual groups of glands early. Cancer of the anterior two-thirds of the dorsum of the tongue first involves the lingual, submaxillary, and superficial cervical lymph-nodes. Cancer of the under surface of the tip of the tongue first involves the submaxillary glands. Sooner or later the superior deep cervical glands about the carotid bifurcation become involved as a result of cancer of the tip or edges of the anterior portion of the tongue. In cancer of the dorsum the deep cervical glands finally become involved as well as the superficial nodes. The lymphatic system of the base of the tongue is distinct from that of the balance of the organ. It drains into the deep cervical groups.

It was formerly my belief that in a very recent and limited case only the glands on the diseased side required removal, but that in an advanced case the glands should be removed from *both sides* of the neck. Experience has convinced me that in any

case the glands on both sides should be removed. Kuttner, of Tübingen, has demonstrated that lymph from one side of the tongue may flow to glands on the same side of the neck, but some also may flow to the opposite side of the tongue. Remove the obviously involved glands by the *block dissection* of Crile. In a bad case everything is removed but the carotid arteries. The sternocleidomastoid muscle, the omohyoid, the jugular vein, even the pneumogastric and phrenic nerves of one side may be taken away. After a week or two the other side of the neck should be operated upon. It seldom requires a wide removal of structures. If the pneumogastric or phrenic were cut on one side it must be preserved on the other. The jugular vein can be removed after a collateral circulation has been established subsequent to removing the jugular of one side. Two operations are to be considered—partial removal and complete removal.

Partial Removal of the Tongue.—This operation is restricted to recent cases in which one side only of the anterior portion of the tongue is involved. The operation does not offer so good a chance of cure as complete excision, because lymph containing cancer-cells may have reached the opposite side of the tongue. Even in partial removal the glands should be removed from both sides. Intratracheal anesthesia is employed.

In performing the operation of partial excision introduce a mouth-gag, pass a silk ligature through each half of the tip of the tongue, and draw the organ out of the mouth. Place the patient recumbent with the head a little raised. Split the tongue back in the middle line by the scissors, and loosen the cancerous side from the floor and side of the mouth. Pass a stout silk ligature through the base of the tongue posterior to the cancer. Draw the organ out and cut off the diseased side in front of the ligature, but well back of the disease. Tie the vessels, remove the traction threads, and treat subsequently as in cases of complete removal.

Complete Removal of the Tongue (Kocher's Method).—Kocher recommends a preliminary tracheotomy in tongue excision, but the Trendelenburg position renders this procedure unnecessary so far as fear of the passage of blood into the larynx and trachea is concerned. I have operated many times with the patient in that position. At present I operate with the head a little raised and the patient taking ether by intratracheal insufflation. Because of the insufflation there is no respiratory difficulty and the stream of escaping air and ether keeps blood out of the bronchial tubes. The method is most satisfactory. The surgeon stands to the side. Ligate the lingual artery on the side opposite to the one where the main incision is to be made. Remove the glands on that side and suture the wound.

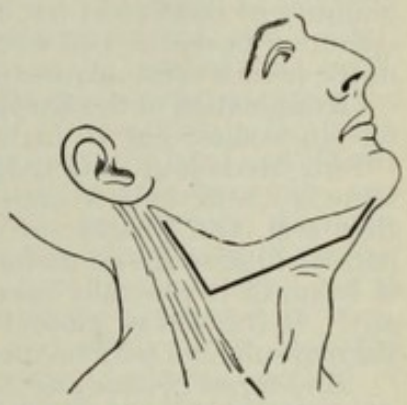


FIG. 744.—Kocher's excision of tongue (Esmarch and Kowalzig).

An incision is then made on the side opposite to that on which the artery was ligated. This incision passes from behind the lobe of the ear, along the anterior edge of the sternocleidomastoid to about the middle of the margin of this muscle. From this point the incision is carried to the level of the hyoid bone and then to the symphysis menti, along the anterior belly of the digastric muscle (Fig. 744). The flap is dissected and turned up; the facial and lingual arteries are ligated; "the submaxillary fossa is evacuated" (Treves); the sublingual and submaxillary glands are removed; the mylohyoid muscle is divided; the mucous membrane is incised close to the jaw, and the tongue, caught by tenaculum forceps, is drawn through the opening. The tongue is split in the middle by scissors, and the near half is removed, bleeding is arrested, the remaining half of the tongue is cut through, and the vessels are tied. Stitch the mucous membrane of the stump to the mucous membrane of the floor of the mouth with catgut sutures. Kocher does not suture the skin wound. I prefer to suture it and employ drainage-tubes. I follow the suggestions of Treves as to after-treatment. Some hours after the operation, when oozing has ceased, dust the mouth wound with iodoform. The patient, as soon as possible, is propped up in bed, and he must not swallow the discharges if it can be avoided. The mouth, every half-hour, is sprayed with peroxid of hydrogen and washed with diluted alcohol. Every three hours, after washing the floor of the mouth and the stump, the parts should be dried with absorbent cotton and dusted with iodoform. For twenty-four hours after the operation nothing is to be given by the mouth except a little

cracked ice, the patient being fed by rectum. At the end of twenty-four or forty-eight hours some liquid food is given from a feeding-cup. The patient will soon learn to swallow; but if he cannot swallow easily, he is fed by a tube. Treves, in his clear and positive directions for after-treatment, states that nutrient enemata are to be continued until sufficient nourishment is taken by the mouth; that the mouth should be flushed by irrigation, and must be washed immediately after taking food; that morphin is to be avoided, and that the patient can usually leave the hospital in from seven to ten days.

Whitehead's Operation.—Whitehead removes one-half of or the entire tongue from within the mouth by the use of scissors. He passes a ligature through the tip, cuts the frenum, draws the tongue strongly forward, and separates by a series of clips with the scissors. The lingual arteries are tied as cut. "The stump should be kept under control, as regards hemorrhage, by a stout silk ligature passed through the remains of the glosso-epiglottidean fold and retained for twenty-four hours."[1]

Heath has shown that if the forefinger be passed to the epiglottis and used to "hook forward" the hyoid bone, the lingual arteries are stretched and portions of the tongue can be removed almost without bleeding. It is rarely desirable in Whitehead's operation to remove the glands and the tongue at one séance. To do so increases shock and the danger of death. The rule of procedure set forth by Sir Watson Cheyne[2] is eminently wise. This rule is as follows: If glandular involvement is trivial or not detectable, it is perfectly proper to remove the tongue first, and after a week or so remove the glands. If the glandular involvement is marked, growth in the glands will be much more rapid than growth in the tongue. In such a case the glands should be removed before the tongue, because, if the tongue is removed before the triangles are cleared, in the week or two of waiting the case may become inoperable. In the majority of cases clear out the triangles before removing the tongue, doing the other operation in one or two weeks when the wound in the neck is healed. If the disease in the mouth is far advanced, do both operations at one séance.

Examination of the Esophagus.—The *x*-rays are of great value not only in detecting foreign bodies, but in finding carcinoma, pouches, and constrictions. As Waggett ("Brit. Med. Jour.," Oct. 19, 1912) says, by means of the *x*-rays we may learn that there is a stricture (or are strictures), where it is (or they are), how narrow it is (or they are), and whether or not there is extrinsic pressure. In this examination the patient first swallows material through which the rays pass with difficulty. A salt of bismuth is generally used. The carbonate of bismuth is a safe and satisfactory salt. It is given in glutoid capsules (Kohler in "Brit. Med. Jour.," Oct. 19, 1912). Barium sulphate may be used instead of a bismuth salt.

Esophageal Sounds and Bougies.—These instruments were long our only mechanical means of diagnosis. They are used far less than formerly. They possess certain dangers. For instance, if an aneurysm exists and we are misled into believing that the condition is stricture, the rigid sound and even the flexible bougie may penetrate the sac of the aneurysm and cause death. I have personal knowledge of such a case. If a person has ever brought up blood, neither a sound nor bougie should be used. Again, neither the bougie nor sound can prove the existence of a slight stricture. They give no information at all as to the nature of a stricture. I find their greatest diagnostic use is to locate the situation of a constriction before passing the esophagoscope. In view of the fact that such an examination may cause bleeding, and that blood interferes with an examination by the esophagoscope, the bougie or sound, if used at all, should be employed the day before the introduction of the esophagoscope. The development of Roentgen-ray diagnosis has rendered even this use of the bougie unnecessary.

The olive tip flexible bougie is made from elastic web. It is a safer instrument than the sound with a hard bulbous tip (see Fig. 683, E). The latter has a series of removable ivory or metal tips which vary in size. Used diagnostically, the olive tip bougie imparts information only as it enters; the bulbous sound, as it enters and as it is withdrawn. On withdrawing the bulbous sound it may catch upon the lower border of a constriction which it passed on entering.

Before being passed the bougie or sound should be warmed and greased with glycerin. The patient sits in a chair and throws the head well back against the breast of an assistant. The mouth is opened widely and is held open by a large cork or by a gag. The patient is directed to breathe deeply and regularly while the instrument is being

[1] "American Text-book of Surgery."
[2] "The Practitioner," April, 1899.

passed. Depress the tongue with the finger and carry the instrument beyond the glottis. As it reaches the back of the pharynx the patient will gag and choke. Tell him to swallow and breathe regularly. The fact that he can breathe regularly shows that the instrument is not within the larynx. It may then be gently urged along the gullet. All maneuvers are to be conducted with the utmost gentleness. Force means danger. Trousseau said that sooner or later all patients with stenosis of the esophagus died of the bougie.

Remember that in an adult the esophageal orifice is 5 or 6 inches from the incisor teeth, that the esophagus has a length of from 9 to 10 inches, hence, that the cardiac orifice of the stomach is from 14 to 16 inches from the incisor teeth (Maylard's "Surgery of the Alimentary Canal"). It is further important to remember that the normal esophagus is of smaller caliber in some regions than in others. There are four points of physiologic narrowing, viz.: On a level with the cricoid cartilage, where it is crossed by the aorta, where it is crossed by the left bronchus, and where the tube passes through the diaphragm.

Auscultation may enable the surgeon to hear the food bolus rub against a stenosis and to note delay in the passage of liquid. Fluid normally passes in four seconds.

The Esophagoscope.—This instrument is of the highest value, a value just beginning to be properly appreciated. It is not altogether free from danger. Deaths have occurred from it. The mandrel does the harm, and should not be used at all or should be withdrawn as soon as the tube has passed the cricoid constriction. The rest of the way the instrument is carried along while the surgeon is looking through it and seeing what is ahead. It is not carried into a constriction; it is not carried by an ulcer or a pulsating lump. It enables us to make diagnoses otherwise impossible, to diagnosticate cancer in an early stage, to treat local conditions, and to remove a fragment of tissue for examination. I prefer to pass the instrument without general anesthesia even in children, and highly nervous people, unless there is very severe spasm. Until I watched Jackson work it was my custom to apply cocain to the back of the tongue, pillars of the fauces, epiglottis and pharynx, and to place the patient on the right side with the head thrown back. This is known as *Starck's position*, and, as Gottstein shows, it relaxes the diaphragmatic crura. An assistant supports the head and follows every movement of the surgeon. The patient is cautioned to breathe tranquilly, and is told if the pain or annoyance becomes intolerable to raise his left arm, when the surgeon will cease for a time. The surgeon must, of course, keep his word on this point. Artificial teeth are removed. The instrument is kept in the midline and is inserted as is a sound or bougie. As soon as it passes the cricoid narrowing the mandrel is withdrawn, and the instrument is passed slowly and gently along while the surgeon is looking through and ahead of it. For Chevalier Jackson's method of esophagoscopy see page 868. His work is a masterpiece which combines knowledge, dexterity, gentleness, and psychical control of the patient.

The cervical esophagus is closed and seems to unroll before the instrument. The thoracic esophagus is open, and when the esophagoscope enters into the upper part of this region, if the gullet is normal, the surgeon can see all the way down to the diaphragm. At the diaphragm the esophagus bends forward and to the left and this point must not be mistaken for the cardia (Kohler in "Brit. Med. Jour.," Oct. 19, 1912).

The cardia may be found closed or may be seen to open and close with respiration. This instrument is of enormous value in the extraction of foreign bodies, in the diagnosis and treatment of many esophageal diseases, and in the diagnosis of certain periesophageal conditions. Every surgeon should be able to use the esophagoscope. (See Gottstein in "Keen's Surgery," vols. iii and vi; Waggett in "Brit. Med. Jour.," Oct. 19, 1912; Kohler in "Brit. Med. Jour.," Oct. 19, 1912; "Reports of Eightieth Meeting of the British Medical Assoc.," July, 1912; Lewisohn in "Annals of Surgery," Jan., 1913; "Bronchoscopy and Esophagoscopy," Chevalier Jackson, Text-book, W. B. Saunders Co., 1923.) For Chevalier Jackson's directions as to the use of the esophagoscope see page 868.

Stricture of the Esophagus.—*Fibrous* or *cicatricial* stricture or scar of the esophagus is due to the healing of an ulcer, and results from traumatism, chronic inflammation, scarlet fever, syphilis, tuberculosis, chronic ulcer, prolonged vomiting, variola, gout, or to swallowing a corrosive substance or a boiling liquid. In about 15 per cent. of cases of scarlet fever there is inflammation of the esophagus and larynx and stricture may result. Fibrous stricture is commonest in the young, and is apt to be situated opposite the cricoid cartilage, at the tracheal bifurcation or near the cardiac end.

Cicatricial strictures, except when due to boiling or corrosive liquid, are usually single, but may be multiple. A cicatrix may be of irregular shape, may be cylindric, may be annular, may be narrow, or may be broad. Stricture following impaction of a foreign body is located at the seat of impaction unless the tube has been injured by efforts at extraction, in which case multiple strictures may exist (Maylard). Strictures which result from swallowing boiling fluid or corrosive liquid are usually very extensive, may be multiple, and give early symptoms. In some cases they are slight and may not give symptoms for years after the injury. Syphilitic stenosis is due to the healing of a gummatous ulceration, but there is nothing characteristic in this kind of stenosis. Tuberculous stenosis is extremely rare. The esophagus above an extensive scar is usually dilated.

Many cases of stricture in children result from swallowing a caustic alkali (commercial lye). Clerf reports 20 cases admitted during sixteen months to the bronchoscopic clinic in the Jefferson Hospital.

In all these cases lye had been carelessly left within reach of the child or had been taken down from a shelf in mistake for something else. Occasionally a residue had been allowed to remain in a cup employed to measure lye. Unfortunately, as Clerf says, lye is sold without a poison label. There should be adequate legislation to secure the use of "scare labels."

Symptoms of Cicatricial Stenosis.—The condition is most common in youth, but may begin at any age. The chief symptom is difficulty in swallowing, at first slight, but becoming more and more pronounced until swallowing is almost or quite impossible. The dysphagia is first manifested to dry solids, then to all solids, and finally to liquids. In some cases vomiting occurs after swallowing. If the stricture is high up, the vomiting is almost immediate; if it is low down, the vomiting is delayed, especially if the canal is dilated above the stricture. From time to time the patient vomits independently of taking food, the ejected matter containing no gastric juice, merely saliva and mucus which have gathered in the dilated gullet above the scar. The vomited matter is not bloody. The patient feels weak, hungry, and thirsty, becomes exhausted and emaciated, and suffers from flatulence, gastralgia, and constipation.

There is occasionally slight uneasiness or even pain in the region of the stricture, possibly "about the epigastrium or between the shoulder-blades" ("The Surgery of the Alimentary Canal," by Maylard). If there is certainly no aneurysm and if blood has never been brought up, the flexible bougie may be used first and then the solid tipped sound, in order to find a stricture. The stricture may be located by auscultation over the spine on a line with the supposed obstruction. While a patient is swallowing water, the arrest of the fluid at the seat of stricture may be audible. Even if the fluid passes, it will be delayed for a time and the duration of deglutition is thus prolonged. In order to determine the time of deglutition put the ear just below the angle of the left scapula, or else between the left sternocostal margin and the xiphoid cartilage, place a finger on the patient's Adam's apple, and hold a watch in the other hand. Have the patient take a drink of water. Count the time from the moment the Adam's apple begins to rise until the fluid is heard to gurgle into the stomach (Ogston's method). It ordinarily requires four seconds for fluid to pass from the mouth into the stomach (Maylard, Ibid.). The *x*-rays are used to diagnosticate stricture and to locate it. They are valuable in diagnosis. An emulsion of bismuth or barium sulphate is swallowed and a skiagraph is taken. The metallic salt is seen on the plate as a black mass extending above the seat of constriction (Fig. 745). A fluoroscopic examination shows the bismuth or barium through a constriction. A bougie can be passed until it reaches the block and a skiagraph may be taken with bougie in position.

In a case reported by Seelig ("Surgery, Gynecology, and Obstetrics," Sept., 1908) the patient was directed to swallow a fine gold chain as thick as ordinary wrapping twine. The chain was about 2 feet long. If a diverticulum exists the chain will fill the sac and a skiagraph will show the position of the diverticulum. If no diverticulum exists the plate will show the chain nearly in the middle line of the body. The esophagoscope should be used (see page 868). If a skilled esophagoscopist is available all other diagnostic methods, except the *x*-ray, are superfluous.

The history of the case is of much importance in diagnosis. The surgeon must inquire about impaction of a foreign body, or swallowing of acids, alkalies, or boiling fluids; and must examine for evidence of syphilis. If there is no history of injury, syphilis, tuberculosis, scarlatina, variola, or prolonged vomiting, and the patient is over forty years of age, the indications point to cancer rather than to cicatricial

stenosis. The easy passage of a bougie when the patient is anesthetized shows that spasm is the cause, and not organic disease. Narrowing due to external pressure (*compression stenosis*) is marked by positive symptoms of the causative disease.[1] Compression stenosis may arise in goiter, vertebral growths, enlargement of the heart, glandular enlargement, peri-esophageal abscess, aneurysm, lordosis, and mediastinal tumor (Kohler in "Brit. Med. Jour.," Oct. 19, 1912).

Treatment.—Thiosinamin is given by some physicians, but I have never seen it accomplish the slightest good. Telleky[2] recommends it in old scars without inflammation. He makes a 15 per cent. alcoholic solution and injects from ½ to 1 syringeful at a dose, throwing the fluid beneath the skin between the scapulæ. He uses twenty doses in the course of two weeks. *Gradual dilatation* through the mouth is a method employed for at least a time in almost every case. It is the method of choice when it can be carried out, and usually it can be carried out. To accomplish blind dilatation begin with the largest flexible bougie which will easily pass. Warm the bougie, oil

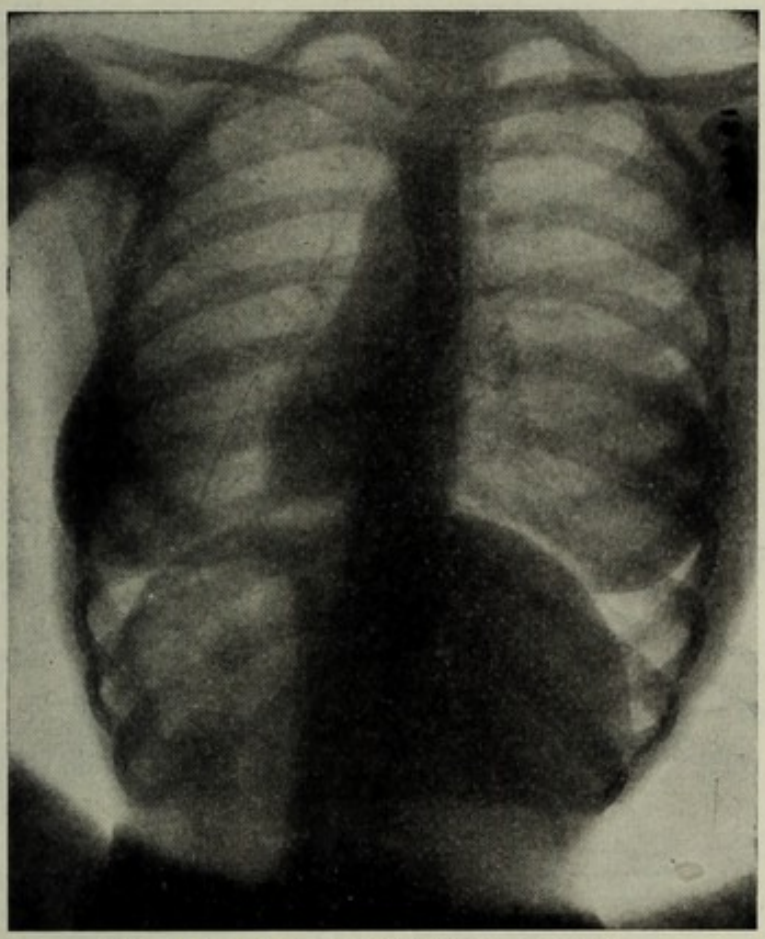


FIG. 745.—Cicatricial stricture of esophagus.

it, pass it gently, and hold it in position for several minutes, prolonging the time of retention of the bougie as treatment progresses. Pass an instrument every second or third day, gradually increasing the size. Chevalier Jackson is impressed with the danger of blind dilatation. He inaugurates dilatation by using instruments through the tube of the esophagoscope. Plummer ("Northwestern Lancet," Jan. 15, 1912) dwells on the danger of using bougies, especially in cancerous constriction, and advocates the use of the string guide of Mixter in tight or tortuous stenoses. Mixter's plan is to have a patient put a piece of cord on the back of the tongue and swallow it while drinking water. The string may thus be floated through the stricture. Plummer proceeds as follows: He takes a spool of buttonhole twist and inserts a safety-pin so as to make a reel. He unwinds the thread, marks it with black ink at intervals of 1 yard, rewinds it, takes a few inches of the free end of the thread, moistens it, places it on the back of the patient's tongue, and gives the patient a swallow of water. The patient is directed to swallow 2 or 3

[1] See the valuable article in Maylard's "Surgery of the Alimentary Canal."
[2] "Wien. klin. Woch.," Feb. 20, 1902.

yards before bedtime, "and an equal amount at the rate of a foot an hour the following forenoon." The first portion, in a state of snarl, enters the intestine during the night. By afternoon the thread may be rendered taut by pulling upon it; yet it will not be pulled out. The thread may remain in place for some time, dilating the stricture. It may be used as a guide to direct a bougie through a tight or tortuous constriction, the eyed bougie being threaded upon the strand (Plummer in "Collected Papers of the Mayo Staff in Rochester," 1911). If the stenosis involves a considerable portion of the esophagus, gradual dilatation by these methods will almost certainly fail to cure.

The most rapid, safe, and thoroughly satisfactory method of treating cicatricial stenosis of the esophagus is with the Tucker retrograde bougie (Fig. 746). The bougies are pulled up biweekly after a gastrostomy fistula has been established. (See "Atlantic Medical Journal," June, 1923; also "Transactions Amer. Laryngological, Rhinological, and Otological Society," 1924.)



FIG. 746.—The Gabriel Tucker retrograde bougie, made in ten sizes for gradual dilatation.

Symonds advocates the insertion of a tube through the stricture and leaving it in place until there is decided dilatation, and then replacing the tube with a larger instrument. The patient is fed through the tube (Fig. 747). In some cases in which it is impossible to pass a bougie through the stricture by the ordinary plan it is possible to pass one when viewing the opening through the stricture by means of the esophagoscope. Whalebone or olive-tipped instruments may be passed in increasing sizes. Strands of silkworm-gut may be passed. If they can be, they are left in place a few hours, when a larger bundle of gut or perhaps an instrument can be passed. Surgeons have divulsed strictures and performed internal esophagotomy through an esophagoscope. Either of these plans is preferable to forcible dilatation or internal esophagotomy by a special instrument, but without the esophagoscope.

Electrolysis has been advocated by Fort and others. Gradual dilatation from below has been practised in cases in which a bougie could not be passed from the mouth. A gastrostomy is performed, and after the gastric fistula has become sound

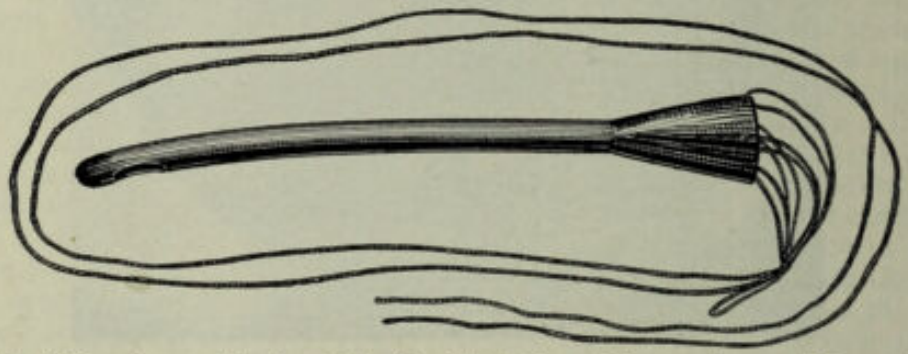


FIG 747.—Symonds's short tube for intubation of the esophagus (Morrow).

the patient is made to swallow "a shot to which is attached a silk thread" (Maylard). The silk thread is brought out through the fistulous orifice and is attached to a bougie (Fig. 746), and the dilating instrument is pulled up through the esophagus. A bougie one size larger is substituted every few weeks. *Forcible dilatation* can be employed through a gastrostomy opening by means of bougies, tents, or divulsing instruments. A fibrous stenosis in the region of the cricoid cartilage which is not cured by gradual dilatation should be treated by the operation of *external esophagotomy*. In this operation the stricture is divided by a longitudinal incision; "funnel-shaped retraction of the cut portion is caused by adhesion to the external tissues."[1] If dilatation fails in the case of a stenosis anywhere above the line of the aortic arch, the esophagus may be opened above the stricture (external esophagotomy). If the stricture is below the wound a tenotome may be introduced through the wound, and the stricture cut and well dilated by the passage of instruments. This operation is known as Gussenbauer's combined esophagotomy.

If a stricture is impassable from above, the stomach should be opened and retro-

[1] W. J. Mayo, "Jour. Amer. Med. Assoc.," July 29, 1899.

grade dilatation be carried out. Billroth showed years ago that a stricture impassable from above may be passable from below. This is because the esophagus above the stricture is basin shaped and immediately below the stricture is funnel shaped (Abbe in "Med. Record," Nov. 30, 1907). If a fine bougie is carried from the stomach to the mouth it is used to carry a piece of string through the same route, and this string is used to pull bougie after bougie through the stricture. For firm, non-dilatable stricture in the thoracic portion of the esophagus it was once the custom to treat it by Abbe's string-saw. The method is now obsolete.

In some cases of incurable stricture *cervical esophagostomy* is performed below the stenosis, and the patient is fed permanently through the opening. The operation is performed like esophagotomy, except that the mucous membrane is sutured to the skin.

Carcinoma of the Esophagus.—(See article "Transplantation of the Diaphragm," by Heuer, Andrus and Bell in "Annals of Surgery," Jan., 1925). Cancer causes obstruction of the esophagus. It arises in those beyond middle life, and is far more common in men than in women. The disease may begin at any portion of the gullet, but is least often met with in the central portion (Maylard, Butlin). Epithelioma is the usual form, but scirrhus or encephaloid may occur. Cancer soon ulcerates, involves adjacent parts, and affects the deep cervical and posterior mediastinal glands. In at least 75 per cent. of cases of chronic obstruction of the esophagus cancer is the cause.

Symptoms of Cancerous Stenosis.—The patient is over forty years of age, is usually a male, and presents the same difficulty in swallowing met with in cicatricial stenosis. Regurgitation is common. The regurgitated matter is alkaline and is apt to contain blood. There is generally decided pain and very rapid and great emaciation occurs. The seat of obstruction may be located by the very gentle use of a soft or semisolid bougie, but it is wiser to use no bougie and to rely on the *x*-rays and the esophagoscope. In a very recent case diagnosis is possible only by esophagoscopy. The stomach is the seat of pain; the mouth is dry, and there is often great thirst. As the disease infiltrates, the involvement of adjacent regions produces other symptoms. Dyspnea may result from tracheal pressure. Pleuritis, pericarditis, or pneumonia may arise. There may be paralysis of the sympathetic or recurrent laryngeal nerves.

In suspected cases of cancer never try to pass unguided bougies or sounds through the constriction. In a cancer case dilating instruments are weapons rather than tools. If a bougie is used to locate the constriction it will probably start bleeding and be bloody when withdrawn. A solid instrument might perforate the esophagus. If it does, death will follow. The *x*-rays should first be used and then the esophagoscope. At Jefferson Hospital we have found that a piece of suspected tissue can be easily removed through the esophagoscope and that the results are absolutely reliable. The esophagoscopy is done in a few minutes without hospitalization and without anesthesia, general or local.

Treatment.—Excision of a portion of the cervical esophagus was carried out successfully by Billroth in 1871. The patient was fed through a fistula in the neck. Surgeons now favor closure of the wound in the gullet by end-to-end suturing or creation of a new tube by some plastic method (see a book on operative surgery). The first successful resection of the thoracic esophagus was reported by Torek ("Surgery, Gynecology, and Obstetrics," June, 1913). Torek's patient was well over eleven years after operation. Eggers reports a success by Torek's method ("Arch. of Surg.," Jan., 1925). The operation was intrathoracic and through the pleura. Zaaijer, of Leyden, successfully resected a carcinoma of the cardia, going through the pleura to accomplish it (Hirschmann and Frohse in "Beiträg. z. klin. Chir.," 1915, xcv). Arch, Voelcker, Kümmel, and Sauerbruch also obtained recovery after such an operation (Meyer in "Trans. of Amer. Surg. Assoc.," 1915). The patient was alive over seven years after the operation and was taking food through a tube carried from the esophageal opening in the thorax to the stomach. Lilienthal in 1921 performed the first successful extrapleural resection without gastrostomy ("Annals of Surg.," Sept., 1921). In selected cases this operation is justifiable. The early and absolutely certain diagnosis by esophagoscopy renders more hopeful the outlook for transthoracic esophageal resection. If the condition forbids radical operation the patient should be put on a soft, bland diet, small quantities being given frequently. When trouble is experienced in swallowing even the bland and soft food, perform gastrostomy. Never postpone gastrostomy until the patient is seriously exhausted. In every doubtful case of esophageal stricture give salvarsan. This might clear up a gumma. In these days of esophagoscopy the chance of diagnostic error is far less than formerly.

Spasmodic Stricture of the Esophagus (*Esophagismus; Hysteric Stricture*).—By

this term is meant a spasm of the circular muscular fibers of the gullet, which is most common near the larynx or the cardia. This condition not unusually arises in a hysteric individual, in whom it will be associated with the stigmata of hysteria, especially globus hystericus. In some cases evidence of hysteria are wanting, although the patient is neurotic and ill-nourished, the condition being due to a reflex irritation. A spasm of the muscular fibers of the esophagus may be clonic or may be tonic. A clonic spasm may arise during vomiting or from some reflex cause; it may affect one part of the tube for a time and then shift to another, or may develop in one particular region only. Globus is a spasm which moves upward. Tonic spasm is in one fixed place. Most reflex spasms are tonic and result from cancer of the liver, cancer of the stomach, tonsillitis, glossitis, pharyngitis, gall-stones, cholecystitis, or inflammation of the epiglottis (A. L. Benedict in "Amer. Jour. Med. Sci.," Aug., 1904). It occasionally occurs in tetanus; sometimes in epilepsy. Spasmodic stricture may also arise during pregnancy and as a result of laryngeal ulceration. I have seen several instances due to cancer of the stomach. In one of these cases the esophageal spasm entirely disappeared after the performance of pylorectomy.

Symptoms of Spasmodic Stenosis.—It arises suddenly in a hysteric or neurotic individual. It may last for a time and suddenly pass away, or may persist for a considerable time. The difficulty in swallowing is irregular, rarely interfering seriously with nourishment. Usually fluids are taken more easily than solids, but sometimes solids are taken more readily than fluids.

There may be regurgitation; but in recent cases, if it occurs, it does so at once on swallowing food. Examination with a bougie detects the obstruction. If the bougie is held firmly against it, in most cases the spasm will, after a time, relax suddenly or gradually and let the instrument pass. A medium-sized instrument or a large one may not pass until the patient has been anesthetized, but in every case a bougie can be passed after an anesthetic has been given. Early cancer cannot be excluded by these means. The most reliable diagnostic method is esophagoscopy.

Treatment of Spasmodic Stenosis Above the Esophagus.—The systematic passage of bougies. Occasionally the passage of an instrument but once will cure a case. The general health must be improved, and in persistent cases it may be necessary to use electricity within the esophagus, employ cold locally, and administer the bromids.

Cardiospasm (Abdominal Esophagismus).—The esophagoscope shows that the stenosis is not at the cardia, but at the hiatus esophageus, the "diaphragmatic pinch-cock failing to open at the proper time in the deglutitory cycle." It may or may not be associated with cancer, ulcer, or some other disease of the stomach, with gall-bladder disease, or cancer of the liver. The attacks are periodic, with a variable time between them, but sooner or later diffuse dilatation occurs. Before dilatation takes place the patient has periodic attacks of difficulty in swallowing, being perfectly well between the attacks. One of Plummer's cases had periodic attacks of dysphagia lasting from three to fourteen days, and during these attacks it was impossible to swallow either solids or liquids. In many cases the attacks are neither so severe nor prolonged. They usually begin suddenly while swallowing, but may begin at a time when no food is being taken. The attack is a feeling of choking or obstruction felt in the cardiac region and the back. Soon after these attacks originate the patient begins to suffer very soon after eating from regurgitation into the mouth. As the esophagus dilates the regurgitation is postponed longer and longer after eating, until finally the gullet is never completely empty (Plummer, "Northwestern Lancet," Oct. 1, 1906). Trousseau, many years ago, described a case of supposed cancer of the cardia which was probably cardiospasm and which was characterized by the symptom now to be set forth. "At the beginning of this disease the regurgitation takes place immediately after deglutition, because the esophagus then reacts more powerfully upon its contents, as it has not yet become accustomed to distention. In proportion as it acquires this tolerance, the food is only rejected from the mouth at an interval more or less protracted after ingestion" (Trousseau's "Clinical Lectures"). It is certain that Trousseau knew that this symptom signified blocking of the lower end of the gullet, but thought wrongly that it always meant cancer. The matter which is regurgitated is not sour, because it contains no gastric elements. Plummer points out that a stomach-tube cannot be passed, but a large sized sound can be passed easily. The fact that a large sound can be passed proves that there is no organic stricture. When external causes of pressure are excluded the diagnosis rests between diverticulum and dilatation of the esophagus (Plummer, Ibid.). The *x*-rays aid in diagnosis. Plummer gives methods in detail (Ibid.). (See article in "Annals of Surgery," Jan., 1925, by P. N. Bull, "Idiopathic Dilatation of Esophagus."

Treatment.—Russell's plan is to dilate the cardia with a silk-covered balloon of rubber. Plummer describes how to construct it ("Collected Papers of the Staff of St. Mary's Hospital, Mayo Clinic, 1905–1909"). The distention is to be gradual, and at once suspended if there is violent pain indicating laceration. Mikulicz and others have performed gastrotomy and dilated the cardia. Willy Meyer ("Amer. Jour. Surg.," June, 1912) has opened the thorax under positive pressure, plicated the dilated portion of the esophagus into two longitudinal double folds, and separated the pneumogastric nerves, tearing off the minute esophageal branches (*esophagoplication* and *vagolysis*). One patient was cured. This operation was attempted on 2 other patients. One was improved. The other turned out to have organic strictures. In another case Wendel performed cardioplasty in the same manner as pyloroplasty is done. He did it by the abdominal route. Meyer suggests that it may be done transthoracically.

Diverticula of the Esophagus.—Rokitansky in 1849 described traction diverticula and pressure diverticula. Maylard tells us that these pouches may be due to one of four causes: they may be congenital; may be due to stricture; may be caused by pressure from within upon a weak spot of the wall; may be due to traction from without by the healing and contraction of an area of inflammation. To these another cause should be added, muscular weakness resulting in dilatation. The usual situation for such a pouch is on the posterior wall of the gullet on a level with the cricoid cartilage. At this point there is a space devoid or nearly devoid of muscle, called the *Lannier-Hackerman area* (Charles H. Mayo, "Jour. Amer. Med. Assoc.," July 22, 1912). As the pouch enlarges the fundus comes toward the side, usually the left side. Pouches are rare in the thoracic esophagus, and when they occur are due to traction and arise on the anterior wall.

Symptoms.—In spite of the statement that a diverticulum may be congenital, we seldom encounter the condition clinically except in adults. The first symptom is difficulty in swallowing, like that in cancer. There may be cough from nerve irritation and dyspnea from pressure on the trachea (Charles H. Mayo, "Annals of Surgery," June, 1910). Regurgitation may occur, the regurgitated matter being free from gastric juice. As the opening of the sac is usually a direct prolongation of the esophageal canal a sound or bougie tends to enter the sac. When the diverticulum is in the neck a lump forms during deglutition, and this lump may be obliterated by pressure. Food will pass into the stomach only when the diverticulum is full. A bougie can seldom be passed by the pouch unless it is full of food, at which time it may pass or may not. Usually it enters the pouch. After a patient swallows an emulsion of bismuth or barium or food mixed with one of these salts a diverticulum may be skiagraphed. At Jefferson Hospital we rely only upon fluoroscopy and esophagoscopy for diagnosis. Under the fluoroscope the pouch is seen to fill first and overflow into the subdiverticular esophagus.

Treatment.—In very early cases dilatation perhaps may cure. In advanced cases in the cervical esophagus we must perform extirpation and suture, as done by von Bergmann, Hearn, Shallow, the author, and others. I believe in preliminary gastrostomy. The operation consists in first exposing the sac. An esophagoscope inside of the sac makes the structure distinctly luminous and easily recognizable. The sac is then clamped, care being taken to maintain the proper caliber of the gullet. The sac is excised, the esophageal wound is sutured, and drainage is introduced down to the tube. There is usually some leakage after several days. The danger is infection of the cellular tissue and spread to the mediastinum. Some surgeons would prevent this by twisting the sac instead of excising it. Others do a two-stage operation, at the first operation inserting packing to induce adhesions about the sac. Excision is practised within the area of adhesions. No attempt should be made to extirpate a pouch arising in the thoracic esophagus. In such a case gastrostomy may be necessary.

Injuries of the Esophagus from Within.—Injuries of the internal surface are more common than injuries from without. Burns and scalds are among these injuries. Wounds may be inflicted by foreign bodies. Injuries of the gullet cause pain on swallowing, and a wound induces bleeding, the blood being both coughed up and vomited. A severe wound may involve a large vessel and cause violent or even fatal hemorrhage. If the bronchus or trachea is involved, there will be "cough and expectoration of blood, mucus, and food" (Maylard). The pleural or pericardial sacs may be perforated.

Treatment.—Feed by the rectum only. Give morphin hypodermically. Do not feed by the mouth for ten days, and even then give only fluid food, olive oil, and jelly. Symptoms are met as they arise. After burns by caustic administer the antidote,

give large drafts of water, and wash out the stomach. From two to four weeks after a caustic has been swallowed and after a burn or scald dilatation should be begun (provided there is no raw surface), and should be persisted in for a considerable time to prevent contraction.

Injuries of the Esophagus from Without, Other Structures Not Being Involved Seriously.—Such injuries are rare. Esophageal injuries, as a rule, are associated with serious damage to adjacent structures. Injuries may be due to stabs or to bullets. Besides the obvious external signs of the injury there will be difficulty in swallowing, cough, bloody expectoration or vomiting, and mucus or the contents of the stomach may run out of the wound.

Treatment.—Suture the wound, and feed by the rectum for ten days.

Spontaneous Rupture of the Esophagus.—By this we mean rupture of an apparently healthy gullet. It is a very rare accident. Most recorded cases of rupture have been in those in whom the esophagus was ulcerated or cicatricial. Vomiting is the cause of rupture. Alcoholism predisposes. Rupture may occur when the wall undergoes autodigestion, as it may do in protracted vomiting. The symptoms are the sudden onset of violent pain, vomiting, collapse, and not unusually cellular emphysema above the clavicle. If a diagnosis is made, operation is indicated provided the case is seen early enough. Without operation death is certain.

Foreign Bodies Lodged in the Esophagus.—These accidents occur especially in children and lunatics, and women are more apt to suffer from them than men. A

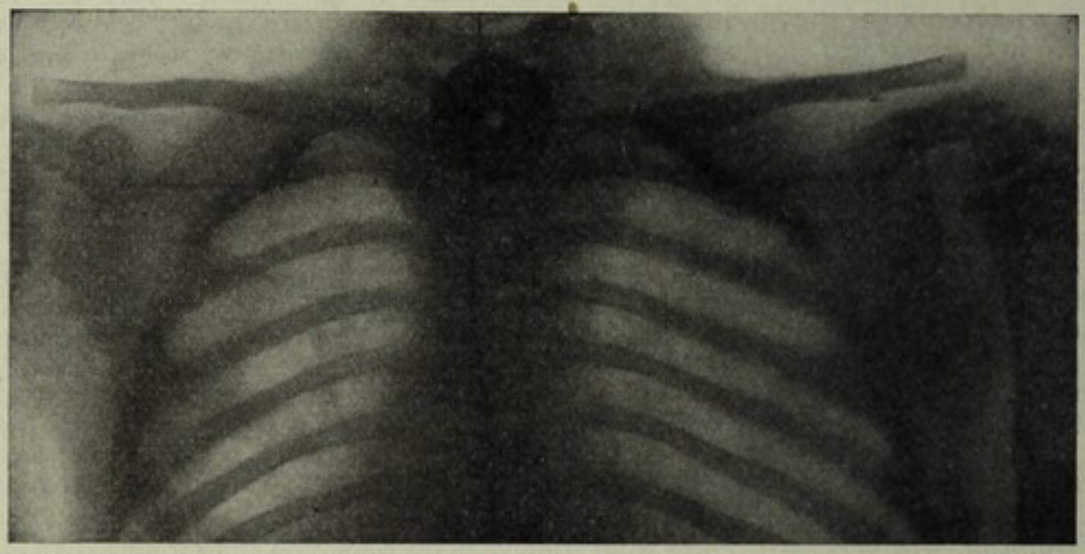


FIG. 748.—Author's case of whistle in esophagus, removed by external esophagotomy.

list of various bodies which have been swallowed will be found in Poulet's elaborate treatise on "Foreign Bodies in Surgery." There are four regions where a foreign body is especially apt to lodge—viz., opposite the cricoid cartilage, at the level of the aorta, at the point where the left bronchus crosses the gullet, and at the level of the diaphragm. Small and sharp bodies may lodge anywhere.

The *symptoms* are variable; if the body is large, there will be pain and difficulty in swallowing, and, in many cases, dyspnea from pressure upon the trachea or bronchus. Occasionally the dyspnea is such a prominent feature that it misleads the physician into the belief that the foreign body is lodged in the air-passages. Death may actually result from asphyxia. In some other cases the symptoms are very slight. If the body is sharp, there will be hemorrhage and severe pain. The blood may be hawked up, or may be swallowed and vomited. In rare cases a patient grows accustomed to a foreign body and ceases to notice it, but, more often, the foreign body produces inflammation. It may even ulcerate into the wind-pipe, the pleura, the pericardium, or the aorta. Sharp bodies are apt to do so, but even blunt bodies may perforate. Periesophageal abscess may result from perforation. A blunt body may perforate after prolonged lodgment (weeks, months, or years). In many cases of impaction a patient makes violent efforts to hawk up the foreign body, and so produces aphonia. There may be violent retching. Even after a foreign body has been removed by swallowing, by vomiting, or by surgical extraction, a sensation is apt to remain as if the body were still lodged. The diagnosis is made by the history, the detection of the body by ex-

ternal manipulation, by esophagoscopy, and, if bone or metal, by seeing it with the fluoroscope or obtaining a skiagraph. Non-opaque objects are revealed by the *x*-rays after swallowing a mixture of jam and barium, or a capsule filled with bismuth subcarbonate.

Treatment.—The surgeon should learn, if possible, the size, shape, weight, and nature of the foreign body, and should locate its point of impaction. The exact point of lodgment of bone or a metallic body is determined by the *x*-rays. An anesthetic is given before operating on a child, a nervous woman, or a lunatic, and is *sometimes* necessary for a man. If the foreign body is soft, external manipulation may succeed in altering its shape, so that it may be swallowed or ejected. If the foreign body is hard, external manipulation may shift its position. It is usually impossible to reach the foreign body through the mouth by means of the fingers (when the body is in the rear of the pharynx it may be pulled forward or pushed down). Sharp foreign bodies may be entangled and carried down when the patient eats mush, bread, or boiled potatoes. The administration of emetics is an old plan which occasionally succeeds, but which is too unsafe to be employed. The esophagoscope is of immense value. By means of it a surgeon, skilled in its use, may remove most foreign bodies which, otherwise, would demand the performance of grave operations (see page 868). Blind extraction should not be tried if a surgeon skilled in the use of the esophagoscope is accessible. I believe all surgeons should be trained to use the esophagoscope. The great danger of blind extraction is perforation. Nevertheless I believe, with E. Fletcher Ingalls, that the esophagoscope "cannot entirely supplant the older methods"

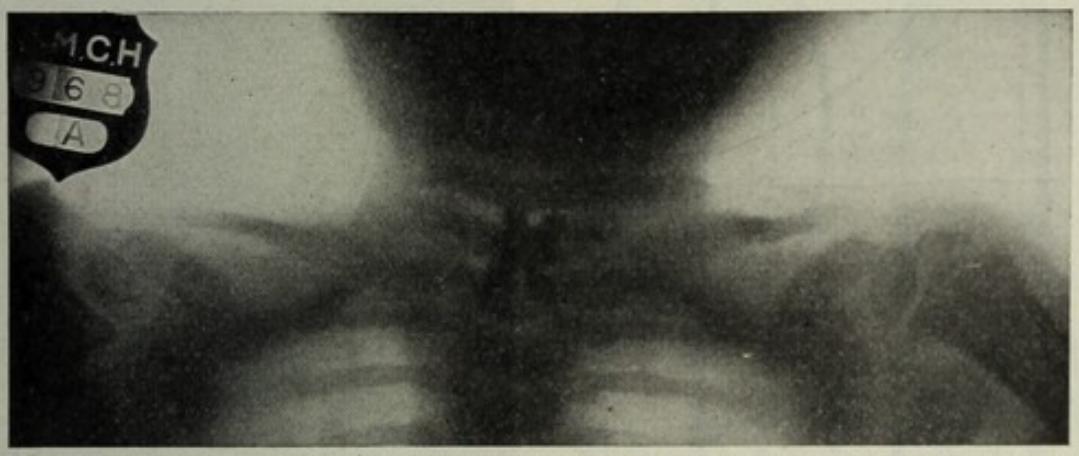


FIG. 749.—Author's case of jackstone in esophagus, removed by external esophagotomy.

("Amer. Jour. of Surg.," Jan., 1912). The instrument is not always at hand, and to use it successfully and safely one must be well trained in its management. Maylard says that when a mass of food is impacted it is occasionally possible to soften and disintegrate the mass by administering a mixture containing pepsin. The bristle probang (Fig. 750, C) is a useful instrument for the removal of fish-bones, pins, and other small objects when the esophagoscope is not available. It may be used to push a soft body downward into the stomach, or to catch a body and pull it up. When this instrument is withdrawn it opens like an umbrella. Its use is associated with high mortality, especially in younger children. It has been shown that in an adult the cardiac opening is from 14 to 16 inches from the incisor teeth, a point to be remembered in deciding whether to push down or pull up the impacted article. Either procedure may be dangerous, as shown in Fig. 751. Esophageal forceps (Fig. 750, A, B) are valuable in some cases. The coin-catcher (Fig. 750, D) is a useful instrument. Créquy's plan of removal is to take a tangled mass of threads, tie a stout piece of string about the middle of it, coat it with sugar, and have the patient swallow it. It may pass the foreign body; if it does so, on withdrawal it may entangle the object and extract it. To remove a fish-hook with line attached the following plan may prove successful: stick the line which projects from the mouth into a metal catheter, carry the catheter down to the hook, and push the hook out. It is not proper to allow a foreign body to remain in the esophagus until it causes ulceration, but the delay of a week to reach a large medical center where an esophagoscopist is available is devoid of danger. Neither is it proper to make prolonged efforts to extract it through the mouth. Such efforts may do great harm, and if one careful and consistent effort fails, and the esophagoscope is not suited to the case, fails, or

is unobtainable, or if there is no skilled man to use it, an operation should be performed. If the body is lodged anywhere above the lower third of the esophagus, *external esophagotomy* is performed, and usually on the left side. Through this wound the foreign body is extracted. The cut is made on the left side, between the trachea and larynx in front and the carotid sheath behind, the center of the incision being opposite the cricoid cartilage. After the foreign body has been extracted the gullet is sutured carefully with chromicized catgut, and the superficial structures are closed with silkworm-gut after a drainage-tube has been inserted. The patient is fed by the rectum for eight or ten days. When a foreign body is lodged in the lower portion of the tube the stomach is opened and the body extracted by this route. In White's case of jackstone in the gullet gastrotomy was performed. A string was tied about some rolls of gauze, the string was passed by means of a whalebone from the stomach into the mouth, and the body was entangled and drawn out. Esophagoscopy has rendered all of these operative and blind methods obsolete in hospital work. Of over 600 cases of foreign body in the esophagus at the Bronchoscopic Clinic of the Jefferson College Hospital external esophagotomy has not been required in a single instance.

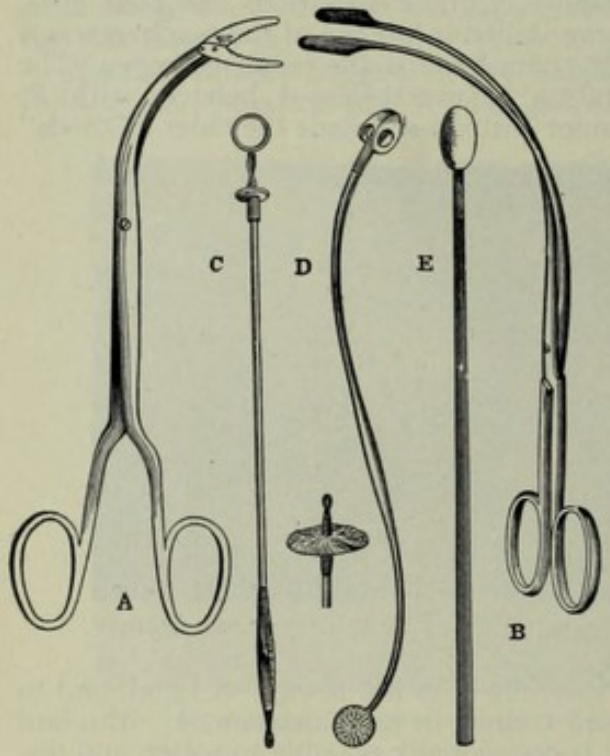


FIG. 750.—Esophageal instruments: A, B, Forceps; C, Gross's bristle probang; D, coin-catcher; E, bulbous esophageal sound. The use of these "blind" instruments is inadvisable where a skilled esophagoscopist is available.

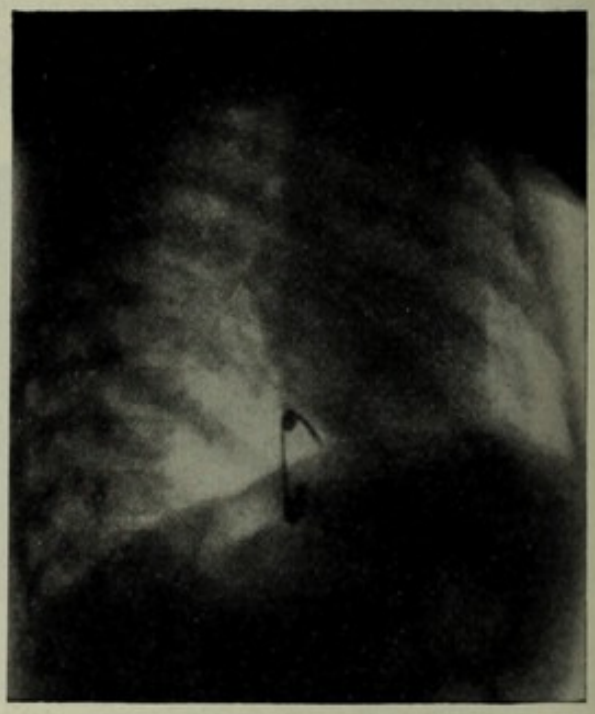


FIG. 751.—Illustration of the danger associated with blind attempts to push down or pull up a foreign body in the esophagus, either of which would have caused perforation. The pin was closed and removed by peroral esophagoscopy, without anesthesia, in two minutes and forty seconds (Chevalier Jackson).

Surgical Invasion of the Mediastinum.—The posterior mediastinum has been entered in order to remove a foreign body from the bronchus and to extract a set of false teeth wedged in the esophagus. The same method can be followed to reach suppurative processes in the mediastinum, abscesses of the lung otherwise inaccessible, and diverticula and carcinomata of the lower end of the gullet. Nassilov resects ribs close to the spine. The portion of the esophagus above the aortic arch can be reached after partial resection of the third, fourth, fifth, and sixth ribs of the left side. Willy Meyer has made four heroic attempts to resect cancers of the esophagus. All the patients perished. He does it under positive pressure ("Surg., Gynec., and Obstet.," Dec., 1912). Out of 35 known operations 1 recovered and 1 lived two weeks after operation. Torek's case was successful (page 923). Lilienthal performed successfully extrapleural resection of a portion of the esophagus (page 923). The anterior mediastinum may be entered to remove a bullet, to drain an abscess, to reach a wound of the heart or lung, and to explore for the cause of obscure and dangerous symptoms. I explored the anterior mediastinum after rib resection, found a bullet embedded in

the aorta, and allowed it to remain. The patient recovered. M. H. Milton[1] splits the sternum longitudinally and separates the two pieces.

Invasion of the mediastinum is much safer if the operation is performed in the Sauerbruch chamber or with the aid of positive pressure within the bronchi, or while using intratracheal anesthesia. These plans prevent pulmonary collapse if the pleura is opened.

XXVI. DISEASES AND INJURIES OF THE ABDOMEN

Diagnosis of Intra-abdominal Emergencies.—The exact diagnosis is always difficult and in many cases is impossible. What a surgeon must try to determine, and what he usually can determine, is whether he is dealing with a trivial and temporary derangement for the relief of which an operation is entirely unnecessary, or whether he is confronted by a grave calamity which imperatively demands immediate surgical aid. We can decide that a calamity exists, but the exact nature of the lesion is often doubtful until operation is performed. Every operation in such a case is exploratory. Before the diagnosis of a calamity is made morphin should not be given, because it allays the pain, relieves the anxiety, causes the disappearance of rigidity, lowers the pulse, abates mental shock, and hence veils the real situation, so that the most discerning surgeon will probably be misled. If shock is profound, diagnosis is usually impossible unless shock is due to hemorrhage, and immediate operation during shock is not to be thought of except for a perforation or to arrest bleeding. If excessive and continued hemorrhage is suspected, or if perforation is highly probable, immediate operation is indicated. If perforation is not probable, or if severe bleeding is not suspected, the patient should be covered with blankets and surrounded with hot-water bags, atropin should be given hypodermically, and hot salt solution should be administered by rectum, subcutaneously, or intravenously. When the patient reacts, and he usually will react, an attempt is made to make a diagnosis. An ice-bag should not be used. Truly it allays pain, but it abates rigidity and masks other symptoms as would a dose of morphin. Morphin is not given until the diagnosis has been made, unless removal is necessary, when morphin may be required. If a patient must be moved to a hospital it is perfectly proper to give a single hypodermic injection of morphin ($\frac{1}{3}$ gr.) after the effort has been made to diagnosticate the condition. The danger of deluding the surgeon is past, and the drug abates pain, lessens peristalsis, relieves mental anxiety, and is distinctly though temporarily beneficial. Before the morphin was given the surgeon had come to a conclusion as to the necessity for operation. After the morphin has been given, if an operation is indicated, it is performed as promptly as circumstances admit. Whenever it is consistent with safety the patient ought to be removed to a hospital for operation.

Foreign Bodies in the Abdomen.—Now and then a sponge, a pad, or an instrument is left in the abdominal cavity during an operation—left, not because of the surgeon's carelessness, but in spite of the most painstaking precautions. Instruments and sponges are counted before and after the operation. A miscount means calamity. The surgeon does not and cannot make the count himself. He has not time. He is doing a more difficult thing which he is trained to do and which the patient expects him to do, that is, operating, closing the wound, and dressing it. The surgeon must delegate the duty of counting pads, sponges, and instruments, and he delegates it to assistants or nurses, who do it with as much accuracy as he could. At least *two* people count sponges, pads, and instruments, and count at least *twice* before and *twice* after the operation. If the count is short, and the missing instrument or material is not discovered on the floor, in a bucket, on or under the table, the abdomen must be opened and the lost object sought for and found.

A great safeguard is to use no small sponge or pad unless it has a bit of tape sewed to it. The tapes stick out of the wound and on each one a forceps is clamped. Another precaution is to refrain from cutting a pad in two after the operation has been begun. The safest way of all is to use rolls of gauze (Halsted's packs or rolls). To do so means a long broad end sticking out of the wound so that the pack cannot be lost in the belly.

If a septic body of any sort is left in the abdomen it almost at once produces acute disturbances.

If an aseptic gauze pad or instrument has been left it may become encapsuled and cause no trouble for months or years. Sooner or later it will cause trouble or even death. The sufferer may become a chronic invalid. The object may make its way into the in-

[1] "Lancet," March 27, 1897.

testine or into the bladder. It may even pass out through the rectum. Usually a piece of retained aseptic gauze or an aseptic instrument produces abdominal pain and a tendency to intestinal obstruction. Sooner or later an abscess forms and the symptoms of an acute septic condition arise.

Schachner says the mortality in reported cases is about 50 per cent. Many fatal cases have not been reported. If we suspect the presence of a metal instrument the *x*-rays will show it.

Treatment.—Laparotomy (which is often exploratory) and removal of the offending material.

Simple Contusion of the Abdominal Wall Without Injury to Viscera.—In some cases of contusion of the abdominal wall, only the parietes are damaged; in other cases the viscera or the abdominal tissues are injured. Contusion may involve the skin alone, or may involve the skin, muscles, and peritoneum. In *simple contusion* there is considerable shock if the injury be severe. There is pain, increased by respiration, motion, pressure, and attempts at urination or defecation. When tenderness is not found soon after the accident but appears some days later there is usually deep-seated injury. Extensive ecchymosis may appear. Even after a severe contusing force has been applied there may be no discoloration, and it may happen that after a slight force there is much discoloration. There is great ecchymosis in anemic persons, victims of hemiplegia, obese individuals, opium-eaters, and drunkards. In severe cases the tissues are pulpified and sloughing inevitably ensues. Abscess occasionally follows contusion. The prognosis after abdominal contusion is always uncertain.

Treatment of Simple Contusion.—In treating simple contusion place the patient at rest in a supine position, with the thighs flexed over a pillow. Obtain reaction from the shock. If pain be severe, and we are certain there is no visceral injury and no internal hemorrhage, give morphin. After shock has passed off it is advisable to place an ice-bag over the seat of injury. If much blood is extravasated into the abdominal wall, aspirate and apply a binder. After twenty-four hours apply local heat by means of the hot-water bag, employ an ointment of ichthyol, and move the bowels, if necessary, by salines. Regard every contusion as serious, and watch carefully for the development of signs of internal hemorrhage or visceral injury.

Muscular Rupture from Contusion.—In this injury there are severe shock, and pain (increased by respiration and movement). Separation between the fibers of the muscle is distinct at first, but it is soon masked by effusion of blood. Such injuries may cause death or may lead to hernia. The rectus is the muscle most apt to rupture. The rupture is due to sudden contraction rather than to the direct effect of a blow.

The *treatment* is the same as for simple contusion. Always apply a binder. If a hernia exists it is returned and a compress is applied over the opening through which it emerged. Later operation is performed. If strangulation occurs, operate at once.

Injuries with Damage to the Peritoneum or the Viscera.—Rupture of the Peritoneum.—The peritoneum may be involved in an abdominal contusion. It may rupture even when there is no visceral injury or muscular contusion. The uterine peritoneum, the parietal peritoneum, the visceral peritoneum, or the mesentery may rupture. Rupture of the peritoneum causes intra-abdominal hemorrhage.

The *treatment* consists in opening the abdomen, arresting the hemorrhage, and bringing about reaction.

An injury to the peritoneum creates a point of least resistance, and at such a point peritonitis may develop. The peritonitis is usually local, but may become general. After any severe intra-abdominal injury the symptoms of *peritoneal shock* appear (*peritonism*), and the patient may rapidly die. In the condition of peritoneal shock the temperature is subnormal; the extremities are cold; the face is pallid and sunken; the pulse is small, weak, and very frequent; the respiration is shallow and sighing; there is great thirst; the patient is restless and turns uneasily, and there is rigidity and distention. Vomiting almost always occurs. In some cases there is regurgitation rather than vomiting. The abdomen is the seat of a violent, persistent pain. The patient is fearful of impending death. As the symptoms develop in a grave case they will point to one of two conditions—hemorrhage or peritonitis.

In *intra-abdominal hemorrhage* the subnormal temperature and other evidences of shock persist. Vomiting ceases, but nausea exists. The patient is uncontrollably restless and tosses about in bed. The thirst is great. The abdomen is rarely rigid. Fainting spells often occur. Blood examination shows a marked fall in the percentage of hemoglobin. Percussion demonstrates the existence of an effusion which alters its position as the patient's position is altered, and which gradually increases in amount.

Dulness is first met with in the loins. Digital examination of the rectum or vagina may aid in diagnosis, because in hemorrhage blood gathers in the rectovesical or in Douglas's pouch. If peritonitis develops the vomiting is aggravated, the pain is intensified, and the abdomen grows rigid and, after a time, distended.

Rupture of the Stomach Without External Wound.—The usual cause of rupture is a violent blow, although the accident may happen while washing out the stomach. Rupture is more apt to occur when the stomach is distended with food than when it is empty. The rupture may be partial, the peritoneal coat not being torn. The rupture may be complete. Either the anterior or the posterior wall may suffer. The region of the pylorus is most apt to be lacerated. The symptoms of rupture are collapse, severe pain over the entire abdomen, great thirst, excessive tenderness, especially over the epigastric region, occasionally vomiting, the vomited matter being usually, but not invariably, bloody; tympanitic distention and muscular rigidity coming on after a few hours. Austin Flint pointed out years ago that after complete rupture or perforation gas may enter the abdominal cavity and cause the diminution or disappearance of liver dulness, but the area of liver dulness can be lessened by great intestinal distention, and I have seen cases of perforation of the stomach and intestine in which liver dulness was not lessened at all. (See article on Perforating Ulcer of the Stomach.) The flatter the abdomen, the greater the significance of the sign. After *incomplete* rupture local peritonitis is frequent; in *complete* rupture the escape of stomach contents into the peritoneal cavity causes general peritonitis. The contents of the stomach are not so liable to escape after rupture of that viscus as are the contents of the intestine after rupture of the gut, because of the thickness of the stomach wall and the tendency of the mucous membrane to evert and block the opening. Perforations of the anterior wall are most apt to lead to extravasation and general peritonitis. Posterior laceration may cause subphrenic abscess. To diagnosticate between complete and incomplete rupture, Senn favored distending the viscus with hydrogen gas. In incomplete rupture the contour of the dilated stomach can be made out upon the surface; in complete rupture the viscus cannot be distended, and the gas passes into the peritoneal cavity, producing the physical signs of tympanites. This maneuver is open to the objection that it would increase extravasation in a complete rupture.

The **treatment** for complete rupture is immediate operation. Treatment for shock is at once instituted and an intravenous infusion of salt solution is given before or during operation. In doubtful cases endeavor to bring about reaction and explore. Open the abdomen. Note if gas emerges from the wound or if stomach fluid appears. Search for the rupture in the same manner as we would search for the opening of a perforated ulcer. When the rupture is discovered, flush out the stomach and the peritoneal cavity with hot salt solution; sew up the stomach wound with a double row of silk sutures, the first row being buried and including the muscular coat and mucous coat, the second row being Halsted inversion sutures; drain the abdomen; close the wound in the parietes; place the patient in Fowler's position; let salt water at low pressure flow continuously into the rectum; feed by the rectum for four days, and then begin the administration of a very little food by the mouth. In incomplete rupture the diagnosis cannot be made. The danger is perforation. If we suspect it, after reaction has taken place feed by the rectum for several days. Cases of complete rupture not operated upon occasionally recover, adhesions arising and perigastric suppuration taking place. The mortality is extremely large. In 1896 Petry collected 23 cases in which operation was not performed. The mortality was 59 per cent. This mortality is not so large as one would anticipate. It is quite possible that some of the cases were not genuine instances of complete rupture. Many fatal cases have not been reported. Nevertheless, the lesion, for reasons previously stated, is not nearly so dangerous as rupture of the intestine. Another reason for the greater danger of intestinal rupture is that fecal matter is much more poisonous than the gastric contents. Laparotomy has lessened the mortality of rupture of the stomach. Petry and also Eisendrath mass together operations for rupture of the stomach and rupture of the intestine. Petry finds the group mortality to be 52.3 per cent., and Eisendrath finds it to be 52.5 per cent. Statistics referring to the stomach alone should show a much lower death-rate.

Rupture of the Intestine Without External Wound.—In the great majority of cases the damage is produced by direct violence. In some few cases the force is indirect (falls on the feet or buttocks, blows on the back or loin). The injury may result from *oscillation* or from *compression* (the younger Senn). The common cause is undoubtedly compression of the gut against the pelvis or vertebral column, but it

is certain that a gut containing fluid may be ruptured purely by violent shaking or oscillation. If oscillation produces the damage, the rupture is of the portion of gut furthest from the mesentery; if compression be the cause, any part of the bowel may suffer. Rupture is most apt to occur if the belly is relaxed. It is predisposed to by adhesions, disease of the wall of the bowel, and irreducible hernia. Most ruptures are complete. In a very few cases the tear extends through one or two of the coats only and the rupture is incomplete. A contusion of the gut may be followed by rupture several days after the injury. A complete rupture usually permits leaking of feces, but in very rare cases a small opening is closely plugged by pouting mucous membrane. Leaking from a rupture may be delayed because intra-abdominal pressure may for a time keep the opening pressed against a section of sound gut (the younger Senn). The amount of damage to the belly wall does not convey any notion of the extent of visceral injury. The belly wall may be severely injured and the viscera escape. With only slight contusion of the wall there may be extensive visceral injury. Homer Gage[1] collected 85 cases; in 75 the injury was due to direct force, and in 32 of these the force was inflicted by the kick of a horse or of a man. In 1 of my cases it was due to the kick of a horse, in 1 to the kick of a man, and in 1 to a crush inflicted by a cart-wheel. The victims in the majority of reported cases were young men, probably because young men are most apt to be exposed to violence. In 78 collected cases (Gage) the situation of the injury was specified: The duodenum, 10; jejunum, 20; ileum, 42; large intestine, 6. Curtis found the large intestine injured in 4 cases out of 113, and Poland, in 5 cases out of 64. In many cases there is more than one tear, and sometimes many tears exist. Both the large and small intestines may suffer. Chavasse collected 106 cases in which the ileum or jejunum suffered, 19 in which the large intestine did, 7 in which the duodenum did, 7 in which both the large and small intestines were involved, and 1 case in which the rectum was ruptured (quoted by the younger Senn in "Amer. Jour. Med. Sciences," June, 1904). As Makins points out, the portion of gut most apt to be injured is the portion hanging low in the pelvis, because a loop in this situation is most easily squeezed against bone by a blow on the belly. The mesentery may be lacerated (it is in 7 per cent. of cases, according to Gage; in 16 per cent., according to Curtis). Now and then we read of a death resulting from someone introducing into the anus of an unfortunate person the nozzle of a hose carrying compressed air. The victim of this perversion, cruelty, or morbid sense of humor, whichever it may be, usually dies from multiple ruptures of the intestine. Bendixen and Blything report a case in which operation was followed by recovery ("Surgery, Gynecology, and Obstetrics," 1914, xviii). They call the condition *pneumatic rupture*. In their case there were 9 lacerations in the large gut and 1 in the small gut. The lacerations were from 2 to 7 inches in length. There was also a tear in the mesentery (see Buchbinder, "Jour. Amer. Med. Assoc.," Feb. 19, 1921). The symptoms of rupture of the intestine are profound shock, tympanites, abdominal pain, and rigidity, rapidly followed by peritonitis if the patient survives. In some cases pain is referred to the back. Vomiting comes on soon after the accident, the vomited matter being possibly at first bloody and later stercoraceous. The respiration is costal, there is dyspnea, the tongue is dry, and great thirst exists. The pulse, which may be slow at first, but seldom is, soon becomes small, rapid, and of high tension. Blood in the stools rarely appears early enough to be of diagnostic value, and there may be diarrhea or constipation. There may be no marked symptoms for an hour or two or for many hours. Cases are on record of people with ruptured intestine returning to work perhaps for hours. My case of ruptured ileum walked over two miles to reach the hospital. Holland's patient had no symptoms for twenty-four hours, although the jejunum had been ruptured. Poland's patient ruptured the duodenum, but walked one mile in spite of it. The escape of gas into the peritoneal cavity may cause the diminution or disappearance of liver dulness. After anesthetizing the patient hydrogen gas insufflated into the rectum will come from the mouth if there is no perforation in the stomach or the intestine; if a perforation exists, the hydrogen runs into the peritoneal cavity, tympanites is much increased and the area of liver dulness may disappear. To apply *rectal insufflation of hydrogen* generate the gas in a bottle by means of zinc and sulphuric acid, catch the gas in a large rubber bag, and attach the tube from the gas reservoir to a tip which is inserted in the rectum. Give the patient ether to relax the abdominal muscles, direct an assistant to press the anal margins against the rectal tip, and when the patient is unconscious turn on the stopcock and press upon the reservoir (the elder Senn).

[1] "Annals of Surgery," March, 1902.

It has been suggested that ether vapor, mixed with air, can be used instead of hydrogen gas.[1] In this method a little ether is poured into the bottle of an aspirator, the valves are opened, one tube is carried into the rectum, the other tube is attached to a bicycle pump, and by working the pump the ether vapor is driven into the bowel. If there be perforation, tympanites is notably increased. All surgeons regard the rectal insufflation test as unsatisfactory and often dangerous. Personally, I would never use it. Its application requires considerable time; it must, of necessity, increase fecal extravasation. If we operate after insufflation the gaseous distention is an embarrassment to the surgeon; as Le Conte[2] says, it "so distends the intestines that it may be impossible to return them to the abdominal cavity until they have been emptied of gas."

Treatment for Rupture of Intestine.—After an abdominal injury, if symptoms point to dangerous hemorrhage, and in any case in which the patient does not seem to be reacting, but is rather getting worse, operate at once. If in doubt as to whether or not rupture exists, make every endeavor to bring about reaction and explore. Reaction is brought about as previously directed. Asepticize and anesthetize. Perform a laparotomy, making the incision in the middle line and below the umbilicus; observe if gas escapes when the peritoneum is opened or if fecal material or an inflammatory exudate flows out; check hemorrhage; start at a fixed point and conduct a careful search to find the rent. When the rent is found, it should be closed by Halsted sutures if possible, but only a small rupture can be so treated. A large tear makes resection necessary. Because of the frequency of multiple lesions the surgeon must not be sure he has finished his work when he finds and closes one tear, but he must determine by careful search that no other tears exist. The surgeon notes if there is injury of the mesentery and if the circulation of any portion of the bowel is interfered with. If there is serious impairment of circulation in any part of the bowel wall, perform intestinal resection, followed by end-to-end approximation or lateral anastomosis. In some cases of rupture the patient is so severely shocked that it is impossible to do a resction with any hope of his living. In such a case stitch the ruptured portion of gut to the belly wall. The opening in the gut becomes a fecal fistula, and if the patient survives, can be subsequently closed. The same procedure is proper if the bowel is distended and paralyzed. After closing the opening in the bowel or resecting, flush the abdominal cavity with hot saline solution. and wipe the peritoneal fossæ and the space between the liver and diaphragm with gauze. Finney eviscerates, wipes out the abdominal cavity, and wipes the intestines as he restores them. This is justifiable if the operation is done soon after the rupture, but not in later cases, in which the lymph has gathered on the bowel. Whatever method is used to cleanse the abdomen, remember that infectious material is apt to accumulate between the liver and diaphragm and in Douglas's pouch. Drainage is to be used. Suprapubic drainage is most advantageous. Place the patient semi-erect and employ continuous proctoclysis of normal salt solution as directed for peritonitis. The value of operation for intestinal rupture is conclusively demonstrated. Curtis collected 116 cases which occurred before 1887. Not a case was operated upon, and every patient died. Homer Gage collected 85 cases since 1887; 45 were not operated upon and every one died; 40 were operated upon and 17 recovered. Eisendrath collected 40 cases operated upon: 19 recovered and 21 died (52.5 per cent.). The mortality of cases not operated upon is, according to Eisendrath, at least 93 per cent. The sooner after the injury operation is performed, the greater the chance for success. The younger Senn points out that in operations done within four hours the mortality is 15.2 per cent.; in those done between five and eight hours it is 44.4 per cent.; in those done between nine and twelve hours it is 63.6 per cent., and in those done later it is 70 per cent.

Identification of the Small Intestine and of the Large Intestine.—"In abdominal operations it is frequently imperatively necessary that the large intestine be recognized with certainty or the small bowel be identified positively. The size of the tube will not always aid in this recognition, as a small intestine may be distended enormously, and a large intestine may be contracted to the size of a finger because of obstruction above. The longitudinal muscular fibers of the large bowel are accentuated in three portions; these accentuations constitute the three longitudinal bands which begin at the cecum and terminate at the end of the sigmoid flexure of the colon. Each band is composed of a number of shorter bands, the shortness of these constituent bands permitting the sacculation of the large intestine. Longitudinal bands and sacculation

[1] Emerson M. Sutton, of Geneva, in "Jour. Amer. Med. Assoc.," July 23, 1898.
[2] "Amer. Jour. Med. Sciences," Dec., 1901.

are not met with in the small gut, their presence or absence being a means of identification in many cases; but when the colon is much distended the bands cannot be seen distinctly and the sacculation disappears. From the large intestine only spring the appendices epiploicæ (small overgrowths of fat in pouches of peritoneum), but they are sometimes not well marked except upon the transverse colon, and when emaciation exists they may almost entirely disappear. The relatively fixed position of the large intestine and the free mobility of the small bowel are important points of distinction. The foregoing indicates that it is not always easy to distinguish between colon and small gut, and that, according to old rules, it may be often necessary to make large incisions, to see as well as feel, and to handle a large extent of the bowel. Any scrap of knowledge that will shorten an abdominal operation, that will permit of as certain work through a smaller incision, and that will diminish handling of intraperitoneal structures tends to increase the chances of recovery. For these reasons the writer suggests a method of bowel identification which rests upon the facts that each bowel has a posterior attachment, that the origin of the attachment differs according to the bowel it supports, that a single finger can detect the origin of the peritoneal support of any section of the bowel, and, this origin being known, the portion of the

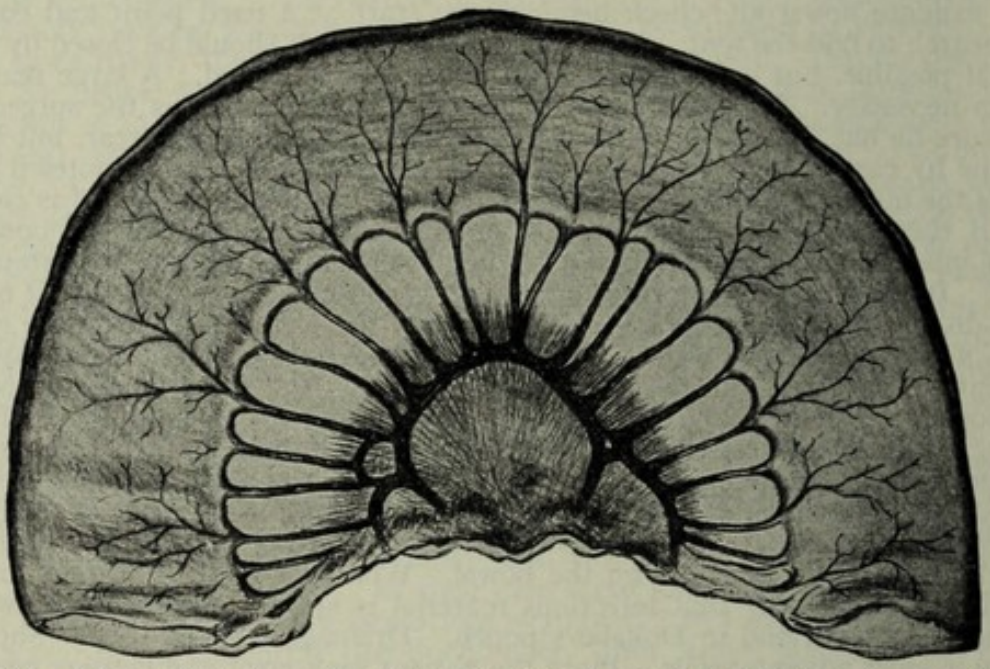


FIG. 753.—A loop of intestine, the middle of which is exactly 3 feet from the end of the duodenum. The gut is of large size. The mesenteric loops are primary, and the vasa recta large, long, and regular in distribution. The translucent spaces (lunettes) between the vessels are extensive. Below the mesentery is streaked with fat. The veins, which had a distribution similar to the arteries, are for simplicity omitted from this and from the subsequent drawings. The subject from which the specimen was taken was a male of forty years, with rather less than the usual amount of fat. The entire length of the intestine was 23 feet (Monks).

bowel it supports is with certainty deducible. In an exploratory operation, for instance, the finger comes in contact with the bowel: to determine whether it is a large or a small bowel, note first if the structure is movable or is firmly fixed; next, pass the finger over the bowel and let it find its way posteriorly. If dealing with a small bowel, the finger will reach the origin of the mesentery between the left side of the second lumbar vertebra and the right sacro-iliac joint; if dealing with the large bowel, the finger will reach the origin of the mesocolon, or the point where the colon is fixed posteriorly and to the side."[1]

Location of a Loop of Small Intestine (Figs. 753–756).—Monks points out a plan by which, in most instances, we can learn with approximate accuracy what portion of the small intestine we may have hold of ("Annals of Surg.," Oct., 1903). He learns first by observation of the mesenteric vessels. Opposite the upper portion of the bowel there are primary vascular loops only with perhaps an occasional small secondary loop. As we descend "secondary loops become more numerous, larger, and approach nearer to the bowel than the primary loops in the upper part," and about the fourth

[1] "The author in "Medical News," June 9, 1894.

foot these secondary loops first become a "prominent feature." As we descend primary loops become smaller, secondary loops become more numerous and nearer

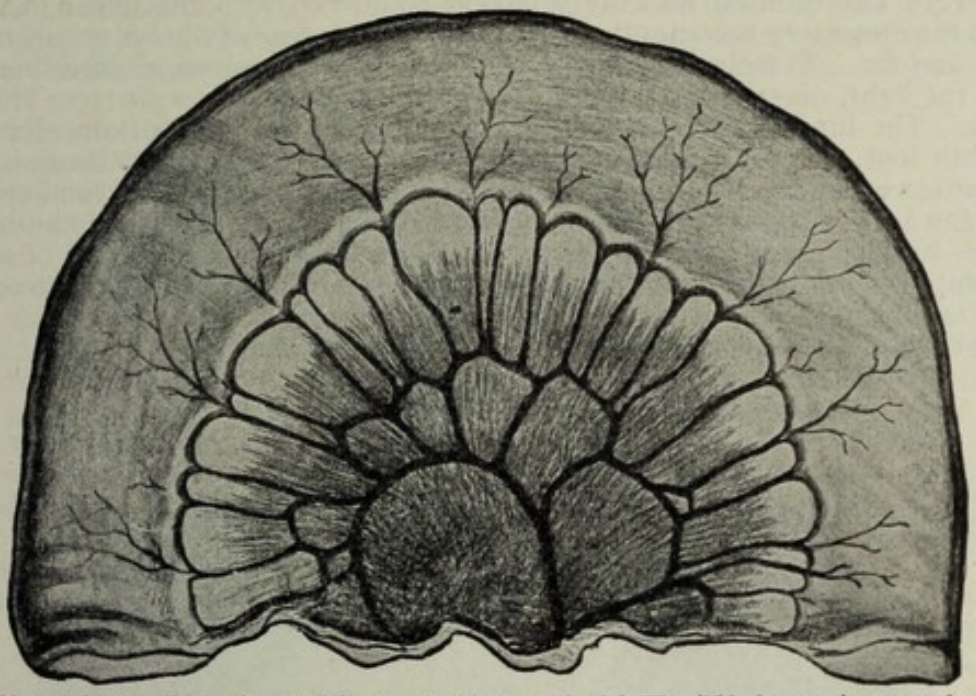


FIG. 754.—A loop of intestine at 6 feet. As compared with Fig. 753 the gut is somewhat smaller. The vascularity of the intestine and mesentery is less. Secondary loops are a prominent feature. The vasa recta are smaller. The lunettes are also present, but are not so large as in Fig. 753. The subject was a male of about thirty-five years, with an average amount of fat. The entire length of the intestine was 20 feet (Monks).

the bowel, and possibly tertiary loops appear. Opposite the lower portion of the ileum the loops are not definite in arrangement, but are simply a network. Monks points out that opposite the upper bowel the vasa recta, when put gently on the

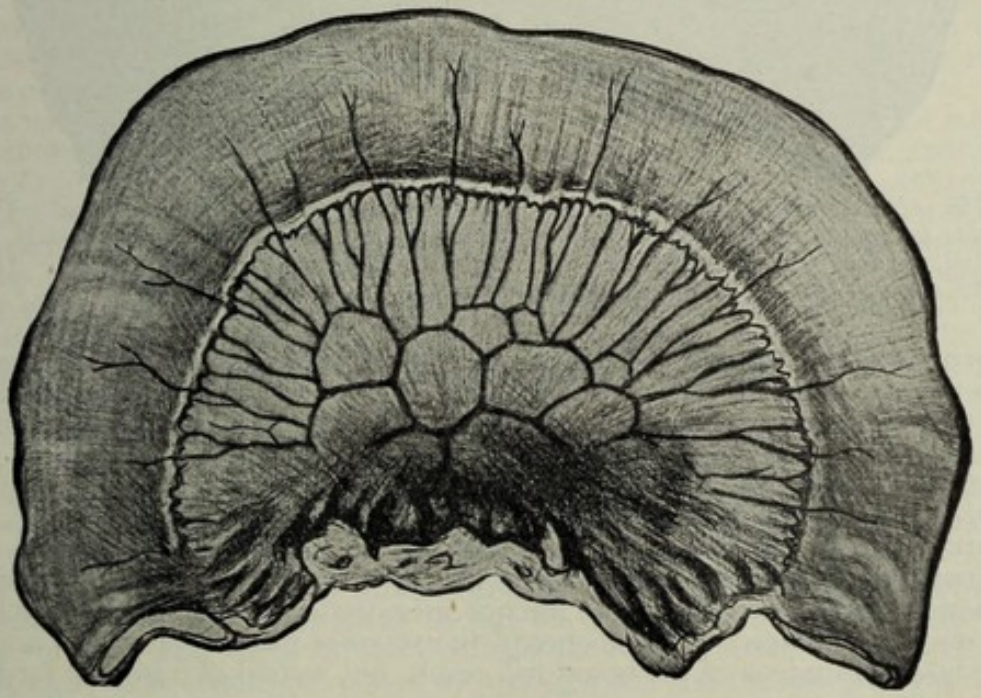


FIG. 755.—A loop of intestine at 12 feet. The vessels are smaller. The primary loops are lost in the fat, but secondary and even tertiary loops are visible. The vasa recta are shorter, more irregular, and branching. The specimen came from the same subject which furnished Figs. 753 and 754 (Monks).

stretch, "are straight, large, and regular, and rarely give off branches to the mesentery," and are about 5 cm. long. In the lower third they are usually less than 1 cm. long,

are smaller, are not quite so straight, are not so regular, and give off numerous mesenteric branches. Monks further shows that fat impairs the translucency of the mesentery. The thinnest mesentery is that connected with the upper gut. As we descend the mesentery becomes thicker and thicker because of fibrous tissue, unstriated muscle, and fat. Translucency varies greatly. If a loop of upper intestine is raised against the light, one notices close to the gut and between the vasa recta transparent lunettes. The lunettes become smaller and fatty as we descend, and disappear at the eighth foot. In an incision in the median line, if the loop of intestine is pulled downward, we can determine if "the line of resistance from above is from the median line of the body or from the left or right of it." This resistance of the mesentery indicates to which point the loop is attached, and hence what portion of bowel the loop comprises. I have used these observations of Monks repeatedly to great advantage.

Rupture of the Liver.—(See page 1016.)



FIG. 756.—A loop of intestine at 20 feet. The gut appears to be thick and large. The mesentery is quite fat and opaque, and large and numerous fat tabs are present. The vessels, which are complicated, are seen with difficulty, and are represented by mere grooves in the fat. The subject was a stout woman, and the entire length of the gut was 21 feet (Monks).

Rupture of the gall-bladder and the bile-ducts (see page 1016) is most apt to happen from injury when gall-stones exist. Peritonitis, general or local, is almost certain to follow such a rupture. Besides those symptoms common to all severe abdominal injuries there may be intense jaundice.

Treatment.—Suture the laceration or make a biliary fistula.

Rupture of the Pancreas.—(See page 1036.)

Rupture of the Spleen.—(See page 1044.)

Rupture of Mesenteric Arteries.—The symptoms are those of hemorrhage. The superior mesenteric artery, the inferior mesenteric artery, or branches of either or both may be damaged. If branches of the superior mesenteric artery are divided near the bowel, gangrene of the bowel will result, but wound of a branch far from the intestine does not cause gangrene. The branches near the gut are terminal arteries, hence the gangrene. The branches of the artery divide and form arcades arranged concentrically and the terminal arteries come from the peripheral arcades. In wounds of the vessels far removed from the gut anastomosis prevents gangrene (Labastie in "Archives Générales de Chirurgie," Jan. 25, 1908). In most cases in which there has been rupture of mesenteric arteries death from hemorrhage rapidly occurs. If the victim should not die of hemorrhage he is in danger of gangrene and peritonitis.

Aldrich[1] reported a case in which death was deferred until the seventh day. The treatment is immediate laparotomy. If the wound is found close to the gut, the portion of gut supplied by the cut vessel should be resected. If well removed from the gut, simply ligate the vessel (Labastie, Ibid.). In a wound near the root of the mesentery perform extensive resection of the gut and remove also a portion of the mesentery.

Rupture of the Kidney.—(See page 1277.)

Rupture of the Ureter.—(See page 1279.)

Wounds of the Abdominal Wall.—Non-penetrating wounds are to be treated on general principles. They are sutured with great care and are firmly supported externally. Ventral hernia may follow a large wound.

Penetrating Wounds.—The *symptoms* of penetrating wounds of the abdominal wall are usually those of shock and hemorrhage, and later of septic peritonitis. Emphysema is apt to occur and viscera may protrude, and often do in the case of a large incised or lacerated wound. Extravasation of contents of intra-abdominal viscera is very apt to occur, and is sure to occur if the viscus was distended when injured. Normal urine and normal bile may do little harm, but if either excretion is septic, disastrous consequences are certain to ensue. If intestinal contents escape, septic peritonitis is sure to arise. Bleeding is usually profuse and prolonged, because spontaneous arrest of hemorrhage from any vessel of considerable size will seldom take place unless the abdomen be opened.

Treatment.—The surgeon endeavors to discover promptly if a wound of the abdominal wall is or is not penetrating in character. This fact may be proved by protrusion of viscera, by the appearance of stomach contents in the wound, or by a flow of bile, urine, or feces from the wound. If none of the above indications exists, and if there are no signs of serious hemorrhage, the wound should be irrigated with hot salt solution, and should be dressed with gauze, and every effort should be made to bring about reaction; otherwise operation should be immediate.

When reaction is obtained, the wound should be enlarged layer by layer until it becomes obvious whether or not the peritoneum is open. Madelung,[2] of Strassburg, points out that incision layer by layer will be of no use in settling the question of penetration if the wound is in the chest, the buttock, the perineum, or the back of a fat individual. If after incision layer by layer it becomes evident that penetration has not occurred, the wound should be closed and treated on general principles. If it becomes evident that it has occurred, the abdomen should be opened at the point of penetration, and a thorough exploration of intra-abdominal structures should be made in order to locate injury and be able to treat it properly.

In a case still doubtful after incision by layers, do an exploratory laparotomy in the middle line. It is impossible from the appearance of the wound and it may be impossible from the symptoms to affirm that visceral injury has not occurred; hence in every case in civil practice in which it is evident that penetration has occurred, laparotomy is necessary in order to detect and correct intra-abdominal injury, and to clean the peritoneum by flushing with hot salt solution. If viscera protrude, they must be washed off with hot salt solution and covered with hot sterile pads, and after the patient has reacted the wound should be enlarged, the condition of the contents of the abdomen investigated, hemorrhage arrested, wounds properly treated, and the viscera returned.

It is customary to flush the belly with hot salt solution, some of the fluid being allowed to remain. This procedure mechanically cleanses the peritoneum, removes blood-clots, strongly combats shock, and antagonizes infection. It is not absolutely necessary to flush out the belly unless a considerable hemorrhage has occurred or feces or stomach contents have been extravasated. If extravasation of stomach contents or feces has occurred, not only should flushing be practised, but evisceration should be carried out; the fouled intestine should be wiped off with gauze pads wet with hot salt solution, and while extruded should be kept wrapped in hot moist towels; the peritoneal fossæ should be rubbed with gauze pads and the space between the liver and the diaphragm should be carefully wiped.

A wound of the stomach should be sutured; a wound of the bowel may be sutured, or resection and lateral anastomosis or resection and end-to-end suturing may be required. Visceral injuries are treated by appropriate means. In a punctured wound or a gunshot wound of the intestine rectal insufflation of hydrogen gas when the abdomen

[1] "Annals of Surgery," March, 1902.
[2] Ibid., Sept., 1897.

is open may disclose the situation of the injury, but evisceration is usually practised instead and is preferable.

After the completion of intra-abdominal manipulations the surgeon restores any protruding bowel.

Drainage is required if the contents of the stomach or the intestines escaped, if hemorrhage was severe, or if the liver, pancreas, kidney, or spleen were found to have been damaged. The peritoneum may be sutured with a continuous suture of catgut; the muscles and fascia, with continuous or interrupted sutures of catgut, and the skin, with interrupted sutures of fine silk or silkworm-gut. If there is need of haste, through-and-through sutures of silkworm-gut may be used. Active stimulation and artificial heat are needed immediately after the operation to combat shock. In many cases intravenous infusion of hot normal salt solution is given. It is of great value. It may be given both during and after operation. Enteroclysis, or high rectal injection of hot saline fluid, is useful. So is hypodermoclysis, or the subcutaneous injection of hot salt solution. The usual after-treatment consists of the semi-erect position, continuous proctoclysis of salt solution, avoidance of food by the stomach for forty-eight hours, and the administration of brandy and water from time to time. For two days the patient should be fed by the rectum. On the appearance of flatulent distention, forty-eight hours or more after the operation, give a saline cathartic. It is not wise to purge during the first forty-eight hours after the operation unless a Murphy button has been used. When there is no evidence of distention a purge should not be given until the fourth day. After forty-eight hours liquid food can usually be given by the stomach. Solid food may be given after seven or eight days, but the patient must not leave his bed until the abdominal wound is firmly united because of the danger of ventral hernia. A support should be worn for a long time. E. D. Fenner[1] reports 39 stab wounds of the abdomen operated upon in the Charity Hospital of New Orleans. There were 9 deaths (23.07 per cent.).

Gunshot Wounds of the Abdomen.—The bullet may penetrate from the front, the side, the back, the chest, the buttock, or the perineum. If a bullet has penetrated, it may or it may not have produced visceral damage; a revolver bullet or the bullet of a sporting rifle almost invariably does. A projectile of a modern military rifle may not or may produce wounds which can be recovered from without operation. A urinary examination should be made promptly to see if blood is present. Note if the wound is perforating.

In gunshot wounds of the belly shock is usually greatly added to by hemorrhage, and in civil practice prompt operation is certainly indicated. The incision is made through the belly even when the shot entered the back. In some cases the opening is made through the wound; in others it is not; but in every case the wound made by the bullet is explored, excised, and disinfected. The incision should be long enough to permit of thorough work. After opening the abdomen our first duty is to arrest hemorrhage, our next is to look for perforations of the viscera and mesentery and close them. If the anterior wall of the stomach is perforated, close the opening and examine the posterior wall through an opening made in the gastrocolic omentum. If a posterior perforation is found, close it, and inaugurate posterior drainage from the lesser peritoneal cavity. As a rule, an intestinal perforation can be closed, but occasionally a portion of the intestine requires resection. If the bullet is encountered it is removed, but a prolonged search for it should never be made. Finally, the abdominal cavity is cleansed, drainage is provided for, and the abdominal wound is closed. In one of my fatal cases the bullet entered the rectum low down and was not found. In a case of mine with 6 perforations of the small intestine recovery followed operation.

E. D. Fenner[2] reports 113 gunshot wounds of the abdomen operated upon in the Charity Hospital of New Orleans; there were 78 deaths (69 per cent.). In a series of 14 cases operated upon by Vaughan the mortality was 64 per cent. ("Amer. Jour. Med. Sciences," Feb., 1906).

Military surgeons have taught that wounds inflicted by the modern hard-jacketed projectile are not so apt to involve fatal hemorrhage and disastrous complications; in fact, such wounds are often recovered from without operation, and sometimes with an entire absence of serious symptoms. Again, it is difficult or impossible to treat such cases as in civil practice, even were it desirable. The belief has been until recently that in military practice the results are slightly better from expectant treatment, whereas in civil practice expectant treatment is a dismal failure. Still, even in war,

[1] "Annals of Surgery," January, 1902.

[2] Ibid., January, 1902.

if conditions permit, operation should be performed if there is hemorrhage or obvious visceral injury, or if septic peritonitis develops. Treves says that in the Boer War only 40 per cent. of cases of gunshot wounds of the abdomen not operated upon died, but, as pointed out by Hildebrandt, many cases die on the battlefield and while being taken to the hospital, hence the real mortality of these injuries is much more than 40 per cent. In the war between China and Japan the mortality from gunshot wounds of the abdomen is said to have been about 77 per cent.

Abdominal Wounds in War.—In the beginning of the World War surgeons were imbued with the conviction of Sir Frederick Treves that in gunshot wounds of the abdomen abstention from operation was the safer course. They were dominated by the axiom Sir William MaCormac put forth after the Boer War, viz., "those shot through the abdomen will live if let alone and will die if operated upon." After four years of violent war most surgeons concluded that the policy of abstention was a ghastly failure. It is true that the mortality was fearful even after operation, but, weighing up everything, I believe that the balance tipped strongly in favor of early operation.

Early operation is often impossible. Any operation may be out of the question because of lack of time, assistants, and materials—because of close adjacency to the line of battle—or because of military necessity demanding evacuation. As yet figures are not conclusive. Claims are made for both sides of the controversy. The advocate of one view is certain to dispute conclusions and perhaps statements of the advocate of the other view. Distinguished surgeons are found in opposition. The published facts lead us to side with Tuffier when he says that if the surgeon has the necessary time, assistants, and equipment operation gives a better prognosis than abstention. Reports demonstrate the following truths: Shell fragments cause the worst, rifle bullets the least serious injuries. The least serious wounds are those above the level of the pylorus.

A wound from side to side is extremely grave. So is a vertical wound. Anteroposterior wounds in the midline are usually rapidly fatal because the spine, aorta, or the vena cava is very apt to be struck (Wallace in "Lancet," 1915, clxxxix). Rifle bullet wounds of the liver, if anteroposterior, and through-and-through, may be recovered from without operation. Oblique wounds, tangential injuries, and shell wounds give a far worse prognosis. The kidney is apt to be injured. Midline anteroposterior wounds are more fatal in the hypogastric than in the epigastric region. A wound of the buttock, thigh, or perineum may enter the peritoneal cavity.

Exploratory operations have proved that a bullet can cross the peritoneal cavity without opening a hollow viscus. In such cases the peritoneal coat of the stomach or intestine may be bruised or torn. Hence it is possible for a rifle bullet to push a hollow viscus out of the way and not perforate it (Wallace, Ibid.). This can only occur when the bullet is traveling with great velocity and the viscus contains very little fluid. Only in such cases is spontaneous recovery possible. Wounds of the large intestine are usually associated with pelvic fracture, wound of the bladder, or damage to nerve trunks. They are more fatal than wounds of the small gut. Wounds of the small gut are often multiple.

In wounds of the liver, spleen, and pelvis hemorrhage is the imminent danger. In wounds of the hollow viscera infection is the great peril.

There may be no rigidity of the abdomen. It is especially prone to be absent when admit there is hemorrhage. Early operation is the indicated treatment if circumstances of it, even if the surgeon must operate without an assistant. As Keen says: "Every hour diminishes such a patient's chance of recovery" ("Treatment of War Wounds").

Wallace, Hughes, and Rees show that operations done within six hours are followed by 62.8 per cent. of recovery; those done between six and twelve hours, only 36.3 per cent.—those done between twelve and sixteen hours, 16.6 per cent. The earlier operations were of course upon the most dangerous cases (see Wallace, in "Brit. Jour. of Surgery," iv; Hughes and Rees, in "Lancet," April 28, 1917; Walters Robinson, Jordan, and Blacksmith in "Lancet," Feb. 10, 1917). Certain it is that intestinal operations are peculiarly fatal if seen late. Bowlby will not operate on such a case if it is seen later than thirty-six hours after the injury because operation offers scarcely the shadow of a chance ("Lancet," Feb. 10, 1917).

Bowlby does not operate on a through-and-through wound of the liver, believing that if the hemorrhage is not rapidly fatal recovery may follow. Liek saw 17 gunshot wounds of the liver recover without operation ("Arch. f. klin Chir.," 1916, cvii). If there is no evidence of severe bleeding he secures rest and gives morphin. If there are signs of continued hemorrhage he operates and finds the mortality to be 29 per

cent. If a patient wounded in the abdomen is suffering from hemorrhage immediate operation is imperative. If there is severe shock but no progressive hemorrhage many surgeons endeavor to establish reaction before operating. Lockwood and his associates consider the pulse a valuable guide. If the pulse is above 120 they postpone operation until reaction occurs ("Brit. Med. Jour.," March 10, 1917). Walters and his associates also regard the pulse as a valuable guide ("Brit. Jour. of Surgery," iv). Webb and Milligan ("Brit. Jour. of Surgery," iv) say that a pulse above 110 gives a bad prognosis for operation, a pulse of under 85 gives a good prognosis. As a rule the incision should be median and should not include or cross the wound (see Fraser in "Brit. Med. Jour.," 1916, i). The situation of the wound or wounds determines where the incision is to be placed. An escape of feces, bile, or urine from the wound gives us valuable information. Foreign bodies, especially bits of clothing, must be removed. If they are allowed to remain fatal sepsis is almost inevitable. Excision of the wound in the abdominal wall is advocated by many.

In intestinal wounds suture is preferred to resection unless there "is extensive damage to the mesentery or extravasation between the two layers of the mesentery at its attachment to the bowel" (Views of Fraser and Drummon as set forth by Keen in "Treatment of War Wounds"). A kidney damaged by a gunshot wound may recover. If nephrectomy is demanded it should not be done immediately except for hemorrhage (Fullerton in "Brit. Jour. of Surgery," v).

Many cases are closed without drainage. Many others are drained. All are placed in the Fowler position and are given salt by the plan of Murphy. In some cases suprapubic drainage is used. The wound inflicted by the missile should be excised; sometimes it is sutured; sometimes it is drained.

Bowlby ("Brit. Med. Jour.," June 2, 1917) published the following statistical table:

	Cases.
Considered with view to operation	1038
No operation advised	73
Number of operations	965

	Per Cent.
Total operative mortality	53.9
Total hollow viscera mortality	64.7
Mortality from uncomplicated stomach wounds	52.7
Mortality from uncomplicated wounds of the small gut	65.8
Mortality from uncomplicated wounds of the colon	58.7

Gunshot Wounds of the Pregnant Uterus.—It is rarely that both walls are perforated by a revolver bullet, as the force of the bullet is greatly lessened by the uterine contents. A rifle bullet usually passes through the organ. Wounds by shell fragments are extremely grave. There are severe shock and hemorrhage, and occasionally amniotic fluid flows from the wound of entrance. Blood may flow from the vagina. The intestine may also be injured. As a rule labor-pains come on soon after the injury. In Albarran's case the fetus was expelled forty-eight hours after operation. Open the abdomen in all cases and empty the uterus. If the patient is late in pregnancy, empty by Cesarean section. Hysterectomy is indicated if the uterus is seriously torn. All cases should be drained (Smead) in "Trans. of Assoc., Obstetrics and Gynecology," 1916. Gellhorn[1] has collected 18 cases. In this series there were 12 recoveries. Smead cites 30 cases. Russel Fowler reports a case of a patient eight months pregnant who was shot twice in the abdomen. There were two wounds in the uterus. Fowler did a Cesarean operation. The incision in the uterus was made by enlarging one of the bullet wounds. The other bullet wound was sutured. The baby was wounded on the fingers of the right hand. Both mother and baby recovered ("New York State Jour. of Med.," Nov., 1911). In Judge's case ("Jour. Amer. Med. Assoc.," vol. i, 1912), a girl of sixteen, nearly at full term, was shot with a Winchester rifle. The child was in the abdominal cavity and dead. The mother recovered. Tucker, of Shanghai, did a Cesarean operation for gunshot wound of the uterus. The mother died and the child survived.

Omental Cysts.—Cysts may spring from the outer surface of the omentum (escaped ovarian cysts, lymphatic cysts, dermoids).

True omental cysts arise within the cavity of the great omentum. Cysts may result from lymph blocking, degeneration of lymph-glands, hematomata, embryonic

[1] "St. Louis Med. Review," Dec. 2 and 9, 1901.

rests, or developmental errors. Some are neoplastic. Teratomata and fetal inclusions are at times encountered (see Arzela, as quoted in "Int. Abstract of Surg.," Dec., 1922). In 50 per cent. of cases the patient is an adult, but in half of the reported cases the patients have been under ten years of age. Some of the cysts are probably of embryonic origin. Dowd is inclined to think that the cyst he removed resulted from omental hematoma ("Annals of Surgery," Nov., 1911). In his case there was torsion of the pedicle of the cyst. Dowd (Ibid.) reports 1 case of omental cyst and collected 37 from literature. Hasbrouck ("Annals of Surgery," Aug., 1908) maintains that the condition is much more common in females than in males, that there are no characteristic symptoms, that the condition begins as omental endothelioma between the two surfaces of omentum which fuse because of inflammation and form a closed sac, that hemorrhages are apt to occur into the cyst, and that operation shows a mortality of 6 per cent. The operation performed is extirpation. A cyst may become adherent to the small or large gut.

Mesenteric Cysts.—These rare cysts are divided into (1) embryonic, (2) hydatid, (3) cystic malignant disease (Dowd, "Annals of Surgery," 1910). A great majority of mesenteric cysts are embryonic. Moynihan believes that embryonic cysts arise in "rests" from "the Müllerian or Wolffian organs or ducts, or from the ovary," which are included between the folds of mesentery. These rests undergo cystic degeneration. Miller ("Bull. Johns Hopkins Hosp.," 1913, xxiv) classifies mesenteric cysts as follows:

1. Cysts of intestinal origin:

(*a*) By sequestration occurring during development of the bowel.

(*b*) From Meckel's diverticulum when it arises from the concave side of the intestine (intramesenteric diverticulum).

2. Dermoids.

3. Cysts springing from retroperitoneal organs (duct of Müller, body of Wolff, ovary, or germinal epithelium). Mesenteric cysts grow and pass along between the layers of mesentery until they reach the gut and then compress the gut and push its wall ahead of them. A cyst may cause intestinal obstruction. Volvulus is one of the results.

Such a cyst may contain embryonal material, bloody fluid, serous fluid, chylous fluid, or lymph. In Harry C. Deaver's report of a case ("Annals of Surgery," May, 1909) it is shown that in 40 cases there were 25 females and 15 males; that the size varies from that of a split pea to enormous dimensions; that there may be a pedicle form in front of the vertebral column or from the intestinal wall; that the sac wall may be exceedingly thin or as much as 1 cm. in thickness; that in some cases large veins are present on the surface of the cyst; that adhesions to the abdominal viscera are common; that intestinal obstruction may occur (kinks, volvulus, intussusception); that cysts are most commonly found in relation with the lower end of the ileum; and that there are no characteristic symptoms except perhaps the rapid body wasting mentioned by Moynihan. Moynihan also points out that the cyst fluctuates and is most prominent toward the navel, that it is very mobile, especially transversely (we should add if not anchored by adhesions), and that the cyst is surrounded by a resonant zone and crossed by a resonant band.

Treatment.—Incision and drainage if there are numerous and firm adhesions. Enucleation whenever possible. Resection of the involved portion of gut with the cyst in some cases.

Torsion of the great omentum is usually caused by a fall or strain or attempts to reduce a hernia. In nearly all cases a hernia is present. Hedley ("Brit. Med. Jour.," Nov. 11, 1911) studied records of 73 cases. In 60 there was or had been a hernia. In 5 cases without a hernia there were adhesions. In 48 of the hernia cases the omentum was attached in the sac, in 4 it was anchored near the sac, in 3 to the bowel, and in 1 to the Fallopian tube.

Symptoms are like those of a strangulated omental hernia or of appendicitis.

The **treatment** is by laparotomy.

Stomach and Intestines

Foreign Bodies in the Stomach and Intestines.—Foreign bodies of considerable size are rarely taken into the alimentary canal except by children, insane people, or drunkards. Small bodies (bits of straw, fragments of bone, etc.) are frequently swallowed. Most foreign bodies swallowed are passed with the feces, but some lodge in the stomach or intestine. Any body which can pass the esophagus is not too large

to pass through the intestines. Lodgment is an accident, not an inevitable consequence—an accident which is due to the shape and size of the body. A foreign body may lodge in the stomach. In some cases there are no symptoms or slight symptoms. In other cases symptoms are violent. The severity of the symptoms depends upon the shape and character of the body. Some nervous women have a tendency to chew and swallow bits of their own hair. If a person continues doing so for years a *hair-ball* (*trichobezoar*) may form. It consists of a tangled mass of hairs agglutinated together by mucus and food remains. It grows slowly. When small it acts like a ball-valve at the pylorus ("Dyspepsia," by W. S. Fenwick), when large it fills the stomach and is molded to the shape of the organ. Matas reported an interesting case of hair-ball ("Tr. Southern Surgical and Gynecological Assoc.," 1914). A hair-ball gives rise to dyspeptic symptoms. If the ball is large it causes pain and can be palpated. The *x*-rays make the diagnosis. I have seen 1 case. Operation was declined.

Persons who have acquired the habit of drinking an alcoholic solution of shellac may eventually have a mass gather in the stomach. An addict usually tries to precipitate the resin before drinking by mixing with water. A *phytobezoar* is a food ball composed of the skins of fruit or vegetables, seeds, or vegetable fibers. W. E. Hart ("Jour. Amer. Med. Assoc.," Dec. 1, 1923) mentions persimmons, prunes, celery, muscle and elastic fiber, starch granules, and crystallized fatty acids as constituents of phytobezoars.

In some cases it is possible to feel the body from without. A metal body in the stomach will deflect a magnetic needle held over the viscus (Polaillon). Many foreign materials can be skiagraphed. A body of small size may pass through the entire canal and emerge without having done any harm, but it may lodge and may cause perforation. If perforation occurs, the foreign matter may become encysted, for instance, in the mesentery; may cause an abscess or may cause general peritonitis. A fish-bone may cause an anal abscess. An epiploic appendix may cause sacculation of the bowel, perforation by a foreign body may take place in this sac, an *epiploic abscess* resulting, which may attain considerable size and may be mistaken for carcinoma (Sir J. Bland-Sutton, in "Lancet," Oct. 24, 1903). It is not wise to attempt to recover a foreign body from the stomach by inducing vomiting. For all pointed bodies and for many others gastrotomy is necessary. When a small or sharp foreign body has been swallowed and has not caused perforation, abscess, or obstruction, the usual treatment is as follows: a purgative should *never* be given to expedite the passage of a foreign body, because increased peristalsis increases the danger of impaction or of perforation. Endeavor to encrust the foreign body, and thus lessen the danger of perforation, by feeding with bread and milk only for several days, and at the end of this period give a mild laxative. An exclusive diet of mush or of mashed potatoes has been suggested. Suet dumplings may be given. Pain is relieved by opium. A foreign body rarely lodges in the duodenum, but may lodge lower down, and may cause ulceration, perforation, abscess, or intestinal obstruction. Operation is necessary in such cases.

Volvulus of the Stomach.—This condition is very unusual. According to T. Kocher 28 cases were on record ten years ago, and of these, 18 were operated upon ("Internat. Abstract of Surgery," Dec., 1914). The condition may be inaugurated by vomiting, peristalsis after vomiting, by body movements or abdominal trauma when the stomach is prolapsed and dilated, or by a tumor. One-third of the cases are associated with diaphragmatic hernia and one-fourth with hour-glass stomach. The symptoms come on suddenly. There is violent abdominal pain. Distention and collapse are early. There is nausea, but the patient can neither vomit nor belch. In the upper left abdomen there is a tender, tense, and tympanitic area. The rotation of the stomach may be on its vertical or on its longitudinal axis. An hour-glass stomach may undergo twisting on its vertical or on its longitudinal axis. Berg operated successfully for volvulus of the stomach. He opened the abdomen, relieved distention by tapping the stomach with a trocar, and then easily corrected the twist. The gastrohepatic omentum should be shortened by Beyea's operation (see page 1087). Kocher had a case in which an hour-glass stomach twisted. At the first operation he untwisted the organ. At a second operation gastro-enterostomy was performed upon the larger sac. The patient was cured ("Internat. Abstract of Surgery," Dec., 1914).

Fibromatosis of the Stomach.—This condition was long ago described by Brinton as cirrhosis of the stomach. Over ten years ago Alexis Thomson published an admirable description containing many new things ("Annals of Surgery," July, 1913). He shows that ulceration of some form is the cause (simple ulceration or cancerous ulceration). The condition may be and commonly is localized, but it may involve the entire

stomach ("leather-bottle stomach"). There may be glandular enlargement. The local form starts at the pylorus and resembles cancer, but is not nodular. There may or may not be adhesions. There is no "cicatricial stenosis of the pylorus," but the canal of the pylorus is narrowed by submucous thickening. The thickening is not scar tissue, but is more like a fibroma (Ibid.). Thickening is probably a reaction against infection. Thomson proves that there is an innocent form of fibromatosis, and thinks it probable that there may even be an innocent form of leather-bottle stomach (Ibid.).

The **symptoms** suggest ulcer, cancer, or some sequel of ulcer. It is often possible to be mistaken as to the nature of the mass even when it is exposed by exploratory incision. The cases of "pyloric cancer" which have recovered after gastro-enterostomy and some of the cures of gastric cancer by gastrectomy are explained when we know how easy it is to mistake innocent fibromatosis for cancer.

Treatment.—Thomson always insists on an immediate microscopic examination of a portion of the tumor or, better, of an enlarged lymph-gland. He advocates resection for local fibromatosis because he believes cancer is liable to arise. In some cases gastro-enterostomy is performed; in some, jejunostomy.

Carcinoma of the Stomach.—Innocent tumors and sarcomata occasionally attack the stomach, but they are infinitely rare in comparison with primary cancer. In only 1 per cent. of cases is cancer secondary (Friedenwald, "Amer. Jour. Med. Sciences," 1914, cxlviii). Cancer is a common disease, in fact, "30 per cent. of all cancers in civilized man are in the stomach" (William J. Mayo in "Surgery, Gynecology, and Obstetrics," 1918, xxvi). The reason for this great gastric liability to cancer is unknown. Mayo (Ibid.) thinks it may be caused by hot drinks. Steadman ("Brit. Dental Jour.," Dec. 1, 1923) maintains that oral sepsis is the common cause of cancer of the alimentary canal. The "Lancet," Dec. 15, 1923, inquires, if this is the case, why should cancer of the buccal cavity be seven times as common in males as in females, when both are equally liable to pyorrhea. This disease is unusual before the age of forty, and is very seldom seen before the age of thirty. The period of greatest liability is between the ages of forty and sixty. I operated upon a man of twenty-three for gastric cancer. It is more common in men than in women, the proportion being as 5 to 4. Beyond question, in some cases cancer arises from the margins of an ulcer. We used to regard such an origin as extremely rare. We now look upon it as far from uncommon. In the Mayo Clinic it is thought that 70 per cent. of cases thus originate. Friedenwald from a study of 1000 cases decided that 7 per cent. exhibit a definite history of ulcer, but in only 23 per cent. of the cases could the cancer have arisen from an ulcer ("Amer. Jour. Med. Sciences," 1914, cxlviii). In over half the cases there is a history of overeating or overdrinking. The forms of cancer which may arise in the stomach are the spheroidal cell growth (either the hard form known as scirrhus or the soft form known as medullary or encephaloid), the cylindric cell growth or adenocarcinoma, and colloid (due to the myxomatous degeneration of either a spheroidal cell or a cylindric cell carcinoma). Scirrhus more than any other form produces constriction of the pylorus and less often than any other produces hemorrhage. It may spread for a considerable distance along the submucous coat, muscular coat, and subserous coat without apparent involvement of the mucous membrane wide of the primary focus of disease. Fibromatosis may develop about it. In some cases scirrhus is limited to the pyloric region, in others it is a limited tumor of some other part of the wall of the stomach. In the condition known as malignant "*leather-bottle stomach*" a scirrhus has invaded the entire stomach wall, or fibromatosis has developed about the cancer and the wall of the viscus is thick and rigid.

Medullary cancer and adenocarcinoma always produce hemorrhage. Both of these forms most often arise in the pyloric region. Medullary cancer may remain limited, but, as a rule, a cauliflower growth arises and eventually fills the stomach and portions of the mass may slough away.

Adenocarcinoma is apt to spread along the mucous membrane instead of "infiltrating the deeper layers," as other forms are prone to do ("Cancer and Tumors of the Stomach," by Samuel Fenwick and W. Soltau Fenwick). Spheroidal celled carcinomata are twice as common as cylindric celled, and medullary cancer is about as common as scirrhus. Any cancer may be accompanied by fibromatosis.

Cancer may be limited to the body of the stomach (either curvature or either wall), the pyloric end or the cardiac end, but it may involve two of these regions or almost the entire stomach, or, being multiple, may be found in many parts. Sometimes there is a primary cancer on one wall, and another growth, due to contact, on

a corresponding point of the opposite wall (*contact cancer*). All forms of carcinoma most frequently begin in the region of the pylorus. In many cases of gastric carcinoma adhesions form between the stomach and the liver, pancreas, colon, or diaphragm. Even in cancer of the pylorus the duodenum is seldom invaded. Medullary cancer not unusually passes into the esophagus. Gastric cancer is usually fatal in from four months to two years, and most patients die within one year. In 60 per cent. of cases the pylorus is involved. In 80 per cent. of cases the lesser curvature is diseased. In over half of the cases of cancer of the pylorus there is no important lymphatic involvement (McArdle). In investigating any gastric disorder follow the advice of the Mayo brothers and study the history of the case, the size and situation of the stomach, the existence and situation of pain and tenderness, the presence of a tumor, and whether or not the passage of food is unhampered.

Symptoms.—Examine with care a patient in whom cancer is suspected. In unusual cases (1 per cent. of all cases) it produces no symptoms until it has lasted for some time and has attained a large size (latent cancer). There may then be a sudden hemorrhage or a rapid development of other symptoms. In nearly all cases it does produce symptoms fairly early. The growth exists for a time before symptoms arise and they may arise gradually or almost suddenly. The gradual onset is marked by indigestion and physical weakness. In over nine-tenths of the cases the patient has persistent dragging pain, which usually is increased by eating and pressure, and attacks of vomiting are frequent. In seven-tenths of the cases there is definite tenderness. After a short time the victim of cancer becomes very weak and exceedingly anemic, and it is often possible to feel a tumor in his stomach. Blood examination shows diminution of red corpuscles and hemoglobin and perhaps absence of any increase of leukocytes after a full meal. There is rapid loss of weight and strength. The general tendency is downward, but now and then there may be temporary gain in weight and strength. Cachexia is not deferred long. The vomiting of a patient with gastric cancer is at first occasional only, but as the case progresses it becomes more and more frequent. Vomiting soon after eating occurs when the cardiac region is involved; vomiting an hour or so after eating occurs when the pyloric end is involved. When the body of the organ is the seat of disease, vomiting may be absent. The vomited matter in nine-tenths of cases is mixed with a small amount of altered blood (*coffee-ground vomit*). As a matter of fact the vomited matter looks more often as though it were mixed with soot than with coffee grounds (*sooty vomit*). In one-fourth of the cases there is definite melena and in most cases occult blood is found in the feces, especially if hydrochloric acid be absent from the stomach contents. These symptoms above cited associated with the absence of hydrochloric acid and lactic acid in the stomach contents are strongly indicative of cancer (William J. Mayo in "Surg., Gynec., and Obstet.," May, 1908). A *test-meal* is given, and important conclusions are sometimes derived from the presence or absence of hydrochloric acid and lactic acid. It is my custom to have the stomach washed out and then have Ewald's test-breakfast given. This consists of one roll of white bread (35 gm.), 400 gm. of H_2O, and 400 gm. of tea without milk or sugar. In one hour the stomach is emptied by means of a tube and a pump or a tube and abdominal compression, and the material is examined. If the result of the test seems out of accord with the other symptoms, repeat the process (L. Boas in "Berlin. klin. Woch.," No. 440, 1905). In most cases free hydrochloric acid is not found in the stomach contents, but lactic acid is found and Oppler's bacillus can often be detected. There may be red blood-corpuscles in the fluid. If the cancer is not ulcerated, free hydrochloric acid will probably be found; if it is ulcerated, it will usually be absent.[1] Free hydrochloric acid may be absent from the stomach because of atrophy of glands, cessation of secretion, or neutralization by the products of the cancerous area. Friedenwald (Ibid.) says that 89 per cent. of cases exhibit anacidity, 3 per cent. normal acidity, 4 per cent. hyperacidity, 3 per cent. subacidity. Lactic acid is present in 81 per cent. of the cases, Oppler's bacillus in 79 per cent., sarcinæ in 32 per cent., coffee-ground matter in 71 per cent. I believe that a cancer arising from an ulcer is apt for a time to be accompanied by hyperacidity, and that the advent of anacidity is delayed. Free hydrochloric acid may be absent in individuals in whom cancer does not exist. I have noted its absence in several cases of cicatricial stenosis of the pylorus.

It may be absent in cancer of the esophagus, advanced Bright's disease, cancer of the duodenum, distant cancer, febrile conditions, and amyloid disease. The con-

[1] Reissner in "München. med. Woch.," Dec. 3, 1901.

stant presence of considerable quantities of hydrochloric acid is strong evidence against the existence of cancer of the stomach. An *x*-ray examination is imperatively necessary.

Distend the stomach with gas or fluid and map out its outlines. Feel for a tumor. A tumor can usually be felt if it involves the greater curvature or anterior wall, and a large tumor of the pylorus can be palpated, but in other regions the tumor can rarely be felt. In Friedenwald's 1000 cases a tumor was palpable in 72 per cent., but in only 30 per cent. within the first six months after the appearance of symptoms (Ibid.).

Cancer of the cardiac end interferes with the entrance of food into the stomach, and in such a case the stomach is shrunken and the esophagus is dilated immediately above the growth. In cancer of the pylorus the food is partially or completely arrested as it is being urged on to pass the pylorus, and the stomach becomes much dilated. Dilatation occurs in nearly half the cases. The vomited matter in a case of cancer rarely contains recognizable fragments of the growth, but fluid with which the stomach has been irrigated may contain pieces which can be identified as cancer (Rosenbach).

In cancer of the stomach the general course of the temperature is normal, but there are occasional deviations to below or above normal. Febrile seizures occur in nearly half the cases. In many cases the urine contains albumin, indican, acetone, and casts. Occasionally cancer of the stomach produces spasm of the esophagus. I have seen this in several cases. Cancer of the stomach is apt to involve secondarily adjacent lymph-glands (especially along the lesser curvature), or other structures, especially the liver; in fact, the liver is involved in 30 per cent. of the cases (Welch). Occasionally there is enlargement of the supraclavicular glands of the left side. Metastases are usual and early, but in cancer of the pylorus over half of the cases show no distinct lymphatic involvement. In many doubtful cases exploratory incision is required imperatively. Friedenwald (Ibid.) shows that the average expectation of life is less than one year in 66 per cent. of cases, between one and two years in 22 per cent., and over two years in 11 per cent.

Treatment.—The *medical* treatment consists in milk-diet, the use of morphin, and of *lavage* if the pylorus or body of the stomach be diseased. Perform lavage as follows: The tube for lavage should be long enough to extend about 3 feet out of the mouth when the other end is in the stomach, it should be flexible, should have an opening in the stomach end and another opening on the side about 1 inch above the stomach end. The tube should be chilled in a bowl of cracked ice and greased with glycerin. The patient sits down, throws the head back, opens the mouth widely, and is directed to take deep breaths at regular intervals. The tube is carried into the pharynx, the patient is ordered to make efforts to swallow it, and the tube is thus taken into the stomach. About 1 quart of fluid is poured into the funnel-like end of the tube, and just before the tube empties itself of the last of the water the funnel is lowered and the liquid runs out. This proceeding is repeated until the washings become clear. The best fluid to use is a solution of bicarbonate of sodium, a teaspoonful of the salt to a quart of warm water. Lavage should be practised before breakfast, and sometimes also at bedtime.

The *indications for operation* are well set forth by Macdonald[1]: They are progressive aggravation of symptoms in spite of a rigid diet and medical treatment, loss of gastric mobility, progressive diminution of gastric peristalsis, progressive diminution of free hydrochloric acid, emaciation even under forced feeding, progressive reduction of hemoglobin to 65 per cent. or under, and moderate leukocytosis.

Surgical treatment aims to remove the growth or to obviate the effect of obstruction at one of the orifices of the stomach.

In cancer of the body of the stomach, if the tumor is not extensive, excision of the growth may be performed; if it is extensive, it is useless to attempt it unless the mass is absolutely non-adherent. Conner, of Cincinnati, attempted total excision of the stomach in 1883, but the patient died on the table. In 1897 Schlatter, of Zurich, successfully removed the entire stomach. Brigham, Richardson, Macdonald, Boeckel, De Carvalho, Bardeleben, Haine, Gallet, Dollinger, Ferry, Ribera, and others have successfully removed the entire stomach and attached the esophagus to the small intestine (*complete* or *total gastrectomy*). In the successful cases digestion was satisfactorily performed after removal of the stomach. Very rarely will cases be found suitable for such a radical proceeding. The case suitable for this treatment is one in which the entire stomach is involved in the growth, in which there is no obvious glandular involvement beyond the lesser curvature, and in which the stomach is not adherent, but is freely movable. Herbert J. Paterson ("The Hunterian Lectures for

[1] John B. Murphy in "Chicago Med. Recorder," June 15, 1902.

1906") collected 27 cases of total gastrectomy for cancer; 10 died and 17 recovered. If a small portion of the fundus is left the operation is called *subtotal gastrectomy*. H. J. Paterson (Ibid.) collected 20 cases of subtotal gastrectomy for cancer, with 6 deaths. In limited cancer of the body of the stomach perform *partial gastrectomy*. In cancer of the cardiac orifice of the stomach excision may be possible, as a rule; the surgeon simply keeps the passage open as long as possible by the frequent passage of a tube, and through this tube introduces liquid food. Sometimes a small tube is introduced and permanently retained. When it becomes difficult to introduce a tube, *gastrostomy*, *duodenostomy*, or, preferably, *jejunostomy* may be performed. As a matter of fact, in most cases gastrostomy is done as a last resort, and it is scarcely worth doing in cancer of the cardiac end of the stomach. It is far more useful in cancer of the esophagus. Arch, Kümmel, Sauerbruch, Voelcker, and Zaaijer succeeded in removing cancer of the cardia. In cancer of the pylorus, limited in extent and without lymphatic involvement, *pylorectomy* should be performed. In cancer which has widely infiltrated the coats of the stomach and has involved the lymphatic glands, *gastro-enterostomy* is performed as a palliative measure, the patient during the rest of his life subsisting upon liquid or semiliquid foods and submitting to frequent irrigation of the stomach to remove food residue. In cases of irremovable and far-advanced cancer it is often best to refuse to operate and to create deliberately the opium-habit in the patient, although, in some cases, duodenostomy or jejunostomy may be performed.

The most successful of all the above operations are pylorectomy and partial gastrectomy. The mortality used to be large, but has been greatly reduced during recent years. In the Mayo Clinic over 38 per cent. pass the three-year limit and may be called cures (page 1064). There are in literature many cases which have survived three years or over. In the Mayo Clinic gastro-enterostomy for cancer has a mortality of 8 per cent. It seldom prolongs life more than a few months, although in some cases it does prolong it a year or more.

Sarcoma of the Stomach.—Of recent years it has been proved that sarcoma of this region is more common than was once supposed. There are over 60 cases on record. I have had one case, for which I performed jejunostomy. It can occur at any age, but is more usual in early life than carcinoma. It has been estimated by William T. Howard[1] that 37.7 per cent. of cases are under the age of forty, and 11.44 per cent. are under the age of twenty. The pylorus is involved in about one-fourth of the cases. In most cases the posterior wall and greater curvature are involved. Howard says there is a diffuse growth in 21.31 per cent. of cases and that the cardiac end is involved in only 4.9 per cent. of cases. Sarcoma arises in the submucous coat. Any form of sarcoma may arise. It causes stenosis in less than one-tenth of the cases. There is no sex predisposition in sarcoma. The growth may attain a great size.

Symptoms.—A tumor forms, grows rapidly and often attains a large size, and not unusually actually causes a projection of the abdominal wall. If it ulcerate there will be hematemesis, but it often does not ulcerate, and bleeding is much rarer than in carcinoma. Not unusually this growth arises in a person under forty, and sometimes in one of less than twenty years of age. Stenosis is uncommon. The liver is involved secondarily in only 11.47 per cent. of cases (Howard), metastases are more rare than in carcinoma, free hydrochloric acid is usually absent from the gastric contents, and microscopic examination of washings from the stomach may detect fragments of sarcoma. Certain diagnosis is impossible without exploratory incision. Howard estimates the average duration of life to be from nine to ten months.

Treatment.—If the liver is free and if there are no metastases, partial gastrectomy or complete gastrectomy may be advisable. If pyloric stenosis should arise, gastro-enterostomy may be performed. Scudder ("Annals of Surgery," Aug., 1913) reports a case. He performed jejunostomy. Six weeks later he removed the tumor by partial gastrectomy, closed the jejunal opening, and did anterior gastro-enterostomy. A year later the man remained well.

Ulcer of the Stomach (Peptic Ulcer of the Stomach).[2]—Ulcer of the stomach is a condition due to digestion of a portion of the stomach wall by gastric juice, the destroyed portion having been the seat of lowered vitality. The reason for the lowered vitality of the gastric mucous membrane is uncertain. Venous thrombosis has been suggested as a cause, but it is rare in gastric ulcer. Embolism is assigned by some as a cause, but emboli are seldom found on pathologic examination. Long ago Vir-

[1] "Jour. Amer. Med. Assoc.," Feb. 8, 1902.

[2] There is an admirable collective Review of Gastric and Duodenal Ulcer, by R. C. Coffey, in the "Internat. Abstract of Surgery," March, 1917.

chow was led to suggest, because of the funnel-shaped character of many acute ulcers, that arterial embolism or venous thrombosis was the real cause; "but neither clinically nor experimentally is there any considerable body of evidence in support of this" (Matthew J. Stewart, of Leeds, in "Brit. Med. Jour.," Nov. 24, 1923). There is some evidence that vascular spasm might be responsible for blocking of vessels. It is well known that sudden changes of temperature may aggravate an ulcer and that an ulcer patient has impaired peripheral circulation (Stewart quoting from Hurst, Ibid.). Spasm of the stomach is apt to arise in ulcer cases, but can scarcely be causal. It has been asserted that menstrual disorders may be responsible for ulcer, that tight lacing may be, and that habitually bending over (as in making shoes) may be a cause. Seamstresses, domestic servants, sweat-shop workers, saddlers, carpenters, shoemakers, and sales girls in stores have been thought to have particular liability to ulcer. The very poor are more prone to the disease than the well-to-do or rich. The swallowing of a caustic may be followed by ulcer formation, but the lodgment of foreign bodies seldom is. The taking of very hot food and drink, after the method of Mr. Quilp, is thought by some to be provocative of ulcer. If this were true it is scarcely possible that so many commuters, who gulp their meals, would escape. It is very doubtful if external traumatism is ever a cause. Some have mentioned burns of the surface as an occasional cause. The Mayos are of the opinion that the grinding action of the pyloric portion of the stomach may be a traumatic exciting cause of ulcer of that region. Some assert that mental anxiety, alcoholism, and syphilis may be causal (Alderson). Thirty-two per cent. of the cases in the Mayo Clinic used alcohol. Ulcers due to syphilis and tuberculosis are not peptic ulcers.

It is known that gastric ulcer may arise as a result of general sepsis. Many surgeons believe that focal infection may be causal (dental caries, sinus infection, tonsillar infection, gall-bladder disease, appendicitis, prostatic infection, etc.). Robson attaches much importance to oral sepsis. "Mild sepsis leads to gastritis and hyperchlorhydria, which, in its turn, provokes and keeps up ulceration" (A. W. Mayo-Robson in "Keen's Surgery," vol. iii). Lane thinks intestinal toxemia a common cause. In 140 cases studied by Smithies in the Mayo Clinic ("Collected Papers by the Staff of St. Mary's Hospital," Mayo Clinic, 1912) 26 had had enteric fever, 6 pneumonia, 5 syphilis, 8 malaria, and 27 some other general infection. Twelve had previously been operated upon for appendicitis and 2 for gall-stones. The question of cause is involved in uncertainty. It has long been taught that anemia predisposes to the secretion of very acid gastric juice (*hyperchlorhydria*) and to ulceration. In some cases chlorosis is associated with ulcer. According to William J. Mayo there are three known causal factors of the first importance, viz., anemia, hyperchlorhydria, and traumatism (April 16, 1904). It seems certain that the gastric juice causes ulcer by digesting an area of stomach mucosa which is the seat of impaired function. Normal or even subacid juice may do it. Hyperacid juice is particularly apt to do it. Moynihan found that only 21 per cent. of his cases of gastric ulcer had hyperchlorhydria (Stewart in "Brit. Med. Jour.," Nov. 24, 1923). Moynihan claims that heavy smokers are more liable to ulcer than non-smokers and thinks this is due to the fact that excessive smoking causes hyperchlorhydria. That all cases of hyperchlorhydria are not cases of ulcer is proved by the studies of Bennett and Ryle, who showed that 10 per cent. of healthy persons are hyperchlorhydric (Stewart, Ibid.). That in some way the gastric secretion is responsible for ulcer is proved by the following facts. Peptic ulcers arise only in the stomach, the duodenum, or the jejunum after gastro-enterostomy, and very seldom in the lower gullet.

It used to be stated that ulcers are far more common in females than in males. This statement is not correct. It applies to acute ulcers, but not to chronic ulcers. The surgeon finds chronic ulcers three times as often in men as in women. Up to July 1, 1912, the Mayos had operated on 404 proved ulcers of the stomach, and over 70 per cent. of these patients were males (Smithies in "Collected Papers by the Staff of St. Mary's Hospital," Mayo Clinic, 1912). The acute round ulcer is more common in women, and in young women rather than in those of middle or advanced age. The chronic indurated ulcer is most frequent in men. Men about forty, and women between twenty and thirty are particularly liable to ulcer. Between thirty and forty is the period of greatest liability. I have only once found ulcer in a person under twenty, but ulcers do occur in children and even in infants. There is usually a single ulcer, but in one-fifth of all cases there are two or more, and when there is an ulcer on the anterior wall it is not very uncommon to find one exactly opposite on the posterior wall (*a kissing ulcer* Moynihan calls it). The Mayos divide ulcers into two clinical forms—the *in-*

durated and the *non-indurated*. In the indurated ulcer all the coats of the stomach are involved, and the mass of scar tissue indicates an effort at repair. The most common situation for this form of ulcer is the region of the pylorus (William J. Mayo in "Jour. Amer. Med. Assoc.," Oct. 21, 1905). The non-indurated ulcer may involve the mucous coat only and may be of microscopic size, and even a microscopic ulcer may cause death from hemorrhage. The non-indurated ulcers exhibit no sign, or almost no sign, on the outer surface of the stomach, and may not be detected even when the stomach is opened by the surgeon. The non-indurated ulcers are divided into the *mucous erosions* of Dieulafoy (*exulceratio simplex*), in which the superficial epithelium only is involved, and the true round fissured *peptic ulcers* (William J. Mayo in "Jour. Amer. Med. Assoc.," Oct. 21, 1905). Both conditions are rare. Ulcers are also divided into *acute ulcers* and *chronic ulcers*.

The **simple** or **circumscribed acute ulcer** seldom attains any considerable size. It involves the mucous membrane and submucous structure and commonly the muscular coat, but very seldom the peritoneal coat. Perforation is unusual. Such ulcers may become chronic, but usually heal in three or four weeks (Charles Bolton in "Brit. Med. Jour.," Jan. 26, 1924). During healing the separation of a slough may lead to bleeding, perhaps to fatal hemorrhage.

The **spreading acute ulcer** is the **round** or **peptic ulcer.** It tends to reach the peritoneal coat, which coat may adhere to the pancreas, liver, or some other structure. It is liable to bleed and may perforate. Protective thickening means that the ulcer has become chronic.

Chronic ulcers probably always result from acute ulceration and were not chronic from the start. They may have periods of acute exacerbation and periods of relief or apparent cure. Chronic ulcers may heal, may perforate, may cause hemorrhage. The peritoneal coat may adhere to liver, pancreas, or omentum. Destruction of this coat, if it is adherent, means that the ulcer floor will be liver, pancreas, or omentum. In some chronic ulcers there is enormous thickening. An acute ulcer may heal, may perforate, or may become chronic. Surgeons see little of acute ulcers, much of chronic ulcers. A chronic ulcer may perforate, may heal, or may heal partly. Healing or attempt at healing produces a dense scar. An ulcer may become cancerous. The most common seats of ulcers are the posterior wall and lesser curvature, especially in the pyloric region; in fact, 80 per cent. occur in the pyloric region. Only 1 or 2 per cent. of ulcers on the posterior wall perforate, as they tend to form adhesions to adjacent structures. Ulcers on the anterior wall are very unusual, do not tend to form adhesions, and are apt to perforate. It is not uncommon to have ulcer of the first portion of the duodenum associated with gastric ulcer. An ulcer may be accompanied or followed by fibromatosis which gives a deceptive likeness of cancer (see page 942). Gastric ulcer is at least four times as frequent in England as in the United States. In 2830 autopsies made in the Philadelphia Hospital there were 40 gastric ulcers, and in 3763 autopsies made in four Philadelphia institutions there were 51 gastric ulcers—a percentage of 1.35. (See A. P. Francine in "Proceedings Phila. County Med. Soc.," March 31, 1905.)

Ulcer is a not infrequent cause of cancer (page 943).

Symptoms.—In an acute ulcer the symptoms may be typical; but only if there are pain, tenderness on pressure, slight or distinct unilateral muscular rigidity, vomiting, hemorrhage, and hyperchlorhydria. In a chronic ulcer the symptoms may be clear, may be misleading, may be variable, and in some cases even absent (*latent ulcer*). In ulcer dyspepsia usually exists. It is usually but not always acid dyspepsia, and is associated with much flatulence. In most cases, though not in all, food promptly causes pain. There may be a gnawing sensation (*hunger-pain*) when the stomach has been long empty, and there may be actual pain. The taking of food may *temporarily* relieve pain, but as gastric peristalsis arises and perhaps as quantities of gastric juice are poured out to digest the food the pain increases. A small quantity of bland food may relieve pain for a short time, and a larger quantity or coarser food may cause pain quickly. If hyperchlorhydria disappear (as it may from chronic gastritis and does from gastric dilatation following pyloric obstruction), pain may not be increased during digestion. In ulcers of the cardiac end and lesser curvature gnawing uneasiness is but briefly or not at all relieved by taking food, and pain develops immediately or almost at once after eating (usually in about half an hour). In ulcer of the pyloric region the gnawing uneasiness may be distinctly relieved by taking food, but within an hour or a little more is apt to become severe. As a rule in ulcer a stomach recently emptied is free from pain. Pain in most cases is relieved promptly by lavage,

by vomiting, or by the administration of an alkali. Pain is hardly due to acid gastric juice, but rather to muscular contractions. Pain when the stomach is empty means muscular contractions with a closed pylorus. Alkalies relieve pain by relieving muscular contractions and pyloric spasm. The time after eating when pain occurs is usually the same in an individual case. In ulcer the pain is paroxysmal. It is at times very violent in the epigastric region and about the ensiform cartilage and may pass to the back, being located between the eighth and ninth dorsal vertebræ to one side of the midline (the right more often), into the esophagus, into the chest, to the left side of the abdomen, or to the top of the ensiform process.

In gastric ulcer it is usual to find distinct or severe tenderness developed by epigastric pressure, and tenderness is associated with more or less rigidity. In ulcer of the lesser curvature pain and tenderness are in the neighborhood of the left costal margin. In ulcer of or near the pylorus they are above the umbilicus in or to the right of the midline. In ulcers of the anterior wall tenderness is most acute. Vomiting usually relieves the pain, so does lavage. Spontaneous vomiting occurs in some cases, not in most. Any patient may have episodes of vomiting and periods of freedom from it. Patients frequently induce vomiting in order to relieve pain. When spontaneous vomiting occurs it does so in from half an hour to one hour and a half after eating. The vomited matter is acid, may contain a little blood, and has a foul odor. Examination of the gastric contents after the administration of a test-meal shows in from 25 to 50 per cent. of the cases hyperacidity. Hyperacidity in all probability occurs at least for a time during the progress of every case. Obvious hemorrhage from the stomach occurs in less than one-half of the cases. From 3 to 8 per cent. of cases actually die of hemorrhage. William J. Mayo states that "more than 90 per cent. of hemorrhages from the stomach are from chronic ulcers with a well-marked ulcer history" ("Surg., Gynec., and Obstet.," May, 1908). The blood may be brought up with food, and is then black and clotted, or may be vomited clear and in large amount. Blood may be present in vomited matter or stools in such small amount that its presence is observed by the microscope only. The demonstration in the feces of minute quantities of blood (occult blood) is important diagnostically. It may be demonstrated by the guaiacum test or the aloin test. For two days before this test the patient must not eat rare meat, sausages, or fish. Blood in the stools does not prove the existence of gastric ulcer. The blood may have come from any spot from the mouth to the anus. As William J. Mayo ("Surg., Gynec., and Obstet.," May, 1908) says: "Visible or occult blood in the stool affords proof as to the fact that there is blood, but it should never be lost sight of that it bears with it no evidence as to its exact gastro-intestinal origin. The patient may have bleeding gums or hemorrhage from some slight abrasion in any part of the many feet of mucous membrane which exist between the lips and the anus. If occult blood is found by one chemical test, it must be corroborated by others, as some unsuspected food or drug may give rise to the reaction.

"As a matter of fact, hemorrhage from ulcer is by no means of frequent occurrence. The base of the ulcer is clean and free from granulation tissue, so that bleeding may be infrequent. Careful examination of the stools for many days may be necessary to detect its presence."

In hemorrhage from an ulcer a pint or two may be vomited in a few minutes, and such a patient presents all the general symptoms of dangerous hemorrhage. As a rule, when a patient has a very large hemorrhage he feels weak and nauseated, is deadly pale, falls in a faint, and later passes a quantity of blood by stool. When an ulcer bleeds the blood is far more apt to be vomited than passed by the bowels, but in some cases blood from the stomach is passed by the bowels in part or wholly. A very large hemorrhage may occur, and yet the bleeding never be repeated, or a large hemorrhage may be followed by another or be the first of three or of a series. In a great many cases after a large hemorrhage there is no further bleeding or there are subsequently a few small hemorrhages. Small hemorrhages may occur indefinitely, and may after a time eventuate in a large hemorrhage. In chronic ulcer in which small hemorrhages recur over a long period the condition is due to bleeding from congested mucosa, dilated veins, or to the erosion of small vessels which cannot contract or retract because they are embedded in fibrous tissue. A large hemorrhage may be due to the erosion of a large vessel, but is often produced by a great number of erosions of the mucous membrane, erosions perhaps so numerous that blood seems to pour from every portion of the mucous surface. We speak of such erosions as the *erosions of Dieulafoy* or *exulceratio simplex*. It is usually stated that in a sudden acute violent hemorrhage

there will probably be no history of antecedent stomach trouble, but William J. Mayo is of the opinion that "a single hemorrhage from a patient who has not had previous gastric symptoms is probably not due to ulcer" (Ibid.). It may arise from rupture of veins about the cardia, from blood from hemoptysis having been swallowed, or from unsuspected cancer. Ulcer is not the only cause of hemorrhage. It may result from disease of the liver, spleen, or pancreas, from infections of the gall-bladder or appendix, and from gastric cancer.

In a chronic ulcer it is sometimes, though seldom, possible to palpate the indurated area.

Constipation exists in at least 90 per cent. of cases. There is often very marked anemia, aggravated and, some think, occasionally caused by continued loss of blood. Indigestion aggravates anemia and also may cause it. Most cases complain of prolonged indigestion. There is often a tender area in the back a little to the side of the eighth and ninth dorsal spines (usually the right side). A triangular area of hyperesthesia may be found in the left epigastric region (Head). Cold extremities, indicative of feeble circulation, are usually noted. The symptoms of gastric ulcer tend to periodicity. A person suffers for some weeks and then may enjoy a period of remission or intermission for several or many weeks, perhaps for months. Cold and wet, worry and exhaustion, seem to be factors in precipitating attacks. Ulcer, especially pyloric ulcer, is apt to cause hypersecretion of gastric juice. Spasm is a common effect of ulcer. Pyloric ulcer causes pyloric spasm and pyloric spasm causes retention of stomach contents and prevents the entrance into the stomach of protective alkaline duodenal fluid. Hence pyloric spasm causes hyperchlorhydria. Ulcer of the body of the stomach may cause ring spasm of the viscus (Charles Bolton, Ibid.).

If the ulcer does not cicatrize, but progresses, causing pain and hemorrhage, the patient usually becomes thinner, more anemic, weaker, and even exhausted. In 140 cases in the Mayo Clinic studied by Smithies ("Collected Papers by the Staff of St. Mary's Hospital," Mayo Clinic, 1912) 107 showed loss of weight. The average loss of weight was 20 pounds. The maximum loss observed was 65 pounds in six months. The average hemoglobin finding was 72 per cent.

It is certain that many cases of gastric ulcer are unrecognized; in fact, as Habershon says, diagnosis is rarely made unless hemorrhage exists, and in certain latent cases both vomiting and bleeding are absent. It is believed by some that latent ulcers are even more common than are ulcers causing symptoms. Hall ("Amer. Jour. of Med. Sciences," May, 1909) says: "Rather than look too narrowly for exactly this or that evidence, we should take the broader ground that ulcer probably exists in most patients complaining of persistent indigestion, even though not of an acid character, if pain, tenderness, vomiting and rigidity, or two or three of these phenomena be present, and even though hyperacidity be not proved." A bleeding ulcer with palpable thickening of the pylorus, especially if there be anemia and loss of weight, is frequently mistaken for cancer. *Fibromatosis* of the stomach with or without ulcer is usually diagnosticated as cancer. This condition was fully described by Alexis Thomson at the 1913 meeting of the American Surgical Association. The entire stomach may be indurated. It is cases like the above that may get well after gastro-enterostomy and thus furnish the first proof that the condition was not cancerous (see page 943). The diagnosis of ulcer is far less difficult when there is food retention than when there is not.

In many cases it is impossible to make a differential diagnosis between pyloric ulcer and duodenal ulcer. In duodenal ulcer the pain and tenderness are above the umbilicus and in the midline or to the right, and if the duodenal ulcer bleeds the blood is most apt to pass by the bowel, but vomiting of blood is not unusual. A small percentage of duodenal ulcers also involve the pylorus.

The fluoroscope is a valuable aid in diagnosis. Skiagraphs after a bismuth or barium meal give highly important information as to the existence of scars, dimples, contraction of the pylorus, dilated stomach, and hour-glass stomach.

A gastric ulcer may cicatrize and thus be cured, but the cure of the ulcer may prove the ruin of the stomach by producing stenosis of one of the stomach orifices or hour-glass contraction of the body of the stomach. An ulcer may perforate. Perforation occurs in about 15 per cent. of cases (Robson). A *perforation* may be *acute*; that is, the ulcer suddenly breaks open when the stomach contains food or liquid, and the contents of the stomach are poured into the free peritoneal cavity. A *subacute* perforation occurs when the stomach is empty or nearly empty. The opening is small in size, there is no escape of stomach contents or the escape of only a small amount, and the opening may be quickly closed by adhesion to an adjacent surface

of peritoneum or to a piece of omentum. If a small amount of stomach contents is extravasated, it is usually surrounded by adhesions or tracks slowly toward the pelvis. In what is known as a *chronic* perforation the break takes place usually in the posterior wall into a box of preformed adhesions, the extruded gastric contents are circumscribed by these adhesions, the general peritoneal cavity is not invaded, but circumscribed suppuration is inaugurated.[1] This condition is known as *perigastric abscess*, and the subphrenic form is the commonest. In such a case the abscess may break into the pleural cavity or even into the lung. I operated on a girl of sixteen and found a perigastric abscess and a perforation of the anterior wall near the pylorus, and this condition was tuberculous. A fistula persisted for months, but finally healed.

Perforation is generally preceded by a history of indigestion, but it may come on without a suggestion of antecedent stomach trouble, it may be brought about by muscular effort, and is most common after a full meal, but it may occur when the patient is perfectly quiet and has not eaten for some time. The real cause is spasm of the pylorus which causes tension of the stomach walls and keeps the viscus from emptying. Pyloric spasm is very common in sufferers from ulcers. In acute perforation food is the most active cause; in chronic perforation, muscular effort. "The severity of the symptoms depends upon several conditions: the previous state of health, the size and number of the perforations, the condition of the stomach, whether full or almost empty, the bacterial virulence of its contents, and the occurrence of vomiting."[2] Normal stomach contents after a test-meal are usually free from pyogenic bacteria. The situation of the ulcer has some influence on the symptoms. "If in the fundus, at the cardiac end, or in the body of the stomach, an acute infection of the whole peritoneal cavity rapidly follows; if the ulcer be at the pylorus or in the first portion of the duodenum, the fluid is directed down the right side of the abdomen, owing to the hillock formed by the transverse mesocolon at the pyloric end of the stomach."[3] In such a case the fluid may gravitate into the right iliac region and the condition may be mistaken for appendicitis. In a case of subacute perforation I operated, believing that appendicitis existed. Alderson calls attention to the fact that the sudden perforation of an ulcer may be mistaken for poisoning, and he cites the death of Henrietta, Duchess of Orleans, in 1670, a doubtful instance.

Acute perforation can be certainly diagnosticated if the case is seen early. Such an emergency has usually, but not invariably, been preceded by positive and prolonged symptoms of gastric disorder. It causes sudden and intensely violent epigastric pain, greatly increased by swallowing fluids, by vomiting, by turning the body, by cough, by inspiration, and by pressure. The pain may radiate throughout the abdomen, but the chief tenderness is in the region of the stomach. The seat of the pain after perforation does not, of necessity, correspond to the seat of perforation. Vomiting occurs in about half the cases after rupture. When it does occur it comes on soon after the pain. It may be an isolated act, may be repeated several times, and may perhaps recur again and again, and does much harm by increasing shock and by ejecting gastric contents into the peritoneal cavity. Vomiting of blood is very unusual. In many cases there is, singularly, little shock. Even when severe shock exists its duration is usually temporary. This important fact is insisted on by Eliot ("Annals of Surgery," May, 1912). We would expect early in the case to find the pulse very rapid. Sometimes if is, often it is not. In some cases it is little above normal. Of course, when peritonitis begins the pulse-rate increases. Board-like rigidity of the abdomen exists. It is apt to be wide-spread, but is most marked in the upper portion of the abdomen. Very early in a case it may not be observed, but soon develops. The area of liver dulness is in some cases diminished and in exceptional cases obliterated. This symptom is due to gas passing into the peritoneal cavity and getting between the liver and the parietal peritoneum. It is seldom present after pyloric perforation or when the stomach at the time of the perforation contained very little food. It is when perforation is far from the pylorus and when the stomach contains fermenting food that enough gas escapes to diminish liver dulness (Eliot, Ibid.). The sign is most significant when the abdomen is flat. There may be dulness in one flank or both flanks due to fluid. Eliot (Ibid.) lauds auscultation as an aid to detecting small amounts of fluid, and calls attention to *Shoemaker's symptom*, that is, a dull note on light percussion giving way to a tympanitic note when the percussed finger is pressed firmly against the abdominal wall, thus coming nearer to the

[1] See paper by B. G. A. Moynihan in "Brit. Med. Jour.," Jan. 31, 1903.
[2] Ibid. [3] Ibid.

intestine by pushing fluid away. The pulse may be very rapid, but often shows curiously little disturbance. Some few cases die rapidly in shock, but, as a rule, reaction occurs and, if operation be delayed, peritonitis arises. Acute perforation of the stomach may be in certain cases mistaken for appendicitis, cholecystitis, or hemorrhagic pancreatitis. If a patient with acute perforation be not promptly operated upon, he will soon exhibit the symptoms of general peritonitis. Subacute perforation causes less violent symptoms and they come on more gradually. There is in the beginning severe but not agonizing pain, which gradually abates. Moynihan points out that there is gastric uneasiness for several days before the perforation. Peritonitis develops slowly and the chief symptoms are often pelvic. *Chronic perforation* gives the signs and symptoms of perigastric abscess.

Treatment.—*Medical Treatment of Non-perforated Ulcer.*—Focal infections should be removed. Intestinal toxemia should be as far as possible corrected.

As a matter of fact medical treatment should be in the hands of an internist, not of a surgeon. He will by proper rest in bed, rigid diet, and perhaps alkaline medication seek to favor healing. That he will often succeed I do not doubt; as to the permanence of the cure I am uncertain. Many cases are apparently cured by medical treatment. Russel's statistics show that 40 per cent. of cases were reported cured under medical treatment. Other practitioners have claimed cure in 80 per cent. No one knows how many of those reported cured again gave evidence of the disease or later perished because of hemorrhage or perforation. Further, 18 per cent. of the 500 London Hospital cases under medical treatment died and 42 per cent. were not cured when discharged. Out of the supposed 40 per cent. of cures many later undoubtedly developed or will develop renewed symptoms and perhaps fatal conditions. The periodicity of the symptoms of gastric ulcer may lead a physician to mistake a remission for a cure. A recurrent case may be counted by two or more practitioners as 2 or more cases cured, thus increasing the apparent number of cures by medical means alone. I believe that a chronic ulcer is almost certain to become sooner or later a surgical case.

Medical Treatment for Gastrorrhagia (Enormous Hemorrhage from the Stomach).—Some claim that surgical treatment is not to be employed in gastric hemorrhage and that statistics are decidedly against it. I believe this statement to be correct. Kraft's table, which was published in 1910, gives 83 cases operated upon, with 30 deaths, a mortality of 37 per cent. (Lindenberg, see "Lancet," Dec. 5, 1914). Lindenberg (Ibid.) looked up the records of 68 cases of acute hemorrhage treated medically in the clinic of Faber, of Copenhagen. There were 5 deaths (a mortality of 7.3 per cent.) and he does not believe operation could have saved 1 of the 5. Some treat stomach bleeding by morphin, and adrenalin by the mouth. Serum may be useful. Transfusion of blood may save life.

I believe Lindenberg's plan to be valuable ("Lancet," Ibid.). I have employed it with apparent success. It is as follows: Raise the foot of the bed. Give no salt solution intravenously and give no stimulants, because they would raise blood-pressure and retard clotting. Give no morphin. It arrests the spasm of the gastric muscle, and spasm by constriction helps to stop the bleeding. No food is to be given by stomach for several days. Put into the stomach daily with a small tube 100 c.c. of a 1 per cent. solution of ferric chlorid; let the patient lie first supine, and then prone, and remove the fluid by aspiration (Bourget's plan).

Once a day give subcutaneously 40 c.c. of a 10 per cent. solution of gelatin, the fluid being at a temperature of 40° C. I omit the gelatin and use serum or blood transfusion instead. I regard gelatin as dangerous.

Surgical Treatment of Gastric Ulcer.—The exact curative value of operation is not settled. Kronlein's clinic claims 85 per cent. cures, Von Eiselsberg's clinic but 52 per cent. of cures and 15 per cent. of improvements. Balfour observed 826 cases of gastric ulcer in the Mayo Clinic and found that operation gave satisfactory results in from 70 to 80 per cent. and that only from 5 to 10 per cent. of operations were total failures (Donald G. Balfour in "Annals of Surgery," Oct., 1921). The nearer the ulcer is to the pylorus, the better the chance of cure. The Mayos do not advise surgical treatment of acute ulcer unless complicated by hemorrhage, perforation, or obstruction; or of chronic ulcer, until careful medical treatment has failed. Operation is indicated for chronic ulcer when a mechanical cause is responsible for retention and stagnation of stomach contents, and in certain cases of hemorrhage. Operation is also indicated in chronic ulcer with frequent exacerbations, but the surgeon should be very chary of operating upon neurotic women with gastroptosis unless, of course,

there be a positive indication (William J. Mayo in "Jour. Amer. Med. Assoc.," Oct. 21, 1905). An advantage of early excision is the prevention of cancer.

In a chronic ulcer, if the patient grows worse in spite of careful dietetic and medical treatment, if hemorrhage has been profuse or if there have been frequent distinct hemorrhages, if the pain is violent, or if tenderness is marked, open the abdomen and inspect the stomach. An ulcer with indurated edges is easily found. The form, called by the Mayos the non-indurated ulcer, gives no evidence or little evidence of its existence when the outer coat of the stomach is felt and inspected (William J. Mayo, Ibid.). Even when the stomach is opened, no ulcer may be found. According to Mikulicz, in some mucous ulcers there is a very little thickening, and, according to Moynihan, the mucous coat may be a little adherent to the muscular coat, so that it does not slide easily. An enlarged gland in a portion of the omentum may be a sign of ulcer (Lund). An indurated ulcer of the anterior wall well away from the pylorus may be removed by an elliptic incision in the long axis of the stomach, the coats being sutured by the usual method, and gastro-enterostomy being also performed. Balfour uses the cautery to effect excision. It leaves a smaller opening than the knife and the wound heals well. In ulcer of the pylorus with great thickening we may excise the pylorus, close both the duodenal and stomach openings, and perform posterior gastro-enterostomy. In some cases gastro-enterostomy alone leads to the cure of chronic ulcer. Finney's gastroduodenostomy seems to be advisable in some cases (see below).

William J. Mayo ("Annals of Surgery," 1910) has described a transgastric method for excising ulcers of the posterior wall which are adherent to the pancreas. The excision passes through pancreatic tissue. Bleeding is arrested by suture ligatures. The wound in the pancreas is not sutured, but is closed by a mobilized portion of gastrohepatic or of gastrocolic omentum.

A strong argument in favor of excision of ulcers instead of gastro-enterostomy alone is the frequency with which ulcer gives origin to cancer. Instead of excising an ulcer it may be destroyed, as Balfour suggested, by the actual cautery ("Surgery, Gynecology, and Obstetrics," 1914, xix). This plan is especially valuable on the lesser curvature and the posterior wall.

Some surgeons do gastro-enterostomy alone when there is a small ulcer in or very near the pylorus. Others prefer some form of pylorectomy even then (page 1063). Cautery excision followed by Finney's operation is suited to cases without perigastric adhesions, without a cicatricial pylorus, and without gastric dilatation. It is more valuable for ulcers of the duodenal side than of the stomach side of the pylorus. A callous ulcer of the pylorus is best treated by some form of pylorectomy (page 1063). When an ulcer is near, but not very near the pylorus, excise the pylorus with the diseased portion of the stomach and do gastro-enterostomy. In ulcer of the anterior wall without great deformity perform cautery excision. Some advocate, some oppose, the addition of gastro-enterostomy. In limited ulcer of the lesser curvature do excision, with or without gastro-enterostomy. An ulcer of the posterior wall may be excised by a transgastric of a gastrohepatic omentum route. Callous ulcer of the anterior wall with hour-glass deformity is treated by sleeve resection. A bleeding ulcer is best treated by cautery excision. Great reasons in favor of the excision of chronic ulcers are the prevention of cancer and the removal of early cancer. (For a full and able consideration of all of the questions regarding operations see Donald C. Balfour's consideration of 826 cases of chronic ulcer in the "Annals of Surgery," Oct., 1921.)

Operation for Gastrorrhagia.—Rydygier proposed in 1882 to operate for hemorrhage. The first operation was done by Mikulicz in 1887, and the first successful operation was reported by Roux in 1893. It may be wise to transfuse blood before operating.

In acute and violent hemorrhage threatening life the proper course to pursue is somewhat uncertain. It is not proper to operate if there has been but one hemorrhage, because the chances are that the bleeding will not be repeated. Again, the chance of arresting such a hemorrhage by operation is, on the whole, poor. The danger of waiting after one hemorrhage is not so great as the danger of immediately operating, because collapse antagonizes renewed hemorrhage, but adds enormously to the risk of an operation. In over 90 per cent. of cases the hemorrhage ceases spontaneously. In over 18 per cent. of those dying of hemorrhage death is so rapid that operation is impossible (Savariaud). If the bleeding is from a distinct ulcer, we may succeed in excising the ulcer or in ligating the bleeding point. Roux, of Lausanne, saved a patient by excising an ulcer and ligating the bleeding coronary artery on each side of it. As

a rule, however, the bleeding is not from a distinct point, but from a multitude of excoriations. In the light of our present knowledge we may lay down the following rule: Do not operate for one acute hemorrhage. Simply bring about reaction by gentle means and follow Lindenberg's plan (page 952). If the bleeding recurs once or twice in comparatively trivial amounts, do not operate at that time; but if it recurs violently and the case is one of chronic ulcer, we should consider operation. After full recovery from a severe hemorrhage operate and excise the ulcer. Persistent or frequent bleeding, even if in small quantities, calls for excision of the ulcer, with or without gastro-enterostomy, according to circumstances. I have been shaken in my faith that we must always operate after a second severe hemorrhage by 2 of my cases. In 1 case a man had two tremendous hemorrhages. He was transfused, was treated by Lindenberg's plan (page 952), and recovered.

I was associated with my colleague, Professor Hare, in the case of a young woman. She had two immense hemorrhages, refused operation, and recovered. In cases of ulcer in which bleeding in small amounts persists, operation is indicated. In operating for a severe hemorrhage the surgeon opens the abdomen while hot salt solution is being thrown into a vein. The stomach is opened, the clots washed out, and a search made for the source of the blood. If it be found that the blood comes from an area of ulceration, this area may be extirpated, ligated, or cauterized with the thermocautery. Cautery destruction is easy and rapid. Some advise surrounding the ulcer with a purse-string suture. Others, notably Moynihan, simply perform gastro-enterostomy, which is of service by draining and giving rest to the dilated stomach, the hemorrhage being perhaps arrested by contraction of the gastric walls and the rest secured, preventing the detachment of hemostatic clot. Gastro-enterostomy is of most service in ulcer near the pylorus and in duodenal ulcer. If the ulcer is well above the pylorus it should be subjected to cautery excision, if possible. As a rule, it will be found that the vessels entering the ulcer are varicose. Excision, by cautery, or otherwise is made more necessary by varicosity. If excision is impossible, "the main blood-vessels leading into the ulcer should be ligated and the peritoneum and muscular coats drawn over it" (Wm. J. Mayo in "Surg., Gynec., and Obstet.," May, 1908). If it be found that the bleeding comes from a multitude of excoriations and that the stomach is, as Moynihan expresses it, "weeping blood," we can do nothing but gastro-enterostomy, which, in such a condition, is of uncertain value.

Operation for Perforation.—In perforation of the stomach the mortality is much larger than from perforated duodenal ulcer. In acute and subacute perforation operate at once, having all proper means taken to bring about reaction from shock, while the abdomen is being sterilized and while ether is being administered (hot saline enemata, external heat, atropin hypodermically, etc.). As a matter of fact, shock is seldom so profound as to cause us to hesitate about operating. I formerly advised waiting until reaction was established before operating. I now believe such advice erroneous. To delay after an acute perforation is to wait for what may never come. Cases *in extremis* should be operated upon with the aid of local anesthesia only. If there is shock, give salt solution intravenously while preparing for the operation. In all other cases be prepared to give it during the operation. Protect the patient from chill. Prepare the abdomen with iodin. Open the abdomen at the point of greatest tenderness, or, if there be no such point, open it in the epigastric region, a little to the right of the mid-line. When the abdomen is opened there may be an escape of odorless gas, and food or fluid may be discovered in the peritoneal cavity. The perforation is sought for and is usually found in the anterior wall near the pylorus. When found, its edges should be cauterized and the opening should be buried and overlaid by stomach wall, a portion of which must be inverted by two layers of Halsted sutures. The suture line in pyloric perforation is to be at a right angle to the long axis of the pylorus in order to prevent constriction (Gibson). I do not believe that knife excision is necessary or desirable unless the ulcer is callous; even then, if it be too large to close, some surgeons simply stitch a plug of omentum into the opening or insert a tube and create a temporary gastrostomy. If no perforation is found on the anterior wall, make an opening into the lesser peritoneal cavity through the gastrohepatic omentum, the transverse mesocolon or the gastrocolic omentum, explore the posterior wall, and close and cover any perforation found. In order to reach the posterior wall of the stomach Lardennois and Okinczyc suggested the epiplo-enterocolic method (see B. Sherwood Dunn in "Amer. Jour. of Surgery," Oct., 1916). The great omentum and its mesentery are separated from the colon. When this is done the duodenum, pancreas, and posterior wall of the stomach can be quickly exposed. In addition to closing the perforation, gastro-

enterostomy is indicated theoretically, in order to drain the viscus, give it rest, and lessen the tendency to recurrence of ulceration. As a matter of fact, the ulceration seldom recurs, even if gastro-enterostomy was not done. It need not be done for ulcer in the body of the stomach. For ulcer of or near the pylorus, if the condition is good, and the perforation is less than twelve hours old, do gastro-enterostomy. Otherwise do not do it except as a secondary operation. If a case is in a desperate condition, do nothing at the time, but open, insert a tube into the stomach, and drain the belly. By the time the perforation has been closed the patient is perhaps too severely shocked to render the additional operation of gastro-enterostomy justifiable, and I agree with Gibbon that such an operation should be performed only when the condition of the patient is good, when there are multiple ulcers, or when there is pyloric constriction (John H. Gibbon in paper before the Tri-State Med. Assoc. of Virginia and the Carolinas, Feb. 23, 24, 1904). After closing the perforation the abdominal cavity is irrigated with hot salt solution, and the space between the liver and diaphragm is sponged out with a gauze pad wet with hot salt solution. If the case is operated on many hours after the perforation, or if the peritoneum has been badly soiled, drainage *must* be used, but in other cases it is seldom used. Drainage is obtained by means of a cigarette drain passed to the suture line in the stomach. In cases with much extravasation, especially if the extravasation has reached the pelvis, a suprapubic opening is made and a tube inserted. After the patient has reacted from the shock of the operation he should be placed in a semi-erect position to direct the flow of infective material to the pelvis, and continuous proctoclysis should be employed as in peritonitis (see page 1010). The treatment of chronic perforation is the treatment of perigastric abscess, and consists of incision and drainage. The mortality following operations for gastric perforation is estimated at from 6.5 to over 60 per cent. The earlier the operation, the better the prognosis. Gibson, of New York, combining his cases of gastric and duodenal perforation, found that the mortality according to time of operation is as follows: Within twelve hours, 6.5 per cent.; from twelve to twenty-four hours, 20 per cent.; over twenty-four hours, 66 per cent. ("Annals of Surgery," Jan., 1924).

Cicatricial stenosis of the orifices of the stomach results from the healing of an ulcer, the swallowing of a corrosive substance, or traumatism from a foreign body. Constriction of the *cardiac orifice* is indicated by gradually increasing difficulty in swallowing. After a time the esophagus above the stricture dilates or pouches; the fluid food passes into the stomach, but the solid food lodges in the esophageal pouch and is soon regurgitated. The site of the stricture is located by the esophagoscope, or by the bougie, and by having the patient swallow while auscultating over the esophagus and cardiac end of the stomach. If the constriction be malignant, the patient is found to be beyond middle life, the vomit is occasionally bloody, emaciation is rapid and decided, and occasionally the supraclavicular glands are enlarged. A tumor of the cardiac end of the stomach can seldom be palpated. If the constriction be cicatricial, the history will indicate the cause. Constriction of the *pyloric orifice* causes retention of food and dilatation of the stomach. Dyspeptic symptoms will be found to have been long present. A tube passed into the stomach permits of the injection of fluid so as to fill the stomach. When the fluid runs out it contains portions of undigested food, which was perhaps eaten a day or more before, and measurement of the liquid shows that the capacity of the stomach is enormously increased. If hydrogen be forced through the tube, the outline of the distended stomach is at once made clear. The usual method of distending the stomach is by a Seidlitz powder: two solutions are made; the bicarbonate solution is swallowed at once, and the tartaric solution is taken afterward in small amounts at a time. Percussion over the distended stomach indicates the size of the viscus. It is well to remember that when gastric ulcer exists dilatation of the stomach can occur without cicatricial stenosis. The cause in such a case is pyloric spasm, or perhaps the atonic condition which may result from anemia and neurasthenia.

In malignant disease of the pylorus a tumor may often be palpated; there are tenderness and considerable persistent pain, great cachexia and emaciation, absence of free hydrochloric acid from the gastric juice, diminution of red corpuscles and hemoglobin, and perhaps no increase of white corpuscles after a full meal. There is sometimes enlargement of the supraclavicular glands. Vomiting of bloody fluid occurs in 40 per cent. of the malignant cases. The use of the *x*-rays after a bismuth or barium meal is a valuable aid in diagnosticating pyloric constriction. The diagnosis of cardiac constriction is discussed in the section on Stricture of the Esophagus. In cicatricial stenosis of the pylorus there may be paroxysms of pain, there is no tenderness, emaci-

ation is not so early in onset or so rapid in progress, and the supraclavicular glands are never enlarged. Vomiting occurs, but the ejected matter is not bloody.

Treatment.—Cicatricial cardiac stenosis requires dilatation with bougies and the maintenance of the restored caliber. (See Jackson's method for treating esophageal stricture, page 868.) If dilatation from above is unsatisfactory, perform gastrostomy, and dilate from below. If no instrument can be passed from below, excise the cardia or maintain a permanent gastrostomy. In malignant stenosis of the cardia it may be possible to excise the cardia. If gastrostomy is performed at all, it should be performed early. Jejunostomy is a better operation. Cicatricial pyloric stenosis was formerly treated by gastrostomy and digital divulsion of the stricture (*Loreta's operation*); but this operation is obsolete, experience having shown that recontraction is inevitable. Pyloroplasty was until recently advocated by many surgeons. This is known as the Heineke-Mikulicz operation. In 30 per cent. of the cases the symptoms are not relieved by pyloroplasty, a condition which renders gastro-enterostomy necessary. Mayo points out that in such cases pyloroplasty fails because the pylorus is on a higher level than the gastric pouch, the degenerated muscle of the stomach is unable to lift the food from the pouch to the pylorus, and the symptoms of gastric dilatation and retardation of the passage of food into the duodenum are not relieved. The operation has been generally abandoned. Finney's method of gastroduodenostomy (Figs. 802–805) is a great improvement on pyloroplasty. The opening is large and in a proper position to afford satisfactory drainage. Finney's operation is employed when the stomach is not as yet dilated, when the pylorus is not extensively cicatricial, and when there are no adhesions. An ulcer is usually excised by knife or cautery. Gastro-enterostomy is a satisfactory operation in most cases and usually makes the patient permanently comfortable. If the pylorus is not extensively cicatricial, it may be done alone. An ulcer is usually destroyed by cauterization. If the pylorus is callous, pylorectomy is called for. Malignant stenosis is treated by pylorectomy or gastro-enterostomy. (See under these heads respectively.)

Congenital Hyperplastic Stenosis of the Pylorus or Pyloric Stenosis of Infancy.—Osler tells us that the first case was published by an American, Hezekiah Beardsley, in 1778. Hirschsprung, of Denmark, in 1887 published the first modern case (Bunts, "Amer. Jour. Med. Sciences," Jan., 1912). Stenosis in adults is almost invariably due to cancer or to ulcer, but in very young children one occasionally meets with a form that is congenital. The victim of hyperplastic stenosis may have club-foot or imperforate anus.

The condition exists at birth, and about ten days later the pylorus becomes edematous because of increased activity of the stomach (W. A. Downes in "Surgery, Gynecology, and Obstetrics," 1916, xxii). The history of such a case is that during the first two or three days after birth the child seems in every way normal, but that after several or a number of days or perhaps weeks explosive vomiting suddenly begins—vomiting for which no dietary cause seems responsible, and which persists irrespective of medication. After the stomach has been emptied by vomiting the child seems much relieved, but when, after a time, food is administered, vomiting begins again, either in a very short time or after an hour or so. It has been noted that the vomited matter in congenital stenosis of the pylorus never contains any bile whatever, for obvious reasons—the pylorus is shut and the bile cannot enter the stomach. A child in this condition receives little or no nourishment, becomes quickly emaciated, and soon dies. Some of these children die in a month; others, in several months, and a few may live for five or six months. It is usually possible in these cases to palpate a thickened pylorus. The pyloric mass is always there, but the overhanging anterior margin of the liver may keep the surgeon's fingers from detecting it. Regurgitant vomiting, by keeping the stomach empty, may prevent dilatation. The most common symptom is gastric peristalsis. In Bunts's table gastric peristalsis was present in 84 per cent. and a palpable tumor in 69 per cent. of cases. I believe that careful examination will disclose a lump in a greater percentage of cases. In true congenital stenosis there is hyperplasia of muscle. The circular muscular fiber undergoes great increase, perhaps with some fibrosis. The mucous membrane is hypertrophied and thrown into folds. The opening into the duodenum may be no larger in diameter than a pin and may be totally blocked by folds of mucous membrane. Even when there is only a little hyperplasia the lumen of the pylorus may be closed temporarily by edema. These are the cases regarded by some as pyloric spasm (see Palmer in "Archives of Pediat.," Sept., 1922). It is these latter cases which are benefited by medical treatment. In true congenital stenosis the intestines are very much collapsed, and the child

is, of course, much constipated. In many of these starving patients the temperature is decidedly elevated. There may be a large thymus, but that condition is not uncommon in infants. An *x*-ray picture of the stomach and thymus should be made. It is not necessary to administer bismuth, because the air-bubble in the stomach enables us to take a skiagraph of the organ (Palmer. Ibid.). Cases of pyloric closure have recovered after lavage, carried out daily for some weeks, and careful breast feeding. Such cases are instances of temporary edema. A trial may be given this method unless the condition of the patient demands immediate relief. If there be palpable thickening of the pylorus, operation is called for imperatively. The delay in employing surgery in hopes of lavage succeeding must never be so long as to permit emaciation of the patient. If the condition does not soon show signs of improvement operation is indicated. The victims of stenosis lose weight and soon show evidences of dehydration, starvation, and probably acidosis. Prepare a case during twenty-four hours before operation. Such a delay may seem dangerous but to operate without preparation is far more dangerous. The plan of Dudley W. Palmer (Ibid.) is eminently wise. During the twenty-four-hour wait give salt solution subcutaneously, from 30 to 100 c.c. at a dose, and several enemas of bicarbonate of sodium and glucose (5 per cent.). After operation glucose and soda by rectum will be needed. Give a gastric lavage of soda and repeat it just before the operation. Keep up feeding in hope that some nourishment will slip through. The Fredet-Rammstedt operation is the best procedure. The stomach is to be well washed out. The patient is to be protected in every way from shock. Nitrous oxid and oxygen can be given, but local anesthesia is better. A high right rectus incision is made. The peritoneal coat of the pyloric region is divided by a longitudinal cut in the non-vascular area on the anterior face near the upper border. The incision invades the muscle to a slight degree. Division of the muscle to the mucous area is made by blunt dissection. The mucous membrane bulges into the wound and it must not be cut. Bleeding is arrested and the wound is left gaping. Occasionally bleeding persists. A suture ligature cuts out through the edematous tissue. Pressure and very hot water will usually stop bleeding. If it does not do so, place a bit of rectus muscle upon the bleeding point. If the surgeon should be so unfortunate as to fail in effecting closure of cut mucous membrane he must do gastrojejunostomy. The after-treatment (Palmer, Ibid.) is as follows. Give sterile water with a medicine-dropper within a few hours of the operation, and by evening diluted milk, an ounce every hour or two hours. Human milk is given, if possible. The morning after operation castor oil is administered. We have referred previously to the rectal use of soda and glucose. The operation originally used for congenital stenosis was gastro-enterostomy, but it has been almost entirely displaced by the Fredet-Rammstedt procedure. In children gastro-enterostomy is difficult and the mortality is considerable. Scudder's mortality from gastro-enterostomy was 13.8 per cent. ("Annals of Surgery," 1914, lix). Many operators report a much higher mortality (from 23 to 35 per cent.). Palmer's table shows 35 cases of the Fredet-Rammstedt operation recovered, and one year later all but one were doing well. That one was under weight and vomited occasionally. Palmer also has 3 posterior gastro-enterostomies living and well one year later. He operated upon 42 supposed cases and found the diagnosis correct in 39. There was 1 death out of 39 cases. (See the valuable practical article by Dudley W. Palmer in "Archives of Pediatrics," Sept., 1922.)

Perigastric Adhesions.—That perigastric adhesions are frequently responsible for stomach pain and digestive difficulty is undoubted. Such adhesions often arise in cases of protracted ulceration of the stomach or duodenum. A common cause of perigastric adhesions is gall-stone disease. Tuberculous peritonitis causes dense adhesions. In some cases adhesions are traumatic, in some are due to syphilis, in many the cause is uncertain (Fred. D. Bird, "Intercolonial Med. Jour. of Australia," Dec. 20, 1900). Adhesions may cause blocking or kinking of the pylorus, or may glue the stomach to the parietal peritoneum or to some adjacent viscus. In Fenwick's table of 123 cases he finds that the adhesions usually cause the stomach to adhere to the pancreas or to the liver. The formation of adhesions in cases of gastric ulcer is, in many instances, conservative, serving to prevent perforation or to limit extravasation, if perforation of the stomach wall occurs.

Adhesions more or less extensive follow every abdominal operation. Surgeons try to prevent them by scrupulous asepsis, by gentle handling and by rapid operation. Any raw surfaces should be smeared with sterile vaselin or be covered with peritoneum or omental grafts.

The **symptoms** are variable. In some cases the adhesions produce little or no trouble, but in the majority of cases they cause definite symptoms, and sometimes the condition becomes one of absolute disablement. The symptoms may be due to blocking of the pylorus, a condition that is followed by gastric dilatation. They may be due to dragging upon the adhesions when the stomach contracts during digestion, or when peristalsis occurs in an adherent piece of intestine.

Sometimes adhesions slowly stretch and eventually give way. In such cases symptoms gradually disappear. The usual symptom is pain, frequently of a violent character. The pain comes on in paroxysms, and recurs over and over again, it may be during years. H. Hale White[1] points out that in these cases there is usually some pain persisting, which is now and then increased into violent paroxysms, and that the only other condition that produces persistent pain with violent exacerbations is cancer. Pain may be caused or may be relieved by the assumption of a particular position of the body. In *adhesion-dyspepsia*, however, there is no distinct loss of weight; the condition may exist in youth, as well as in middle age or old age; it is not always increased by taking food, and it very rarely causes death. If there be a history of antecedent gall-stone disease or of ulcer of the stomach, it is possible to make the diagnosis without exploratory operation. Even in other cases the condition may sometimes be diagnosticated, because, although there are these attacks of violent pain, there is no tenderness. In rare cases the matting together of inflammatory exudate produces a palpable mass. In doubtful cases of chronic and disabling stomach disease an exploratory operation should be performed; if adhesions exist, they will then become manifest.

Treatment.—Adhesions may gradually stretch, thin out, and give way. In some cases simply dividing an adhesion and covering the raw surfaces with peritoneum, or smearing them with sterile vaseline, effects a cure; in other cases it is necessary to make extensive separation of adherent structures, covering the raw surfaces with omental grafts. In serious adhesions about the pylorus gastro-enterostomy is usually the proper operation.

Bilocular Stomach (Hour-glass Stomach).—It is usually stated that some cases are congenital, but the writings of Mayo-Robson, Moynihan, and H. L. Paterson cause us to doubt if the condition is ever congenital. Even in the so-called congenital cases ulcers are found, or ulcer scars exist, or ulcer adhesions are demonstrable. The advocates of a congenital origin say that the ulcers are secondary to the narrowing, and that ulceration tends to occur, particularly at the seat of constriction. Beyond doubt, a very great majority, at least, of cases of bilocular stomach result from contractions produced by the healing of ulcers. In hour-glass stomach with a large opening between the two sacs there may be no symptoms. When the opening is small the symptoms resemble those of pyloric stenosis. The sac toward the cardia is frequently much dilated.

Symptoms.—The diagnosis of cancer is often made. The protracted gastritis may have caused free hydrochloric acid to disappear and acids of fermentation are usually found. The patient vomits from time to time, bringing up food which was eaten a day or two before, proof that food has been retained in the stomach and not digested. Occasionally, perhaps, blood is vomited. There is pain and the patient is harassed by foul-smelling eructations. Emaciation becomes pronounced. Cumston[2] points out that in a thin belly, distention of the stomach may make the condition evident; further, that if water is thrown into the stomach, only a part returns, and when the stomach is emptied as much as possible by a tube, a splashing sound can still be elicited in the stomach because the pyloric pouch is not empty. One cause of death is torsion on the axis. A skiagraph taken after a bismuth or barium meal gives diagnostic information of the first importance.

Treatment.—The diagnosis becomes certain after exploratory operation, and exploration also enables the surgeon to decide with certainty what operation should be performed.

1. In many cases resect the stricture and suture the two pouches together (sleeve-resection).

2. If there is trivial ulceration or a slight scar, do gastroplasty, an operation upon the constriction exactly similar to pyloroplasty (Cumston in "Med. News," Dec. 7, 1902).

3. The most popular operation in most cases has been gastrogastrostomy—that is,

[1] "Lancet," Nov. 30, 1901.
[2] "Med. News," Dec., 1901.

anastomosis of the cardiac pouch to the pyloric pouch; but this cannot be done if the pyloric pouch is small. Then do gastro-enterostomy, making an anastomosis of the jejunum to each pouch. Gastroduodenostomy has had advocates.

4. The best operation, if the surgeon is experienced in stomach surgery, is sleeve-resection. It removes the stricture and the ulcer, if there is one, does not distort the stomach, and leaves a practically normal viscus.

In malignant disease resection (partial gastrectomy) is indicated. After gastroplasty recontraction is common, and I do not believe in the operation. Gastro-enterostomy is unsatisfactory. The ordinary operation drains but one pouch. Weir and Foote advised a double gastro-enterostomy, tapping each sac. In some cases gastro-gastrostomy followed by gastro-enterostomy is employed. Usually resection is the best procedure.

Chronic Dilatation of the Stomach.—A dilated stomach, roughly speaking, is one which can contain more than 1.5 quarts (Ewald). Some few cases of dilatation result directly from atrophy of the muscular coat brought about by drinking quantities of liquid, especially carbonated liquid; chronic catarrh of the stomach; and conditions such as cancer, tuberculosis, diabetes, etc. The common cause of dilatation is constriction of the pylorus. In order to drive food through the pyloric narrowing more force is necessary than is required normally, hence the stomach muscle hypertrophies. The muscular hypertrophy is compensatory, and dilatation does not occur so long as the muscle is efficient. But finally the pyloric opening becomes so narrow that compensation fails, the stomach contents accumulate, and the stomach dilates.

Symptoms of Dilated Stomach.—There is annoying hunger unless cancer exists. Thirst is complained of. At intervals of a day or two the patient vomits enormous quantities, and portions of food may be identified which were eaten one or more days before. The vomited matter is sour and foul smelling, contains numbers of yeasts, and much fermentative acid. Free hydrochloric acid is often absent. In some cases vomiting occurs two or three hours after each meal. The patient suffers from foul gaseous eructations. There are progressive emaciation, constipation, scantiness of urine; sometimes cramp in the legs, belly, and arms; tetany may occur (see Parathyroid Tetany, page 1249); insomnia is the rule; cardiac palpitation occurs, and there is dyspnea, particularly at night. The *x*-rays show a block and the dilatation.

Physical Signs of Dilated Stomach.—The epigastric region is hollow and the left side of the abdomen is more prominent than the right. The outline of the greater curvature of the stomach can be distinguished. If the stomach contains air, percussion gives a tympanitic note; if it contains fluid, a dull note. When it is partly full of fluid, by altering the position of the patient we can show by percussion that the fluid changes its position. In a doubtful case give a light meal in the evening, and in the morning, before the patient has eaten, introduce a tube and remove any material contained in the stomach. The presence of undigested food points to dilatation.

To Test the Motor Power of the Stomach.—*Klemperer's Test.*—Wash out the stomach. Introduce 100 c.c. of olive oil by means of the tube. After two hours withdraw the oil. The stomach cannot absorb oil, and if the amount withdrawn is subtracted from the amount introduced the difference is the amount which passed the pylorus. If the condition is normal, not more than from 20 to 40 c.c. should be found in the stomach after two hours.

The Salol Test of Ewald.—Salol is not decomposed in the stomach, but in the intestine is broken up into phenol and salicylic acid. Salicylic acid is absorbed and salicyluric acid soon appears in the urine. If salol cannot reach the intestine, salicyluric acid will not appear in the urine. If salol reaches the intestine more slowly than normal, salicyluric acid will appear after a longer interval than when there is no pyloric block to retard the emptying of the stomach. In a normal person salicyluric acid is found in the urine in from three-fourths of an hour to an hour after swallowing a dose of salol. In stenosis of the pylorus it appears much later. The test is made as follows: The bladder is emptied and the patient is given three capsules, each containing 5 gr. of salol. The patient is directed to pass water every half-hour until he has done so four times. Each sample voided is examined for salicyluric acid by adding neutral chlorid of iron. If salicyluric acid is present, a violet color is noted.

To Test the Absorptive Power of the Stomach.—The absorptive power of the stomach can be tested by giving the patient a capsule containing $1\frac{1}{2}$ gr. of iodid of potassium. Normally the drug should be found in the saliva in from ten to fifteen minutes. When absorption is deficient, it may not appear for an hour or longer. In

order to test for it, moisten starch paper with the saliva and touch the moist paper with a drop of fuming nitric acid. If iodin is present, a blue color develops.

While the diagnosis of dilatation of the stomach can be certainly made, the determination of the causes, if the *x*-rays do not make it evident, may require an exploratory operation.

Treatment.—Cases not due to pyloric obstruction are much improved by lavage, regulated diet, use of an abdominal belt, electricity, aperients, and other agents called for by symptoms.

In all cases in which there is pyloric obstruction, in many doubtful cases, and in cases in which medical treatment fails, exploratory operation is indicated. In dilatation without pyloric obstruction some surgeons advocate gastroplication. If pyloric obstruction exists, the surgeon may elect to do pylorectomy, or gastro-enterostomy, the method selected depending on the condition discovered. If gastroptosis exists, gastropexy or Beyea's operation may be performed.

Acute Dilatation of the Stomach.[1]—This condition may arise suddenly in the course of chronic dilatation or when no previous dilatation existed. Its clinical features were described by Brinton in 1859. Hilton Fagge in 1873 furnished us with the first comprehensive description of the signs and symptoms. It can occur in association with intestinal paralysis and if it does do so it constitutes but part of the picture of postoperative paralytic intestinal obstruction. We are considering only acute dilatation of the stomach. The cause is uncertain, and is a subject of active investigation at the present time. It is said to be due to degeneration of the gastric muscle in the course of specific fevers, to paresis arising in the course of chronic gastritis, or to the drinking of a quantity of effervescing liquid. It is occasionally a fatal sequence of abdominal operations, particularly operations upon the gall-bladder and bile-ducts. The surgeon sees it in the course of sepsis and during shock from operations in which a general anesthetic was used, and occasionally in cases of spinal curvature.

One set of observers maintains that the condition is brought about by actual constriction of the duodenum, the duodenum dropping because of relaxation of its supporting structures, the constricting cause being the root of the mesentery and the superior mesenteric artery, and the duodenum being squeezed against the vertebral column (Rokitansky, Albrecht, Robinson, and Kundrat). Codman believes that normally in man there is more or less tendency to such constriction on standing erect or lying supine, and that a trivial increase of the constriction, which may be brought about by various causes, may completely obstruct the duodenum ("Boston Med. and Surg. Jour.," 1908). Lewis A. Conner collected 18 fatal cases shown apparently by necropsy to be due to mesenteric obstruction ("Amer. Jour. Med. Sciences," March, 1907).

Another set of observers asserts that acute dilatation is due to lesion of the nerve-trunks or nerve-centers, resulting in paresis of the muscle of the stomach wall and perhaps in spasm of the pylorus, putting the stomach in such a condition that it cannot empty itself. The cause of the nerve lesion is variously held to be hyperacidity of gastric secretion, the absorption of the toxins of fermentation, the secretion of chloroform into the stomach, the overdistention of the viscus with ether vapor, or an enormously great secretion of fluid into the stomach. Those who hold this view claim that the abdominal organs are not supported by ligaments (if they were, the supposed supporting structures would contain ligamentous fibers), but are supported by the organs beneath them and these by the floor of the pelvis, and that all are sustained by intra-abdominal pressure. Furthermore, they are of the opinion, that traction on the mesentery sufficient to cause duodenal occlusion would lead inevitably to thrombosis and gangrene, and that the dilatation of the stomach and upper portion of the duodenum, when contrasted with the collapse of the lower part of the duodenum, leads to the mistaken view that a constriction exists between the two portions.

Conner (Ibid.) says that the theory of pyloric spasm being causative is untenable, because in most cases vomited matter contains bile, and in two-thirds of the cases the duodenum is involved in dilatation. The constriction is regarded as secondary to the dilatation. Some think that acute dilatation occurs only in those with atonic stomachs. Others regard it as due to lack of adrenalin or to toxic influence upon muscular fiber. We do know that neurotics and the victims of gastric disease are predisposed, that the anesthetic is a danger (chloroform being more dangerous than ether), that early feeding or giving of much liquid during the first few hours after

[1] See Kelling in "Archiv. f. klin. Chir.," 1901, lxiv; Albrecht in "Virchow's Archiv.," 1899, clvi; Conner in "Amer. Jour. Med. Sciences," March, 1907.

operation may be an exciting cause, that a person who is predisposed is insatiably thirsty and hence that great thirst is a sign of danger, that the condition never occurs unless the stomach is full of fluid or gas, and that slight conditions of dilatation are very common but pass away in from twelve to twenty-four hours.

It seems probable that some cases of gastric dilatation are associated with mesenteric constriction of the duodenum, brought about by the intestines descending into the pelvis. The constriction inaugurates the dilatation and is aggravated by the dilatation. Conner points out that the intestines enter the pelvis as a result of dorsal decubitus, a long mesentery, and a gut nearly empty of gas and feces, and that this condition is favored by relaxation of the belly wall ("Jour. Amer. Med. Assoc.," March, 1907).

Symptoms.—Violent, profuse, gushing vomiting is the most frequent and the most prominent symptom; it inaugurates the attack and continues throughout the illness, although occasionally it ceases for some time before death. The amounts vomited are always large and often enormous. The vomitus is thin and of a green or black hue, usually contains bile and sometimes a little blood, but very seldom feces.

In most cases, but not in all, there is epigastric or umbilical pain and tenderness. Distention is the rule. Rigidity is rare. In many cases there is no passage of gas or feces, but in some diarrhea exists. There is great thirst, there may be hiccough, and delirium may arise before death. The temperature is nearly always normal or below normal. There is seldom visible gastric peristalsis (Conner, Ibid.), and splashing sounds are obtainable over the stomach.

Collapse arises early and quickly becomes profound. Tetany occasionally occurs. A case of my own died of acute gastric dilatation after an operation for stone in the kidney. He suddenly developed attacks of violent and profuse vomiting, rapidly went into collapse, lividity developed, hiccough arose, and he died in forty-eight hours.

A case may die in less than twenty-four hours or may die after ten days or more. Conner's group of cases shows a mortality of 72.5 per cent. Fluid cannot reach the small intestine, and as none is absorbed from the stomach and little from the duodenum, the tissues starve for the want of it (Laffer in "Annals of Surgery," April, 1908). The condition is frequently diagnosticated as acute intestinal obstruction or peritonitis from perforation.

Treatment.—When the stomach has dilated greatly and when collapse is profound, treatment is usually of no avail. When an early diagnosis is made treatment is often of the greatest value. The stomach must be at once emptied by the use of a tube and the treatment be repeated at intervals of a few hours. Neither food nor drink should be given by the mouth. Saline enemata and perhaps nutritive and stimulating enemata should be given. The patient should at once be placed upon the belly and kept there with occasional changes to the knee-chest or left lateral prone position until the condition abates, in the hope that this posture will relieve duodenal constriction.

Gastro-enterostomy has been employed, and is advocated by Mayo-Robson. Byron Robinson had a recovery after operation. In a number of cases the stomach has been opened and washed out without benefit. Petit opened the abdomen and discovered a kink at the junction of the duodenum and jejunum; he raised the jejunum and sutured it to the transverse colon and the patient recovered (Conner, "Jour. Amer. Med. Assoc.," March, 1907). I cannot see how gastro-enterostomy can drain an acutely dilated stomach. The atonic muscles must be helpless in forcing stomach contents through the new exit.

Not until we know definitely the cause or causes of acute dilatation of the stomach will we be able to lay down with precision and accuracy the treatment which is indicated. There is much difference of opinion as to the causation of the condition, and widely different methods of treatment are advocated by various surgeons.

Gastroptosis (Fig. 757).—In this condition the stomach has undergone displacement downward, the greater curvature in many cases being but little above the pubic symphysis and the lesser curvature being between the ensiform cartilage and the umbilicus. This condition is far more common in women than in men, and is especially common in women who have had many children. It may be produced by tight lacing and may follow movability of the right kidney, of the liver, or of the spleen. It is often associated with enteroptosis, mobile cecum, and prolapse of the colon, and is particularly prone to arise in the anemic and tuberculous.

Symptoms.—There may be no symptoms for a long time, but sooner or later

dyspepsia arises because the stomach cannot empty itself. The stomach becomes atonic, its secretions are scanty and altered, and while the viscus may be normal in size or even shrunken, it is usually dilated. The malposition can be made out by percussion when the stomach is distended with air or with fluid, and by the *x*-rays after the patient has drunk a pint of a solution of mucilage of acacia containing subnitrate of bismuth. The bismuth lines the stomach and intercepts the *x*-rays and a radiograph shows the outlines of the stomach and hence its size and position. The pylorus descends to the umbilical region, which it does not do in plain dilatation. In dilatation the pylorus is but slightly lower than normal, but the lower border of the stomach is notably depressed. In gastroptosis there is often a constriction a short distance from the pylorus, due to a kink produced by the sagging.

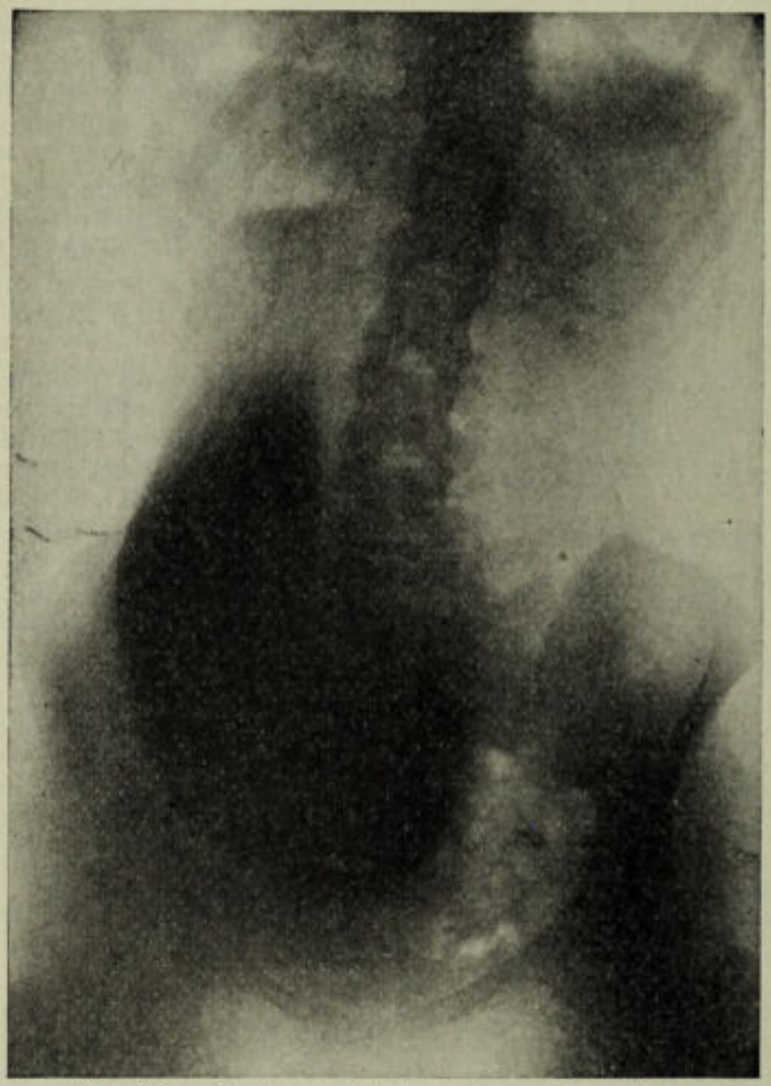


FIG. 757.—Gastroptosis (shown by a skiagraph).

When a patient with gastroptosis stands erect the bulging is most prominent in the region of the umbilicus and the epigastrium is deepened.

Gastroptosis is not infrequently associated with chlorosis and commonly with neurasthenia.

Treatment.—Lavage, regulation of the diet, improvement of the general health, the wearing of an abdominal binder, and placing the patient supine for a time after each meal comprise the medical treatment. If medical treatment fails and the condition is producing grave impairment of the general health, it may be necessary to perform a surgical operation. Gastroenterostomy is advocated by some on the ground that the unpleasant symptoms result from stagnation of gastric contents. Good results have been reported by this plan. The operation of Depage is unphilosophic. Duret's operation is objectionable (see page 1087). Beyea's operation, Coffey's operation, or Ransohoff's method is preferred (see page 1087).

Chronic Intestinal Stasis.—This is a term employed by Sir Arbuthnot Lane to designate such a delay in the passage of material along the gastro-intestinal tract as to permit of the absorption of so much toxin that the body cannot successfully deal with it (Lane's paper before the Derby Med. Soc., Oct. 17, 1911). Defective drainage permits absorption of poison, and absorption of poison is responsible for ill health and the lowering of vital resistance to various bacteria. Lane and his followers are of the opinion that toxemia so induced may cause chronic mastitis, rheumatoid arthritis, gastric ulcer, duodenal ulcer, appendicitis, and, by lowering resistance, may be responsible for progressive tuberculous disease. They believe that the block to drainage is brought about by kinks, and that the kinks, which tend to form in certain situations, are due to bands; in other words, the condition is due to a mechanical cause (Lane, Ibid.). William Mayo regards such bands as congenital. Lane holds that faulty feeding in early life causes abnormal distention and pull on the gut, that when the erect posture is assumed the condition is exaggerated by the formation of new peritoneal bands which are formed to resist the dropping of the intestine. The wall of the intestine strongly opposes the passage of bacteria, but studies on animals indicate

that some bacteria may pass, most of them lodging in mesenteric glands, but a small number entering the blood by way of the thoracic duct (Moody and Irons in "Jour. Infect. Dis.," March, 1923).

Coffey, in his valuable monograph, says there are prenatal bands to furnish support. If prenatal bands are deficient, continued stasis leads to the formation of acquired bands.

In 1909 Jabez Jackson described a pseudomembrane occasionally seen over the peritoneum of the lower ileum and colon and loosely attached to it. Sometimes it is also attached to parietal peritoneum and thus limits movements of the gut. This thin membrane is known as *Jackson's veil*, and it is probably identical with Lane's bands. Some observers regard Jackson's veil as the result of pericolitis, some as due to infantile colitis, some to chronic colitis, some to appendicitis. Isaacs ("New York Med. Jour.," Oct. 26, 1912) points out that this pseudomembrane may be found in other regions than over the colon, and suggests calling the condition *membranous perienteritis*. He believes the membrane is formed because of ulceration or inflammation of the gastro-intestinal tract.

The large intestine is thought by many to play such a prominent part in toxin absorption that Barclay Smith (quoted in "Brit. Med. Jour.," Dec. 7, 1912), Metchnikoff, Lane, and others put under ban that portion of the gut, regard it as a useless and dangerous encumbrance, and would take it out and cast it away. Biologic teaching opposes the view that the large gut is useless. It has been shown that animals like the wombat, which have come down from an antediluvian species, have long large intestines. Were the theory, that the large gut is harmful, true, those animals should have been the first to disappear.

If kinks cause stasis, it is strange that the *x*-ray pictures fail to demonstrate it at the hepatic flexure or in the ascending colon (Knight, "Lancet Clinic," cxiv).

Treatment.—If a band or membrane exists, remove it, and if a raw surface is left, try to cover it over with peritoneum. Coffey divides bands, replaces and fixes the drooped viscera. After freeing adhesions cover raw surfaces as far as possible with peritoneum and then any raw areas left with vaselin (Mayo).

In partial blocking of the beginning of the large intestine or of the lower ileum some perform ileocolostomy. Lane found that in 20 per cent. of his operations impaction of the cecum necessitated a subsequent colectomy, so now he extirpates the colon and fastens the upper end of the divided ileum to the rectum. He does the same operation for rheumatoid arthritis, tuberculous joints, and other conditions—long steps on a radical road where, so far, few have gone more than a short distance.

Cystic Intestinal Pneumatosis.—(See the valuable article by Cyril A. R. Nitch in "Brit. Jour. of Surg.," April, 1924.) The first case found in the living was by Hahn in 1899. Nitch finds 85 cases on record, and 56 of them were noted during life. In 65 per cent. of recorded cases gastric or duodenal ulcer existed. Other associated conditions are cancer or stenosis of the pylorus, tuberculous peritonitis, tuberculosis of the intestine, and intestinal obstruction. The condition, according to Nitch, is three times as common in males as in females and is most often met with between the ages of thirty and forty. It may involve a considerable area of intestine or of stomach, omenta and intestine, but may be limited to a portion of the stomach, ileum, jejunum, cecum, ascending or transverse colon. The commonest site is near the lower end of the ileum. It tends to occur in groups. Some of the cysts are of pin-head size. Others are much larger. One case had cysts the size of a man's fist (Nitch, Ibid.). Some are submucous, some are subserous. They are found on abdominal exploration. The subserous cysts glisten, are rounded, are translucent, and may have pedicles. The submucous cysts do not have pedicles and are not translucent. The gas in the cysts contains O, H, N, and NO_2. Nitch (Ibid.) believes that the spaces are in lymphatics. There was an abrasion of mucous membrane, air was forced into the lymphatics, the gas irritated, obliterative endolymphangitis resulted, and gas cysts formed. The condition may cause obstruction or vomiting, colic, and distention, but it causes no distinctive symptoms. The condition is not attacked surgically unless it is causing obstruction. The cure of an associated gastro-intestinal lesion usually cures pneumatosis.

Intestinal obstruction (**ileus** or **enterostenosis**) is a condition in which fecal movement is mechanically impeded or prevented. It may be either *partial* or *complete*, *acute* or *gradual*. *Acute obstruction* is due to a sudden narrowing or occlusion of the lumen of a portion of the intestine. *Chronic obstruction* is due to a gradual narrowing of the lumen of a portion of the intestine, and it may at any time become acute. If

there is not only interference with the passage of the fecal current but also obstruction to the blood-current in the wall of the bowel, the condition becomes *strangulation*. The primal cause is mechanical in nature, in most cases a mechanical block. In paralysis of the bowel from peritonitis there is inability of the bowel wall to contract and force the feces onward. In all cases of unrelieved obstruction the nerves are sooner or later damaged and paralysis occurs. In acute obstruction the stagnated intestinal contents become charged with powerful poisons which are thought to act most harmfully on the musculature of the intestinal wall, and, after absorption, attack the heart and nervous system.

Various views have been put forth as to the cause of death in acute obstruction. Among them may be mentioned:

1. Absorption of toxin from the stagnated contents of the blocked gut, the poison being a product of putrefaction.
2. Anemia of the brain.
3. A great depletion of the circulation.

Pringle ("Lancet," 1923) says that death is due to a toxin elaborated in the duodenum, which is not absorbed by the normal, but is from the obstructed intestine. The poison may be derived from the disintegration of protein by bacteria and the pancreatic juice.

Sweet, Peet, and Hendrix ("Annals of Surgery," 1916, vol. lxiii) believe that the poison is formed in the cells of the mucous membrane of the small gut and do not regard it as a proteose material. (See also Ellis in "Annals of Surgery," April, 1922.)

The inaugural shock is due to the production of the block; later the increasing depression is due to absorption of poisons. Gas forms in great amount in the intestine and produces distention. Distention impairs the circulation in the wall of the intestine and embarrasses respiration by pushing up the diaphragm.

Acute Obstruction.—The worst forms of this grave condition are due to sudden and absolute blocking of the bowel with strangulation, as when a portion of bowel is caught under a band or in a hernial aperture.

As soon as strangulation occurs there is violent peristalsis. The bowel above the strangulation for a short time vainly lashes itself into efforts to force intestinal material past the obstruction. The peristalsis below empties the bowel below the obstruction, leaving it empty and contracted, but not paralyzed.

Peristalsis above the obstruction soon ceases, and the bowel in this region becomes greatly distended with bloody fecal fluid and gas. The putrefaction of the intestinal contents forms great quantities of gas: none of it can pass the obstruction and little of it can be absorbed because of circulatory disturbance in the bowel wall. It is only early in an acute obstruction that the distended bowel above the block is thin. It soon becomes congested and edematous, bleeding may occur from the mucous membrane which desquamates and may be eroded. When the mucous membrane is desquamated, bacteria pass through the bowel wall and cause peritonitis, or erosions may perforate. Miles ("A System of Surgery," edited by C. C. Choyce) points out that swelling of the gut is greatest when obstruction is in the small intestine because "secretion of a considerable amount of fluid is reflexly stimulated." The distention may ascend all the way to the stomach.

In most cases strangulation at first blocks veins; later, in severe cases, it also blocks arteries. In a very sudden and complete strangulation both arteries and veins are shut off simultaneously. Early in the case, when the veins only are obstructed, the coil of gut is purple, edematous and distended, and bloody serum may pass into the lumen of the bowel and also into the cavity of the peritoneum. Later the arteries are blocked and then gangrene soon occurs. In very acute cases, when the arteries and veins are blocked simultaneously, gangrene arises promptly. In such a case the strangulated coil is not distended and is gray or greenish in color. When strangulation occurs bacteria soon begin to pass through the walls of the strangulated coil and cause peritonitis. Perforations may take place in the coil, at the seat of constriction, or even in the gut above the block.

Chronic Obstruction.—This comes on gradually. A tumor may slowly fill up the lumen of the bowel or a cicatrix or tumor in the bowel wall may constrict more and more. Pressure outside the bowel may be responsible. In regions where the feces are fluid, great narrowing can occur without symptoms. When fecal passage is seriously hindered the bowel above the obstruction becomes distended and its muscular wall undergoes hypertrophy. The hypertrophy depends on the exercise of greater and greater effort to overcome the obstruction. Miles ("A System of Surgery,"

edited by C. C. Choyce) states that above the obstruction the bowel becomes thick, "elongated, and tortuous"; that in the small intestine hypertrophy exceeds dilatation, and in the large intestine dilatation exceeds hypertrophy.

The mucous membrane is inflamed because of irritation of retained decomposed material and ulceration may occur. Peri-intestinal suppuration may arise. Gas does not gather above the obstruction because the circulation is still active in the bowel wall and because some gas can still pass naturally. When the narrowed channel in a partially obstructed bowel suddenly and completely closes, acute obstruction arises. When it does the bowel above becomes congested and distended. An active purgative or indigestible food may be responsible for acute obstruction.

Various Causes of Intestinal Obstruction.—Obstruction by Adhesions (Fig. 758).—Adhesions result from previous peritonitis. There may be a few adhesions or a multitude of them. A portion of bowel may be bent or twisted by the traction of adhesions or gaseous movement may twist a coil or bend it above an adhesion. The obstruction may be acute or chronic. Even when acute, strangulation is unusual.

Volvulus (Fig. 759).—By this term we mean twisting of a loop of bowel upon its mesenteric axis. It is true that under peculiar circumstances the bowel may twist on its own long axis because of adhesions, but such a twist is not a true volvulus. Fifteen per cent. of acute obstructions are due to volvulus (Briggs, "Ohio State Med. Jour.," Nov., 1912). Volvulus may occur in a hernial sac. In rare cases two coils of intestine twist together. It is not limited to the pelvic colon, but, in a very large majority of cases, it is this portion of bowel which suffers. The twist may be partial, a complete turn, or even two or three complete turns. This very dangerous condition occurs particularly in adults. A colon loaded with feces predisposes; so does a long mesocolon and a mesocolon with a narrow base, and so may adhesions. Rotation may be caused by straining at stool, by a sudden shift in position, by lifting, by a blow upon the abdomen, or by peristalsis induced by an active purgative. In most cases the twist is tight enough to occlude the blood-supply of the loop. The loop becomes plum colored and edematous, bloody serum flows into the bowel and into the peritoneal cavity, and immense distention of the loop occurs. The colon above the obstruction also distends. Peritonitis occurs early. Perforation may occur and is most apt to take place above the loop.

Intussusception (Figs. 760, 761).—By this term we mean the invagination of a portion of bowel wall into the lumen of an adjacent part of the gut. In nearly all cases an upper segment invaginates into the lower. One-third of all cases of obstruction are due to this cause (Treves). In young children it usually causes acute obstruction; in an adult, chronic obstruction, ending perhaps in an acute attack. Most cases of obstruction in children are due to intussusception. Pitt reports that in St. Thomas's Hospital, from 1875 to 1900 inclusive, there were 115 cases of intussusception, and every patient was under fifty years of age. Gibbon's patient was fifty-eight. Rutherford Morrison had a case due to polypus, and the patient was sixty-two years of age. Males are twice as liable as females. During the performance of peristalsis a localized circular constriction forms and the invagination takes place through the constricted area. The great relative frequency of intussusception in childhood is due to the greater mobility and irritability of the child's bowel (Treves). The irregular and localized spasm is due to bulky or irritant material within the gut, and, according to Rushmore ("Annals of Surgery," Aug., 1907), the starting-point of invagination is obstruction. Were peristalsis alone the cause the condition would be far more common than it is in the diarrhea of children. There are four chief varieties: the *ileocecal*, in which the ileum and the ileocecal valve pass into the cecum and colon; the *colic*, in which the large intestine is prolapsed into itself; the *ileal*, in which the small intestine alone is involved; and the *ileocolic*, in which the ileum prolapses through the ileocecal valve. Other forms are *diverticular* (with a diverticulum), *retrograde* (due to reversed peristalsis), *of Meckel's diverticulum*, *ileo-appendical*, and *cecal*. The ileocecal variety is vastly the most common. In Rushmore's table ("Annals of Surgery," Aug., 1907) the location was definitely stated in 237 cases: 140 of these were ileocecal and 31 were ileocolic.

The *intussusceptum* consists of the entering tube and the returning layer.

The *intussuscipiens* is the sheath or receiving tube. As the intussusceptum grows longer and longer the mesentery is drawn between the entering tube and the sheath. The mesentery becomes curved and draws the involved intestine toward the back and left side. The dragging, twisting, and squeezing of the mesentery impairs the blood-supply of the intussusceptum. The invaginated portion, especially the return-



FIG. 758.

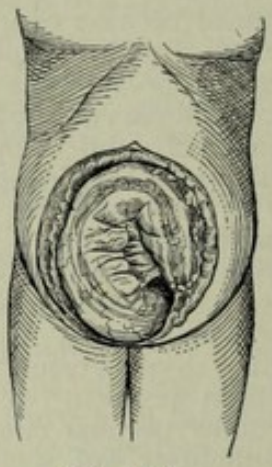


FIG. 759.

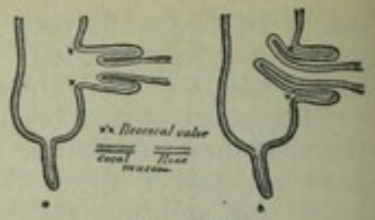


FIG. 760.

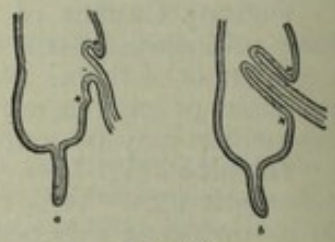


FIG. 761.

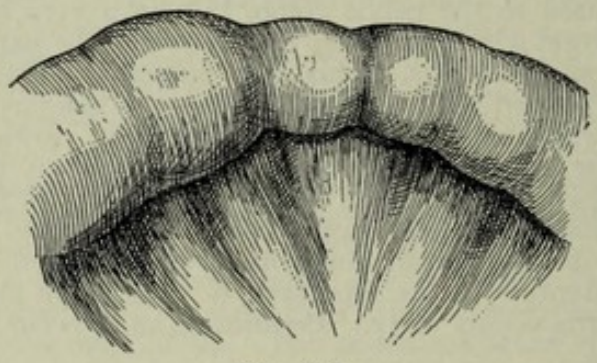


FIG. 762.

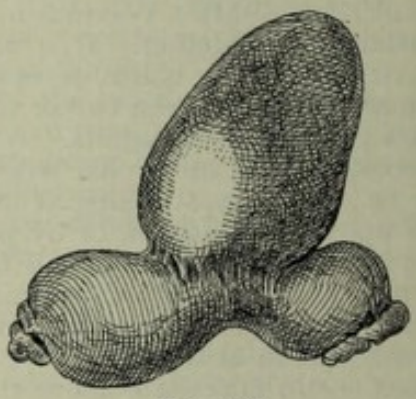


FIG. 763.

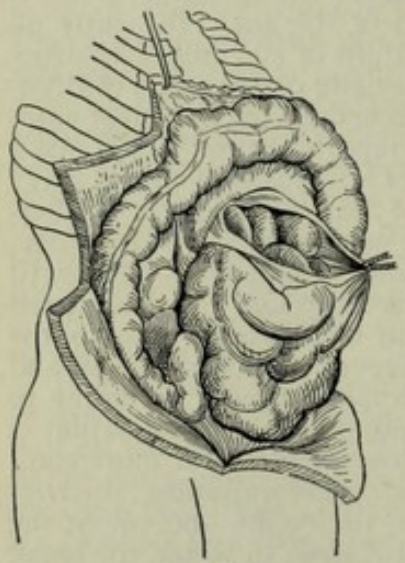


FIG. 764.

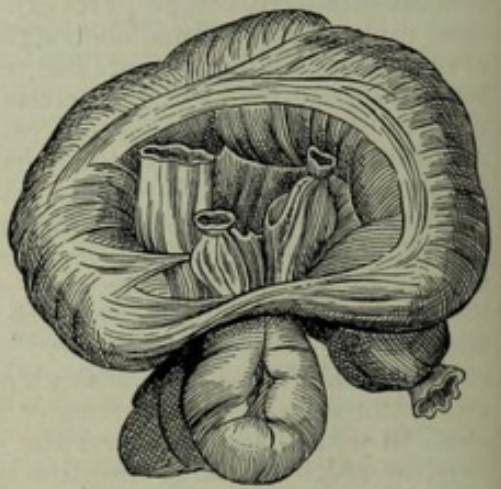


FIG. 765.

FIGS. 758–765.—Forms of intestinal obstruction.

FIG. 758.—Stenosed ulcerated tumor of the pylorus; coils of intestine agglutinated by numerous adhesions. Resected intestinal coils (Payr).

FIG. 759.—Volvulus of the sigmoid flexure (Richardson's case).

FIG. 760.—*a*, Invaginatio iliaca; *b*, invaginatio ilia-ileocolica (H. Lorenz).

FIG. 761.—*a*, Prolapsus ilei; *b*, invaginatio ileocolica (H. Lorenz).

FIG. 762.—Obstruction of the jejunum due to gall-stone, showing the contraction of the muscular fibers of the intestine upon the stone, which is smaller in diameter than the lumen of the gut (Mixter's case).

FIG. 763.—Meckel's diverticulum (Bunts).

FIG. 764.—Hernia into the fossa duodenojejunalis (after Cooper).

FIG. 765.—Strangulation by a band (Warren Museum).

ing tube and apex, becomes congested and swollen, the mucous membrane secretes profusely, and blood passes into the bowel. From this source come the blood and mucus passed by the bowel. An intussusception tends to become irreducible by adhesion of its walls and by engorgement, particularly of the apex. An intussusception may cause complete obstruction eventually, strangulation may take place, gangrene may occur, peritonitis may arise.

Foreign Bodies, Gall-stones, and Enteroliths (Fig. 762).—Foreign bodies include besides certain substances that have been swallowed, gall-stones and enteroliths or intestinal calculi. Foreign bodies are apt to lodge in the lower portion of the ileum or in the cecum, and they may cause ulceration at the seat of lodgment. If a gall-stone is sufficiently large to cause obstruction, it cannot have passed the duct, but must have ulcerated into the bowel from the gall-bladder. About three-fourths of the cases of gall-stone intestinal obstruction occur in women. The stone is arrested at some point because either local spasm or paralysis of the bowel has developed. It may be arrested high up, but is most apt to be in the lower ileum. A stone under 1 inch in diameter ought to pass. A. W. Mayo-Robson ("Brit. Med. Jour.," May 1, 1909) points out that all cases of obstruction due to gall-stones are not the result of mechanical obstruction by a large stone which entered the intestinal canal by ulceration, but that there are three other possible conditions, viz.: Local peritonitis in the gall-bladder region causing paralysis of the bowel; volvulus of the small intestine due to biliary colic or to ulceration of a gall-stone into the gut; obstruction coming on "after the original cause has disappeared" and due to adhesions without or obstruction within the gut.

Enteroliths (fecal concretions) are usually deposits of salts from the feces, especially apt to be formed when the patient has long suffered from catarrhal inflammation of the bowel. The nucleus may be a hair-ball in a woman who swallows hair, or the stone of a fruit. A gall-stone may have a concretion form about it. Food residues mixed with salts may constitute concretions. So may insoluble materials taken frequently as medicine or from habit (chalk, bismuth, magnesia). An enterolith increases in size up to a certain point, but seldom becomes enormous.

Internal Herniæ (Fig. 764).—These include: (1) retroperitoneal hernia, (2) diaphragmatic hernia, and (3) other intraperitoneal hernia.

A hernia may pass into one of the fossæ about the duodenum, one of the fossæ about the cecum, the intersigmoid fossæ, or through the foramen of Winslow into the lesser peritoneal cavity. Pringle reported a case of hernia into the paraduodenal fossa ("Glasgow Med. Jour.," 1916, lxxxvi). Intersigmoid retroperitoneal hernia is one of the rarest of lesions and only 3 cases have been reported (John B. Murphy's Clinics, Aug., 1914). The appendix may be strangulated in a pericecal fossa and cause obstruction. Diaphragmatic hernia is described on page 1157. An internal hernia may become strangulated just as may an external hernia.

Obstruction by Bands and Abnormal Openings (Fig. 765).—Briggs considers adhesions, bands, and abnormal openings responsible for 40 per cent. of cases. The band may be a portion of the great omentum which has taken on an unnatural attachment, a Meckel's diverticulum, omphalomesenteric remnants, an appendix attached at its tip, a broad band or cord-like peritoneal adhesion, a retroperitoneal pouch or an abnormal opening in the diaphragm. The obstruction in these cases is apt to be acute and is commonly accompanied by strangulation. It usually involves the ileum, sometimes the colon. There may be an abnormal opening, congenital or acquired, in the omentum, the mesentery, or the mesocolon. The bowel may slip through such an opening and be caught and strangulated.

Obstruction may take place by *Meckel's diverticulum* (Fig. 763) (see page 974), a structure due to persistence of the vitelline or omphalomesenteric duct, coming off from the ileum from 12 to 36 inches above the ileocecal valve, and present in about 2 per cent. of persons. The vitelline duct should be obliterated in the eighth week of fetal life. If it persists the individual possessing it is in constant and serious danger. The mortality of a series of cases of obstruction due to Meckel's diverticulum is enormous. Meckel's diverticulum usually has no mesentery, is from 3 to 10 inches long, and arises from the convex side of the gut. It may hang free or may be attached to the umbilicus by its tip or by a fibrous cord formed by the obliterated tip. In some cases it remains open at the umbilicus (see page 347). In other cases a cord runs from the umbilicus to the gut or the tip of the diverticulum, or is adherent to another portion of the intestine. The diverticulum may become gangrenous with or without strangulation, may enter a hernial sac, may ulcerate or perforate like an appendix.

(W. Sheen in "Bristol Medico-Chir. Jour.," Dec., 1901, gives an admirable account of "Some Surgical Aspects of Meckel's Diverticulum"; see also article on "Obstruction of the Bowels by Meckel's Diverticulum," by James E. Moore in "Jour. Amer. Med. Assoc.," Oct. 4, 1902, and on "Abdominal Crises Caused by Meckel's Diverticulum," by Miles F. Porter, in "Jour. Amer. Med. Assoc.," Sept. 23, 1905.) Strangulation of the diverticulum may take place beneath an adherent appendix, a Fallopian tube, a portion of mesentery, or the pedicle of an ovarian tumor, or it may take place in an omental or a mesenteric aperture. Gangrene, inflammation, or twisting may occur. Obstruction may be due to invagination of the diverticulum into the bowel. H. Tyrrell Gray collected 39 cases of invagination and added 1 of his own, 40 in all ("Annals of Surgery," Dec., 1908).

Cicatricial Stricture.—This is not a common cause. I have operated on 1 case due to the scar of a typhoid ulcer. The obstruction occurred gradually and became acute years after the fever. Any healed ulcer may be responsible. Tuberculosis is the most common cause. Syphilis or dysentery may be responsible. A contusion or wound of the bowel may be causal.

Tumors of the Bowel.—They are uncommon in the small intestine. Adenoma, lipoma, fibroma, and myoma may occur. They may cause obstruction from blocking or may be responsible for intussusception. Sarcoma is seldom met with, but more often in the small bowel than in the large gut. The patient's general health is much impaired, and a tumor can be palpated before obstruction occurs, and obstruction may never occur. Carcinoma of the upper bowel is rarely met with. Cancer of the small bowel is more common than benign tumors and sarcoma, but less common than cancer of the large bowel. Cancer of the small intestine is most common in the lower ileum, and arises from columnar cells. It causes constriction and stenosis and usually ulcerates. In the large intestine fibroma, lipoma, adenoma, myoma, or sarcoma may arise. I removed an adenoma from the sigmoid which had produced obstruction. Apparently it has not recurred after nine years. A great number of adenomata may be present (*multiple adenoma of Virchow*). Obstruction is rare from innocent tumors. In sarcoma symptoms are absent until the growth attains a large size and obstruction may be the first symptom. Sarcoma of the intestine causes glandular involvement, as does cancer. The colon is a common site for cancer. It is usually primary, but may be secondary. It produces chronic obstruction. The growth is columnar celled, and may be scirrhous, encephaloid, or colloid. A tumor causes obstruction by a block, a kink, a volvulus, or an intussusception.

Obstruction by Tumors, etc., Outside the Bowel.—Among the causes of such obstruction are retroflexion or retroversion of the womb, especially in pregnancy, cysts or tumors of the kidneys, mesentery, ovaries, uterus, etc., movable kidney, enlarged spleen, or diverticulum of the bowel (sigmoid or small bowel). Obstruction from any of the above causes takes place in the rectum, the sigmoid flexure, or the colon above the sigmoid.

Obstruction from Fecal Accumulation.—Fecal impaction resulting from prolonged constipation is quite common. Obstruction sometimes, but seldom, occurs. When obstruction follows upon impaction it is usually brought about by rotation of a loop of bowel (volvulus) or angulation of a segment, but may be due to abolition of peristalsis because of paralysis. In impaction the fecal mass is usually soft, but may be hard. There may be one large mass or numerous smaller ones. The mass may reach from the rectum actually into the transverse colon and may even be mistaken for a neoplasm. It usually begins to form in the pelvic colon (Miles, "A System of Surgery," edited by C. C. Choyce). The weight of such a quantity of feces may cause a packed loop of gut to sink into the pelvis and may stretch and narrow the mesocolon. Ulcerations of the mucous membrane may form (*stercoral ulcers*).

Postoperative Obstruction.—Obstruction may come on a day or two after, several or many days after, or weeks or even months after an abdominal operation. We deal here with early obstruction.

Obstruction may be due to a mechanical cause at the seat of operation (adhesion of the bowel to a raw surface, volvulus, catching of the gut under a band, etc.). It may be due to a mechanical cause distant from the seat of operation (bands, adhesions, displacement of the intestine, etc.). It may be due to thrombosis of the mesenteric vessels. Although any one of the above conditions may arise after an operation, there is nothing special and peculiar in it when it does. Such conditions are considered under special headings (bands, adhesions, etc.). Again, postoperative obstruction may be due to the pressure upon the gut of gauze packing or of a drainage-

tube. It may be due to paralysis of a loop of gut because of local sepsis (as after an operation for appendicitis), or it may be a paralytic ileus from wide-spread sepsis (general peritonitis).

What we really mean by postoperative obstruction is a condition arising from gaseous distention. Gas begins to accumulate soon after the operation. The patient cannot expel it. He tries, but the straining efforts fail and may burst the belly wound. More and more gas gathers and annoyance becomes torture. The overdistended bowel finally becomes paralyzed and paralytic obstruction occurs. This true postoperative obstruction is particularly apt to arise if evisceration has been practised, if the intestines have been squeezed and handled and not protected from chill, and if the operation has been prolonged.

Embolism or Thrombosis of the Mesenteric Vessels.—The arteries may be the seat of embolism or thrombosis; the veins, of thrombosis. A large artery may be blocked by an embolus or occluded by a thrombus or a large vein may be blocked by a thrombus or filled by the extension of a thrombus from a radical of the portal system (especially from the region of the appendix). The section of bowel, large or small, from which the blood is kept undergoes paralysis. Gangrene and peritonitis soon follow. In thrombosis of the mesenteric artery the bowel becomes edematous and a hematoma may form between the mesenteric layers. This very fatal condition manifests itself in most cases as a paralytic obstruction arising suddenly in an individual who has cirrhosis of the liver or valvular disease of the heart, who has had ulcerative endocarditis, an injury, or an operation.

Reflex Obstruction of Renal Origin.—This condition may occur as a result of Bright's disease, renal calculi and infections, and the stomach may dilate as well as the intestine (see Daniel N. Eisendrath in "Surgery, Gynecology, and Obstetrics," June, 1916). This reflex paralysis is made manifest by distention, sudden obstruction, vomiting (which does not become feculent early), pain, and abdominal rigidity. The condition appears to be due to splanchnic inhibition (Eisendrath, Ibid.).

Pseudo-obstruction or Spasm of the Intestine.—In this condition a limited portion of the bowel undergoes spasmodic contraction, which lasts for several hours or even for a day and then passes quickly away. This contraction is usually in the pelvic colon. In many cases a swelling can be made out. It is due to a loop of distended gut and disappears when the patient is under ether. Such a swelling is known as a *phantom tumor*. These attacks occur in neurotic women, especially those with catarrh of the colon. Besides the causes of obstruction above mentioned we should refer to shrinking of the mesentery.

Symptoms of Acute Obstruction.—Examine the abdomen, the rectum, and every orifice through which hernia might occur. The onset is marked by pain, shock, and vomiting. The tighter the constriction, the more sudden is the attack; the more bowel there is involved, the greater the shock. This element of shock often makes the diagnosis uncertain, and we may suspect abdominal hemorrhage or perforation when the real lesion is strangulation. The pain is generalized, violent and continuous, with fierce exacerbations. The continuous pain is due to the constriction; the exacerbations, to the colic of peristalsis. If the ileum or jejunum is involved the continuous pain is about the umbilicus. If the large intestine or duodenum is the seat of trouble the continuous pain is located about the lesion. The pains of peristalsis are generalized throughout the abdomen. The higher up the constriction, the tighter it is, and the more bowel there is caught, the greater the pain. Later, when paralysis of the gut occurs or perforation takes place, the pain for a time abates, to recur again with peritonitis. Early in the case there is neither rigidity nor tenderness; as paralysis begins tenderness develops. Early in the case pressure may actually afford some relief. When tenderness exists tapping is more apt to cause pain than is pressure; in peritonitis pressure causes more pain than tapping (Battle). When tenderness develops it is at first local. When peritonitis arises, of course, tenderness becomes acute and rigidity develops.

Vomiting comes on soon after the development of pain, but does not give any relief. It is accompanied by nausea and violent retching, continues practically without cessation, and whether food and drink are taken or not.

The vomited matter consists first of the contents of the stomach, next of quantities of bilious matter, and finally of brown or yellow stinking fluid, which was long believed to be feces. Vomiting of this character is called *stercoraceous vomiting*. Vomiting of genuine feces may occur, but is rare. In stercoraceous vomiting the fluid gushes up

in quantity and by regurgitation rather than efforts of vomiting. This sort of vomiting can occur even when the obstruction is in the upper jejunum or duodenum.

A notable characteristic of obstruction is total inability to pass gas or feces. It is necessary to remember that in the very beginning of the case there may have been a bowel movement, due to peristalsis emptying the intestine below the seat of lesion. A single movement early is no proof that the condition is not obstruction. The temperature becomes subnormal. The pulse is weak and rapid. The tongue and breath are very foul. The appearance of the patient indicates desperate illness. It is only in cases of strangulation in the pelvic colon that the patient has a strong desire and makes frequent attempts to move his bowel. If an enema is given it is usually retained, or else leaks away without bringing fecal matter with it. Distention from gas (*tympanites*) is always soon present. The lower the obstruction, the more widespread is the distention. Early in the case the abdomen is flat and relaxed, but this condition is very temporary. We may be able to gain information by studying the distention. If both flanks bulge, the block is in the pelvic colon. If the left flank is flat and the right distended, the block is in the colon well above the pelvic colon. If only the small intestine is distended, the block is on the proximal side of the ileocecal valve. As the case progresses distention increases and causes great embarrassment to respiration by pushing up the diaphragm. In thin patients, early in the case, we may occasionally see waves of peristalsis above the obstruction. We can sometimes feel them even when they are unrecognizable by the eye. In many cases of intussusception and in a number of cases of chronic obstruction which have become acute they can be felt. In many cases of obstruction of the colon peristalsis above the lesion may be seen and felt.

Cases of intestinal obstruction tend to pass into collapse. This condition is due to the absorption of poisons from above the obstruction, and is aggravated by vomiting and sweating which abstract quantities of fluid from the blood. In this form of intoxication the blood contains an unduly large amount of non-protein nitrogen because of great destruction of body protein (Haden and Orr in "The Johns Hopkins Hospital Bulletin," Jan., 1923). When collapse has come on the temperature is subnormal; the extremities cold; the blood-pressure very low, the pulse very rapid and weak, often a mere thread or trickle; the respirations are rapid and shallow, excessive flow of saliva is common, and the face becomes *Hippocratic* (eyes, cheeks, and temples sunken, eyes dull and often turned upward, lids drooping, nostrils thin and drawn, features pinched, the nose pointed, the malar bones prominent, ears retracted and cold, jaw often drooped and mouth perhaps open, lips blue or blanched, skin livid or deadly pale). The amount of urine passed is small, sometimes very small, and the fluid is highly nitrogenous. The higher the obstruction, the less the amount passed. During or after the second day indican is usually present in the urine. It results from putrefaction of proteins brought about by anaërobic bacteria and the formation of indol in the intestine. In obstruction there is leukocytosis, the white count being perhaps from 15,000 to 30,000 (Bloodgood in "Johns Hopkins Hospital Reports," vol. vii).

The mortality from acute obstruction is very high (40–50 per cent.). According to Elsberg, gangrene occurs in 13 per cent. of cases. Seldom can a mass be felt. It can often be felt in intussusception; it can sometimes be palpated when there is a fecal concretion or other foreign body. Obstruction during pregnancy is very dangerous. If the uterus is not emptied by operation most cases will abort or miscarry. The diagnosis is usually made disastrously late because the pain of obstruction is thought to be the pain of parturition.

Symptoms of Chronic Obstruction.—The symptoms come on gradually. There are periods when great constipation exists, alternating with periods of comfort or perhaps with seizures of fluid diarrhea. After a time the attacks of constipation become painful and accompanied, it may be, by vomiting after eating. The patient feels abdominal discomfort most of the time and is much annoyed by gas in the intestine. It is very difficult to expel the gas from below. All the time the constipation is growing more obstinate and the patient is resorting to stronger and stronger purgatives and is obtaining less and less response. Finally, a strong purgative may fail utterly, only serving to cause severe colic and perhaps vomiting. It may also cause pain at the seat of the lesion. Patients in this condition may develop attacks of diarrhea, small amounts of feces mixed with mucus being passed. This condition is due to colonic catarrh, is called the "*diarrhea of constipation*," and affords no mitigation to the discomfort and pain.

During the progress of the case the bowel above the block distends. Because of the hypertrophy of the muscular wall of the gut and of the loss of flesh, painful peristalsis (which can be felt and seen) is often noted above the obstruction. This sign is detected far oftener in chronic than in acute obstruction. The distended intestine showing peristaltic contraction is a strong suggestion of chronic obstruction. The painful peristalsis is often productive of rumbling and gurgling noises (*borborygmi*). By noticing the portion of gut distended we may be able to locate the seat of stenosis (see page 970). This method is more valuable in chronic than in acute obstruction. On digital examination of the rectum the rugæ may no longer be felt and the rectum is greatly distended because of paralysis. This is known as *rectal ballooning*.

The above-described condition may cease to intermit or even remit, all the symptoms may grow progressively worse, constant nausea being present, vomiting ensuing on taking food, and the breath being horribly foul. Such a patient is being poisoned to death by toxins. He may perish from exhaustion, from perforation, or from peritonitis. At any time during the progress of chronic obstruction acute obstruction may develop. The sudden complete block may be due to a plug of hardened feces or some foreign body. It not unusually follows the taking of a strong purgative. It may be due to volvulus or to bending. The acute attack is sudden. One loose movement may occur early in the acute attack.

In some cases of chronic obstruction a tumor may be palpated, in some intussusception can be made out, in some there is a history of antecedent peritonitis, in many there are evidences of malignant disease.

Diagnosis.—*The determination of the seat of lesion* requires abdominal and rectal examination. An intussusception may sometimes be felt by a finger in the rectum and can often be felt by palpation of the abdomen. Vaginal examination may be demanded. Pain is apt to arise at the seat of obstruction or to radiate from there. Abdominal palpation may detect a tumor. Rectal insufflation of hydrogen may locate the obstruction by causing great distention below it. Entire suppression of urine, early vomiting, absence of abdominal distention, and rapid collapse mean obstruction in the duodenum or in the jejunum. Early vomiting, a rapidly progressive case, with great distention of the umbilical region, means obstruction of the ileum or the cecum. Distention of the entire abdomen and of the flanks, linked with tenesmus, with less violent symptoms, less rapidity of progress, and less diminution of urine than in the above-cited forms, means obstruction low down in the colon or in the rectum. An old test for obstruction in the adult large intestine is an injection by a fountain-syringe: if 6 quarts can be introduced, there is no obstruction in the large intestine; if less than 4 quarts can be introduced, there is probably obstruction in the large intestine. This test is unreliable. The passage of a sound in the rectum is useless and is often unsafe. Chronic obstruction of the colon causes weakness, loss of weight, anorexia, discomfort and after a time colicky pains, advancing constipation, and sometimes blood and mucus in the stools. Finally there is sudden acute obstruction (H. W. Wilson in "Lancet," Jan. 26, 1924). Usually the *x*-ray makes evident the seat of obstruction. In some cases the seat of the lesion and the cause of the obstruction can be determined by exploratory laparotomy only. In most cases it is possible to determine without operation whether the small intestine or the colon is obstructed. If we exclude strangulated external hernia and intussusception "there is slightly greater than a 2 to 1 chance of any acute intestinal obstruction being situated in some part of the colon." (See the very able article by Mr. Burgess, of Manchester, in the "Brit. Med. Jour.," Sept. 29, 1923.) No history of previous intestinal trouble suggests small intestine. In obstruction low in the colon the distention is in the flanks if the ileocecal valve does not leak. In low obstruction of the small intestine the distention is central. The seat of visible and palpable peristalsis above the obstruction is significant. In obstruction of the ileum distended coils form what are called *ladder patterns*. If the cecum is obviously distended, or if it hardens and softens under the surgeon's fingers, the obstruction is distal (Burgess, Ibid.). It is imperatively necessary to examine the rectum and vagina.

The *determination of the causative condition* is always difficult and is often impossible. *Intussusception* may arise in child or adult. It is the common cause in children. Intussusception may induce acute or chronic obstruction. In the child acute obstruction is far more common than chronic obstruction. In most cases the child has been previously healthy except for constipation or diarrhea. The attack begins with a violent seizure of colicky pain and vomiting, but although the patient be pale, there is seldom shock at this stage. The vomiting may be occasionally repeated, but

it is not forcible retching and very rarely becomes stercoraceous. The bowel below the obstruction is often emptied in this stage. After a time pain abates or disappears, to recur again and again. Between the seizures of pain the patient often appears to be in good condition, with a normal temperature and an almost normal pulse. Tenesmus soon arises in most cases, bloody mucus in small quantities being passed frequently. The source of the bloody mucus is the squeezed and congested intussusceptum. A sausage-shaped mass can usually soon be felt somewhere over the large intestine. It may be in the right iliac fossa or in the left iliac fossa, but is usually over the region of the transverse colon. Hour by hour it is drawn more toward the attachment of the mesentery on the left side. Osler reports that a mass was palpable in 66 of 93 cases, and in over one-third of these cases it was noted the first day. It has been felt as early as three hours after the onset of pain. It becomes rigid during a pain. It may shift its position hour by hour, and it may disappear after having been obvious. It may be detected only after an anesthetic has been given. Rectal examination gives no information in early cases or in cases involving the small bowel only. In late cases a mass may perhaps be felt in the rectum. The abdomen is rarely rigid, distended, or tender until late in the case, and at this period there may be shock or sepsis. In chronic intussusception in a child the condition may progress very slowly. The stools contain bloody mucus, there are attacks of abdominal pain, a lump may be felt along the colon or through the rectum, and peristalsis may be visible. If an abdominal lump is detectable it will harden during colic and will change its position from day to day.

Acute intussusception in the adult seldom presents characteristic features unless the sausage-shaped lump can be detected.

Chronic intussusception in an adult causes sudden attacks of vomiting and of abdominal colic which last a short time and pass away as suddenly as they arose. Later they may linger longer. A lump can usually be made out. There may be constipation or mucous diarrhea, and blood may be passed with the mucus. Acute obstruction usually arises.

Obstruction from adhesions is chronic obstruction which may become acute. There is a history of antecedent peritonitis. A local distention of the intestine is often noted. In *obstruction from bands* there is a record of antecedent peritonitis, of a traumatism, of a violent effort, or of pelvic pain. The attack is sudden in onset, is fierce in character, and is usually excited by violent exercise or the taking of food. Vomiting is early and intractable, and it soon becomes stercoraceous; pain is violent; peristalsis above the obstruction is forcible for a time; tympanites and abdominal tenderness appear after the attack has lasted for some little time; obstruction is complete, not even gas being passed; collapse soon arises; no tumor can be detected, and rectal examination is negative. *Volvulus*, which is usually located in the pelvic colon, is far commoner in men than in women, in the middle aged than in those at the extremes of life. It is usually preceded by constipation. The symptoms come on with explosive suddenness and rapidly attain great severity. Obstruction is absolute; vomiting is late and is rarely stercoraceous; no tumor can be detected; rectal examination is negative; abdominal distention is early and pronounced, and may become enormous; peristalsis above the volvulus is seldom discovered; collapse is not so rapid nor so grave as in obstruction from bands and internal hernia. There is severe continuous pain with frequent exacerbations. The pain is about the umbilicus and in the left iliac region and left loin. Tenderness is soon manifest and is ominous, as it means peritonitis. If unrelieved, death will occur in from forty-eight to seventy-two hours. Cases of incomplete obstruction by volvulus are rarities. *Obstruction by a foreign body* may sometimes be inferred from the history of some such body having been swallowed. The obstructing body may occasionally be felt during palpation or may be discovered by the *x*-rays. Abdominal distress may exist for days or weeks before obstruction occurs. Vomiting is late and is rarely severe, but pain, tenderness, and distention are marked. In *obstruction from gall-stones* the victim is elderly and usually stout. There may be a history of one or more attacks of hepatic colic, but often the only history is of what was supposed to be painful chronic indigestion. When the stone is ulcerating into the bowel it causes localized pain and tenderness. As it slowly descends along the intestine it may be arrested again and again, causing attack after attack of blocking. When the gut becomes really blocked pain is early and acute, and vomiting is invariable and usually becomes stercoraceous. There is seldom much tenderness. Rigidity is not common. Shock is seldom present at the onset. Distention is not marked. In rare cases the stone can be palpated. The *x*-rays may show it.

In *obstruction by an enterolith* the patient may give a history of many attacks of supposed enteritis or colitis, followed after some time by temporary attacks of obstruction. The calculus in rare cases can be palpated. The *x*-rays will show it.

In *obstruction from fecal impaction* the subject is usually of advanced years, and more often a woman than a man. There is a long history of constipation, flatulent indigestion, abdominal annoyance, painful straining at stool, and of repeated attacks of the diarrhea of constipation (small fluid movements, which bring no relief because the solid masses remain agglutinated to the wall of the bowel). The colon is distended by a mass of feces, usually dough-like, but sometimes hard, which is appreciable by palpation. Sometimes hardened or putty-like masses can be touched by a finger in the rectum. In such a subject acute obstruction may at any time arise. It is characterized by severe colic, great distention, and often by vomiting, but the vomiting is not violent and is seldom stercoraceous. Collapse soon begins. *Obstruction from stricture* or *from pressure* comes on acutely after a prolonged period of disturbance, during which period attack after attack of temporary obstruction, complete or partial, has taken place. A history of blood or pus in the stools suggests *tumor of the bowel;* a history of *blood* or pus having been absent would suggest pressure from without. In *pseudo-obstruction* or *spasm of the bowel* there is sudden apparent obstruction occurring in a neurotic subject, especially a female. It is most apt to arise in a victim of old colitis, or in one who has very recently been subjected to an abdominal operation. There is severe pain, vomiting, distention, and inability to pass gas or fecal matter. The attack is transitory, lasting a few hours or, at most, a day or two, and ceasing as suddenly as it began. Sometimes a limited swelling can be detected. It is due to a loop of distended bowel and results from a contracted segment of gut. It disappears under ether, and is called a *phantom tumor.*

The presence of an *internal hernia* is not thought of until strangulation takes place, and seldom then. In duodenal hernia the patient has long suffered from pain of a colicky character. There is "a circumscribed globular swelling, resembling a movable cyst, except that it is resonant on percussion and yields intestinal sounds on auscultation. Owing to the compression of the inferior mesenteric vein at the neck of the fossa, the patient usually suffers from piles which bleed freely" (Alexander Miles in "A System of Surgery," edited by C. C. Choyce). When strangulation occurs shock is early and overwhelming, and vomiting is early, violent, and persistent. Obstruction from pericecal or intersigmoid hernia is not diagnosticated as to cause.

In hernia into the foramen of Winslow the pain is violent and epigastric, and in this region there is a swelling which gives a dull note on light and a tympanitic note on deep percussion. Diaphragmatic hernia is considered on page 1157.

Obstruction due to embolism or thrombosis of the mesenteric vessels is most common between the ages of thirty and sixty. It is announced by sudden and severe colicky pain which is paroxysmal. The pain may become continuous. Very early in the case there is no tenderness, no rigidity, and no distention, but generalized abdominal rigidity and tenderness, and advancing distention are soon observed. Pain is most acute at the seat of lesion and the greatest tenderness is at that point. As the damaged loop is not unusually in the pelvis, tenderness may be found by rectal examination (Elliot and Jameson in "Annals of Surgery," Nov., 1915). Pain in the loin and back is often complained of (McArthur, "Annals of Surg.," vol. xxxiii). The pulse is weak and rapid. Moderate vomiting may occur and there may be blood in the vomitus. There is great restlessness and usually subnormal temperature. If a lump can be palpated it is due to hematoma in the mesentery, and if an area of dulness is found it is due to edema of the gut (Reed in "Annals of Surgery," vol. ii, 1921). There may be free bloody fluid in the peritoneal cavity. Leukocytosis is noted, the polymorphonuclear leukocytes being increased. In one group of cases there is absolute obstruction. About 60 per cent. of the cases are of this type. In another group of cases there is watery diarrhea which may be bloody. Even when bloody diarrhea does not occur blood may perhaps be found in bowel washings. Peritonitis develops. Cardiac or hepatic disease can usually be demonstrated and albuminuria is common.

In *true postoperative obstruction* (see page 968) as the pulse mounts the abdomen distends, usually vomiting comes on, and there is an almost continuous regurgitation of brownish putrid fluid. It may cease for an hour or two, when there will be a great gush of the fluid. The regurgitated matter may contain blood. There is seldom pain or rigidity, the temperature is subnormal, the extremities are cold, and the face is Hippocratic (see page 970). The condition resembles acute gastric dilatation. The cause is intestinal paralysis. The symptoms of *postoperative thrombosis of the mes-*

enteric vessels, according to A. E. Maylard,[1] are as follows: Abdominal pain, perhaps colicky in character, gradual or acute in onset, and, as a rule, constant. Early in the case there is no abdominal tenderness, no distention, and no rigidity. The pulse is rapid, the patient is extremely restless, there may be vomiting, but it is never violent, as in acute obstruction; often there is diarrhea, and sometimes bloody diarrhea. These symptoms become particularly significant if there be cardiac or vascular disease.

Obstruction from Meckel's diverticulum is usually acute, but is sometimes chronic, and occurs particularly in young adults and children. It has been stated that other and visible deformities are usually present, but in a study of 69 cases by A. E. Halstead[2] this was true of but 1 case, in which harelip existed. In obstruction from Meckel's diverticulum there is often a history of former mild attacks (Ibid.). Halstead sums up the symptoms as follows: As the obstruction is low in the ileum, the abdomen has the shape of an inverted cone; early in the attack there is often local meteorism, especially under the costal arch of the right side, but there is no distention in the flanks. Early, active peristalsis may be visible. The tenderness is just to the right of the umbilicus, on a level with it or below it. In most cases there is early fecal vomiting. Gray ("Annals of Surgery," Dec., 1908) describes invagination of the diverticulum into the bowel. The average age of those attacked is fifteen years. Such cases give a history of previous abdominal crises due to twisting, inflammation, or slight invagination. The acute attack is apt to begin while the patient is active. Gray says that about 30 per cent. of the patients pass blood; that the pain is umbilical and usually very violent; that tenderness is seldom acute unless there be peritonitis; that there may be an abnormal umbilical cicatrix; that in a minority of cases there is a palpable abdominal mass, and that the mortality after operation in acute cases is nearly 60 per cent.

Differentiation of Intestinal Obstruction from Other Diseases.—Always examine for a strangulated hernia at every hernial outlet. If obstruction is complicated by an irreducible hernia above the seat of lesion, the hernia, if it contains gut, will always enlarge and become tender because of accumulation of feces. Functional obstruction may attend peritonitis or may follow the reduction of a hernia. In this condition, if peritonitis be absent, there is no pain, no tenderness, no tumor, no tendency to collapse, but simply absolute constipation, distention, and perhaps non-stercoraceous vomiting. Appendicitis with peritonitis may cause symptoms similar to those of obstruction; but there is fever, a history of pain in the right iliac fossa, and the vomiting is not stercoraceous. Acute pancreatitis produces symptoms so similar to those of intestinal obstruction that a diagnosis cannot always be made (see page 1040). We must consider in the diagnosis perforation of a gastric or duodenal ulcer, rupture of an extra-uterine pregnancy or a pus tube, strangulation of the pedicle of an ovarian tumor, renal colic, and hepatic colic. Poisoning by ptomains, arsenic, or corrosive sublimate should not be confounded with intestinal obstruction.

Prognosis.—Without surgical interference most cases of acute intestinal obstruction die within ten days—usually within seven days. In volvulus death may occur in forty-eight or seventy-two hours. It may occur as early in obstruction by a band, in internal hernia, or mesenteric blocking. Death may be due to shock, to exhaustion, to toxemia, to perforation, to peritonitis, or to obstruction of respiration and circulation by tympanites. Recovery occasionally, but very rarely, happens by the formation of a fistula externally or into another portion of the bowel. In acute obstruction from foreign bodies the obstructing body occasionally passes. Volvulus and strangulation by bands are almost invariably fatal unless an operation is performed. In intussusception recovery occasionally follows the sloughing away of the prolapsed gut, but stricture almost inevitably results from this rare event. Functional obstruction gives a mortality of from 40 to 50 per cent. Deaver and Ross ("Annals of Surgery," 1915, lxi) give the statistics of 276 cases of acute intestinal obstruction. The mortality was 42 per cent. The earlier the diagnosis and the more prompt the operation, the less the mortality. In the table of Deaver and Ross (Ibid.) the mortality of strangulated hernia was 33.5 per cent. Obstruction from postoperative adhesions had a mortality of 49.3 per cent. The mortality from intussusception was 40 per cent. The prognosis of chronic obstruction depends upon the causative lesion. It does not threaten life immediately to anything like the degree that acute obstruction does.

Treatment of Acute Obstruction.—In any abdominal case in which the diagnosis

[1] "Brit. Med. Jour.," Nov. 16, 1901.
[2] "Annals of Surgery," April, 1902.

is uncertain and the patient is shocked give an enema of brandy and hot water, wrap the patient in blankets, surround him with hot-water bottles, and study the development of symptoms and signs. In half an hour, as a rule, reaction will be brought about and a probable diagnosis may be made (Greig Smith). In acute obstruction it is usually customary to empty the stomach by lavage and to evacuate the rectum by means of copious injections given while the patient is in the knee-chest position. The emptying of the stomach is imperative if stercoraceous vomiting has been going on, for vomiting of a quantity of such material while a patient is taking ether may cause death by drowning, the fluid flowing in enormous quantity into the bronchi. In very severe cases a general anesthetic cannot be given and the belly must be opened under novocain. Hutchinson's method of taxis and massage is uncertain, and is as liable to inflict harm as to confer benefit. The passage of a small tube from the anus as high as possible will empty the colon of gas if no obstruction intervenes. Every operation is exploratory. If in doubt as to whether the obstruction is in the ileum or the colon, open the abdomen through the lower half of the right rectus muscle. The incision should admit the hand, and the hand prevents extrusion of the intestines. The cecum is sought for first. If it is distended, the obstruction is distal. Systematic search finds where distended bowel ends and collapsed bowel begins, and this point is the seat of obstruction (see Burgess, Ibid.). If before exploration the obstruction is located in the small intestine, make an incision near the midline and enlarge if necessary. If the obstruction is located in the large intestine, the exact region being uncertain, make a low right rectus incision. If the location in the colon is known, open over the seat of obstruction. In obstruction by bands or adhesions they should be divided or removed and the raw surfaces smeared with sterile vaselin or covered with peritoneum or omental grafts. Internal hernia is to be reduced. Volvulus may be untwisted, the mesentery being narrowed to prevent recurrence. An enterolith or foreign body should be removed. In the small bowel, if gangrene exists, resection with immediate operation may be performed, but not in the large bowel. On the small bowel we can work quickly, the feces are fluid and pass easily, enough bowel can be removed to reach tissue free from edema and congestion, and the ends can be sutured together without tension. An artificial anus in the small bowel impairs nutrition gravely. Resection and immediate union, if there is gangrene of the large bowel, has a forbidding mortality. Although primary resection and anastomosis are advocated for gangrene of the small gut I prefer to bring the gangrenous region outside of the belly and fix it there as described on page 977.

In acute intussusception it is the custom of some surgeons to give no food by the stomach; administer opium and belladonna to arrest peristalsis, wash out the rectum with copious injections, give an anesthetic, and insufflate hydrogen gas or carbonic-acid gas in order to distend the bowel. Other surgeons treat intussusception by forcing air into the rectum by means of an ordinary bellows, and others inject water by a fountain-syringe, the reservoir being at a height of 3 feet. Sir D'Arcy Power believes in the value of hydrostatic pressure in intussusception in children. He states that the child should be anesthetized and the large intestine filled *gradually* with hot saline fluid, the reservoir not being raised more than 3 feet above the patient. The fluid should be retained for ten minutes. My own feeling is that whereas it may be justifiable to try to reduce intussusception by gaseous or hydrostatic pressure during the first twenty-four hours of the attack, early operation, except in newborn infants, gives a better prognosis and is safer and more certain. Without opening the abdomen it is impossible to know the condition of the intestine. Gangrene may occur early (it has been found in less than four hours after the onset of symptoms), and if gangrene exists, gaseous distention or hydrostatic pressure will cause death. Rushmore's reported case shows that there may be "no systemic symptoms to indicate the presence of gangrene" ("Annals of Surgery," Aug., 1907). Another point against conservative treatment, is the common uncertainty as to whether complete reduction has been accomplished. Vomiting may continue for hours after genuine reduction and the bowels may not move for some time. Waiting to be sure that reduction has been accomplished will probably be responsible for death if reduction has not been obtained. After the first twenty-four hours it is never justifiable to use gaseous or hydrostatic pressure because of the great risk that ulcer or gangrene may exist. Pressure cannot be accurately regulated, and if the bowel is much damaged, may lead to rupture. If the case is not seen until after the first day, or if injections have been used and have failed, all surgeons believe that laparotomy should be performed.

Frederick Holme Wiggin made a study of the reported cases of laparotomy for infan-

tile intussusception, and concluded that that operation done within the first forty-eight hours would give a mortality of 22.2 per cent.[1] (see Operation for Intussusception). In very young infants the mortality of laparotomy is very high, and it is a fair question if on them immediate laparotomy should be advised without a trial of conservative methods, if the case is seen during the first twelve or twenty-four hours. The mortality of operation is very large on those under eighteen months of age. But even in those under six months of age Wiggin thinks the mortality after operation is not above 22.2 per cent., if operation is done within forty-eight hours, and my personal feeling is that operation should be the method of treatment even in the case of a young baby.

I agree with Rushmore that operation done during the first twelve hours would greatly reduce the mortality, perhaps to the figures which he expects would follow such a practice, viz., 12.5 per cent. Operation may permit reduction. If not, Maunsell's operation may be practicable (page 1092). Resection with anastomosis is very fatal. Some die from shock, others from leakage at the suture line. Extensive gangrene may be treated by resection, fixing the open ends in the wound, and later end-to-end junction. A better plan is that of Mikulicz (page 977).

In obstruction of the main mesenteric vessels operation is of no avail. In obstruction of branches it may be possible to resect the involved region of bowel, a region which is found to be gangrenous or becoming so. Reich, in reporting upon 91 cases operated upon by resection and anastomosis, records 18 recoveries (quoted by Elliot and Jameson in "Annals of Surgery," Nov., 1915).

Resection and anastomosis are very dangerous. The gut is congested and edematous, the suture line is apt to leak unless a large amount of intestine is removed, and because of paralysis of the bowel the poisons do not drain away. A better plan than resection is that of Mikulicz (page 977). Some surgeons resect the gangrenous area, fix the divided ends of the resected gut in the wound, and perform end-to-end suture as a secondary operation. This shortens the primary operation and saves the patient from the great danger of leakage at the point of anastomosis because of spread of the thrombosis (Jackson, Porter, and Quimby in "Jour. Amer. Med. Assoc.," 1904).

Obstruction in pregnancy is very fatal. The uterus should be emptied before the obstruction is attacked. Some advise vaginal, others abdominal, section. Then the obstruction should be relieved surgically. In most cases it is due to bands.

In acute intestinal obstruction do not delay, but open the abdomen, if possible, before collapse comes on, and find the cause of the obstruction. If it is a gall-stone or enterolith, try to crush it without opening the intestine; if this fails, push it up a little distance into a region of healthy bowel, incise the bowel, remove the stone, and close the incision with Halsted sutures. Pilcher[2] collected 40 cases operated upon for gall-stone obstruction, with 21 deaths. If there is fecal obstruction, break up the masses by pressure and push the fecal plug down without opening the bowel. If there is intussusception, reduce the prolapse without pulling on the proximal bowel (reduce by taxis on the intussusceptum), and shorten the mesentery; but if reduction be impossible, perform a resection and enterorrhaphy, or make an artificial anus. In volvulus untwist and shorten the mesentery; but if this be impossible, treat as an irreducible invagination. In obstruction from adhesions try to separate them and straighten out the bowel, stitching healthy peritoneum over every raw spot to prevent recurrence. In obstruction by a band, free the loop and, if it be gangrenous, resect or follow the plan of Mikulicz (see page 977). Anastomosis may be necessary. In flexion separate the intestines, remove the flexion by a V-shaped incision, and suture the wound in the bowel. In chronic obstruction it is often advisable to perform an exploratory laparotomy, discover the condition, and determine what is to be done to correct it. Some tumors external to the bowel may be removed. Growths in the bowel wall may be removed by resection of the involved portion of intestine, or an anastomosis may be performed, or it may be necessary to make an artificial anus. In obstruction from Meckel's diverticulum that structure may be found twisted, the gut near it may be kinked or twisted, or the diverticulum may act as a band, the bowel being caught under it or kinked over it. Intussusception of the gut below it sometimes occurs; so does invagination of the mucous membrane of the diverticulum; so does chronic inflammation and cicatricial narrowing of the diverticulum or gut (Halstead). The diverticulum may be gangrenous, perforated, or cystic. In internal hernia the constriction must be divided and the bowel removed from the fossa. Any gangrenous gut may be resected if the patient's condition justifies it, but Mikulicz's plan is better (see page 977).

[1] "Med. Record," Jan. 18, 1896. [2] "Med. News," Feb. 8, 1902.

After opening the abdomen the surgeon must be guided by conditions. The diverticulum should be removed, just as the appendix is removed in appendicitis, and complications relating to the gut must be dealt with.

The mortality after operations for acute intestinal obstruction is very high (from 40 to 50 per cent.). If the diagnosis were made earlier, operations would be done earlier and the mortality would be much less. At least 8 out of 10 of these cases that I see in hospital work are gravely shocked and practically dying on admission. If a patient with obstruction be very gravely shocked, I usually follow Moynihan's plan, of simply opening the bowel and draining it in its most distended coil without any search being made for the lesion. The object is to drain the poisons from the intestine, poisons which are the active agents in killing the patient. The abdomen is opened under novocain, the incision being small. A distended coil of intestine is sutured to the peritoneum about the abdominal incision, every care being taken that the stitches do not penetrate the mucous membrane of the gut (Moynihan). A purse-string suture is now inserted so as to enclose an area of the exposed gut; an incision is made into the gut in this enclosed area, and gas and feces flow out. Paul's glass tube (see Fig. 886) is passed into the gut and the purse-string suture is tied. Instead of Paul's tube we may use a rubber tube sutured as is the tube in Kader's gastrostomy (Elsberg in "Annals of Surgery," May, 1908). In acute colonic obstruction even without gangrene primary resection is never justifiable. In such a case mobilize the seat of lesion, divide the mesentery between ligatures, bring the coil outside of the abdomen, place sutures about its limbs, and fix a Paul's tube in each limb (Burgess, Ibid.). The obstruction is thus temporarily relieved, and if the patient recovers, the causative lesion may be subsequently sought for and attacked. If a fecal fistula follows enterostomy and refuses to close, it may be closed by operation. If Elsberg's plan is followed a persisting fecal fistula will be rare. My late colleague, Professor Francis T. Stewart, devised a method by which the bowel can be drained without any risk of infection of the peritoneal cavity, a risk which always exists in using Paul's tube. Stewart placed a clamp at either extremity of the loop of bowel and surrounded it with gauze. One-half of a Murphy button was inserted into the empty loop through a small incision. The other half of the button was squeezed into a rubber tube the diameter of which was somewhat smaller than the flange of the button. The two parts of the button were then clamped, and the clamps were removed from the loop of bowel. The intestine was sutured to the wound margins and the feces drained into a receptacle on the floor. Figure 766 shows Stewart's operation. In any case of intestinal obstruction if gangrene exist the temptation to do immediate resection is strong. I have done it a number of times with a very large mortality. Stitches in the congested and edematous bowel allow leakage and because of bowel paralysis poisons do not drain. Of late I have been following the plan of Mikulicz and results have been far better. The gangrenous loop is brought outside of the abdomen, it is fixed parallel to the wound, and a Paul tube is fixed in each

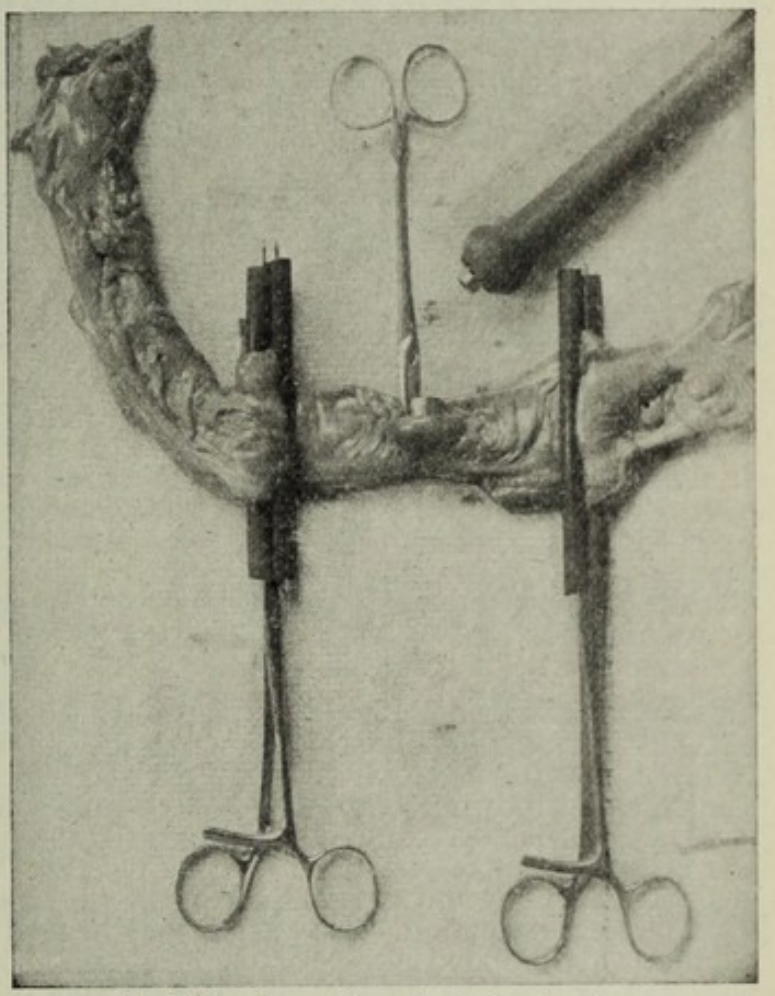


FIG. 766.—Stewart's method of enterostomy.

limb. In a day or two the coil is cut away. Later continuity is restored by end-to-end anastomosis or by dividing the spur with an enterotome. Postoperative obstruction coming on soon after a surgical operation is often not recognized for a time, and the surgeon will be in doubt as to whether he is dealing with peritonitis or intestinal paresis, or both. When distention becomes evident after an operation we should wash out the stomach with warm salt solution, administer salines in small doses frequently repeated, and employ enemata. Many surgeons give two or three doses of atropin hypodermically at intervals of two hours. Each dose should be 1/200 gr. Atropin is given with the idea that it increases peristalsis and contracts blood-vessels. It is probably merely a sedative, relaxes spasm, and is useless if strangulation exists. Eserin stimulates the muscular coat of the intestine. There seems to be no doubt that eserin given soon after an operation tends to prevent distention. A better plan than the administration of atropin is to give hypodermically 1/30 gr. of eserin (physostigmin salicylate) and 1/40 gr. of strychnin every hour until four doses have been taken. During fifteen minutes of this period carry the heated Paquelin cautery to and fro over the abdomen, not touching the skin, but near enough to it to cause distinct reddening. The intestinal tract should be gone over systematically with the cautery, first the stomach and small intestine, then the large intestine. Pituitrin is an extract of the posterior lobe of the pituitary gland. When given intravenously or subcutaneously it raises blood-pressure, is a diuretic, and stimulates involuntary muscle-fiber. It is useful in cases of flatulent distention. It comes in ampules each of which contains 1 c.c. The dose is 1 to 2 ampules, repeated in two hours. I have seen electricity succeed. A continuous current battery is used and it must be able to furnish 50 milliamperes. The patient lies upon the back and a flat electrode covered with chamois damp with salt solution is fastened to the negative pole and is placed upon the belly. The rectal electrode is fixed to the positive pole and inserted in the rectum.

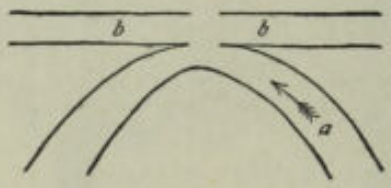


FIG. 767.—Fecal fistula: *a*, Direction of fecal flow; *b*, *b*, belly wall.

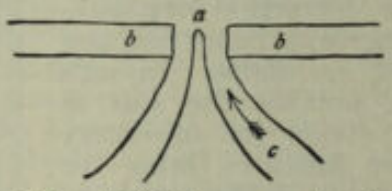


FIG. 768.—Artificial anus, showing spur: *a*, Spur; *b*, *b*, belly wall; *c*, direction of fecal flow.

This electrode is tunneled and through the tunnel salt solution is introduced into the rectum. This solution protects the mucous membrane and diffuses the current. The current is now turned on. At first the galvanometer should register 10 milliamperes. The current is slowly increased to 30 or 40 milliamperes. Every five minutes the place of the abdominal electrode is changed and the current is reversed, the galvanometer being brought to zero while effecting reversal. It is common for gas to escape and then feces. If the salt solution should be expelled, more must be introduced. Fecal matter may appear. The current may be used for fifteen minutes and the procedure may be repeated in three or four hours (the above directions are from a valuable book, rich in practical surgery, viz., Stewart McKay on the "Preparation and After-treatment of Section Cases.")

If these measures are not soon followed by the passage of flatus or feces, open the abdomen; never wait for the advent of stercoraceous vomiting.

Treatment of chronic obstruction is the treatment of the causal lesion (freeing adhesions, correcting a chronic intussusception, resecting a tumor, etc.). If this is found inoperable, it may be desirable to open and drain the gut above. A rectal growth may require inguinal colostomy. For a higher growth a short circuit operation may be done, perhaps after preliminary cecostomy. In obstruction from fecal impaction irrigate the colon and give high colonic injections. Small, repeated doses of salines or castor oil may be useful. If there are signs of inflammation do not give cathartics even in small doses, but use instead opium and belladonna to arrest vomiting and to relax spasm. Rectal impactions should be removed by means of a spoon.

Fecal Fistula and Artificial Anus.—A fecal fistula is an abnormal opening in the intestine through which gas or a portion of the feces escapes (Fig. 767). If all the intestinal contents escape through the opening, it is called an *artificial anus* (Fig. 768, Senn). A surgeon may make a fistula deliberately (*intentional fistula*). A fistula

may be the product of disease or injury (*accidental fistula*). Senn enumerates the following causes of accidental fistula: wounds, injury of the intestines, intestinal ulceration, intestinal strangulation, foreign bodies in the intestinal canal, malignant tumors, actinomycosis, pelvic and abdominal abscess, appendicitis, injury of the bowel during an abdominal operation, the application of ligatures, catching by sutures, and the employment of drainage-tubes.

Treatment.—Most fistulæ of the large bowel close spontaneously. Fistulæ of the small bowel tend to persist. The higher up a fistula is, the more inveterate it will be. A fistula may close temporarily and break out later. Closure and breaking open may be repeated again and again. If the bowel is directly adherent to the abdominal wall a fistula, even of the large bowel, will seldom heal spontaneously. Long sinuses, in contrast, often heal spontaneously. This can be hoped for only if the opening is quite small, if the general health of the patient is good, if the cause has passed away, if the fistula is not lined with mucous membrane, if the bowel is not adherent to the belly wall, and if there is no spur (spur is shown at *a*, Fig. 768). In most cases of fistula not high up it is well to give nature a chance to effect a cure, and not to be in a hurry to operate. The part is cleansed frequently with peroxid of hydrogen, the patient is kept recumbent, food is given which does not leave much residue, pads of gauze are applied with pressure, and the bowels are kept regular by the use of castor oil.

If the track be lined with granulations, it may be touched with lunar caustic; if it be lined with mucous membrane, the actual cautery should be applied. Any collection of pus which exists should be drained. If these methods fail, an operation must be performed. The fistula may be sutured by extraperitoneal manipulation (Greig Smith); it may be covered with skin (Dieffenbach); the spur may be removed by means of a clamp, or resection may be performed. Nassau ("Med. Soc. State of Penna.," Sept. 21, 1916) has had success with his extraperitoneal method in postappendicitis fistulæ in which the large bowel is adherent to the abdominal wall. In cases in which an extraperitoneal operation cannot be done it is best to incise a button of skin around the opening, temporarily suture the fistula, open the peritoneal cavity, deliver the bowel, and suture the bowel opening carefully (Senn's method). In some cases partial exclusion of the fistulous part is necessary, the bowel being divided above the fistula, the end near the fistula sutured, and the other end anastomosed to the bowel below the fistula. In other cases complete exclusion may be performed (see page 1102).

Ulcer of the Bowel.—In typhoid fever and in dysentery ulceration occurs. In erysipelas, septicemia, pemphigus, melena neonatorum, and uremia ulceration may occur. An ulcer may be due to tuberculosis or cancer. Most ulcers of the duodenum (see below) are due to the same causes as ulcer of the stomach. In rare cases ulcer of the duodenum results from a surface burn (Curling's ulcer, see below). An ulcer of the jejunum sometimes develops after the performance of gastrojejunostomy for gastric ulcer (see page 1073). An ulcer may heal and, by causing thickening and constriction, produce chronic intestinal obstruction. It may perforate, causing collapse and subsequent peritonitis.

Ulcer of the duodenum may be due to tuberculosis. It may form during septicemia, erysipelas, melena neonatorum, and uremia. It may be caused by burns. The last named and very rare condition is called *Curling's ulcer*, he having described it in 1841. Moynihan shows in his book on "Duodenal Ulcer" that James Long, of Liverpool, was really the first one to describe duodenal ulceration following burns. He did so in the "London Medical Gazette," 1840. A duodenal ulcer following a burn or scald is "a toxic ulcer, and, therefore, analogous to the ulcer which occurs in septicemia, uremia, typhoid fever, erysipelas, and pemphigus" (Moynihan, Ibid.). It occurs only when the burnt or scalded area has become septic, and septic emboli may be responsible for ulceration. Some believe that the irritant cause is toxic bile. Ulcer from a burn is extremely rare today, rarer than formerly, if older reports are correct. This is probably due to the modern cleanly treatment of burns and scalds. When we use without qualification the term "ulcer of the duodenum" we mean an ulcer like the ordinary stomach ulcer and which may be regarded as a peptic ulcer of the duodenum.

Septic ulcers are acute. The peptic ulcer is nearly always chronic.

Peptic Ulcer of the Duodenum.—The condition was first described by Travers in 1817 ("Duodenal Ulcer," by Sir Berkeley G. A. Moynihan). It occurs usually in that portion of the duodenum which is above the opening of the bile-duct; in other words, in the region acted on by the acid fluid from the stomach. In Perry and Shaw's

list of 149 cases the first portion was involved in 123, the second portion in 16, and the third and fourth portions in 2; in 8 the ulcers were scattered. Moynihan (Ibid.) says the first portion is involved in 95 per cent. of the cases. The most common seat of ulcer is on the anterior wall of the duodenum, ½ inch below the pylorus. The pylorus is definitely marked for the surgeon by the pyloric vein which runs upward from the greater curvature (Moynihan, Ibid.). The ulcer is often puckered like a scar. Any old ulcer is much indurated. In rare cases there is no induration. Sometimes an extensive area of the duodenum is indurated, sometimes a duodenal pouch or diverticulum is formed. In rare cases an ulcer completely encircles the bowel. Duodenal ulceration is much more common in males than in females in the proportion of 3 or 4 to 1. Out of 53 cases reported by John B. Deaver 47 were males ("The Archives for Diagnosis," Jan., 1917). It may occur at any period of life, from early youth to extreme old age, but is most common between the twenty-fifth and forty-fifth years. The average age of Deaver's male cases was 41.5 years. The oldest was sixty-three, the youngest twenty-one. The average age of his 6 female patients was 36.8 years (Deaver, Ibid.). The condition can occur in infancy, producing hemorrhage and vomiting. Veeder reports 5 infantile cases ("Amer. Jour. Med. Sciences," 1914, cxlviii). Duodenal ulcers are usually single, but may be multiple. It was long taught that gastric ulceration is vastly more common than duodenal ulceration. Some recent observers regard duodenal ulcer as likely to be met with one-seventh as often as gastric ulcer. In this connection Codman's statistics should cause us to revise our estimates. In 3000 autopsies held in the Massachusetts General Hospital an open duodenal ulcer was found in 1 per cent. of the cases. The duodenal ulcers were found twice as often as gastric ulcers (quoted by E. R. McGuire, "Buffalo Med. Jour.," June, 1912). A gastric ulcer may exist with a duodenal ulcer. Murphy sums up the supposed causes into hyperchlorhydria, local infection, embolism and thrombosis, and disturbances of the organs of elimination. An indurated chronic ulcer may exist, and this may heal and produce cicatricial stenosis. The scars of two ulcers may cause double constriction or hour-glass duodenum.

An ulcer may heal and break down many times. A duodenal carcinoma seldom arises from ulcer. What Moynihan calls the "tucked back" ulcer becomes adherent to the liver or posterior wall of the abdomen. An ulcer adherent to the pancreas may eat into that organ. An ulcer scar may clutch the common bile-duct in the duodenal wall or block the outlet of the ducts in the ampulla of Vater. Perforation is more common, but walling off is more frequent than in gastric ulceration (William J. Mayo, "Med. News," April 16, 1904). In the vast majority of cases the patient gives a history of having suffered at intervals for many years from attacks of flatulent or acid and painful indigestion. The pain is near the umbilicus and radiates to the right. The attacks are far more common in fall and winter than in spring and summer. Usually tenderness and rigidity are demonstrable in the right epigastric region. A man suffers thus for days or weeks, and then gets apparently perfectly well, but after a variable time the attack returns. The pain comes on from two to six hours after a heavy meal. It seldom occurs after breakfast but comes after lunch and particularly after an evening dinner. If he eats his heavy meal at 7 P. M. his attack may usually be expected about 10 o'clock or later. These seizures of "indigestion" may be brought on by worry, overwork, wet feet or chilling of the body, or by eating some indigestible article of diet. They may be caused to disappear by rest, ease of mind, or change of climate. An alkali relieves pain. They have been called "*hunger-pains*" because food for a time distinctly relieves them. A patient learns this and is apt as soon as the annoyance begins to eat some crackers or drink a glass of milk. It was long believed that hunger-pain was due to an open pylorus allowing acid material to run into the duodenum, and that food or an alkali caused the pylorus to close. Moynihan, Hertz, and others now reject this explanation because *x*-ray studies show that food begins to leave the stomach at once and that pain begins when about half the food has left the stomach (Moynihan, "Duodenal Ulcer"). It may be that the last portion of food in the stomach is much more acid than the portions which pass out earlier. The probable explanation of the pains is muscular contraction. When the stomach is entirely empty there may be no pain; when half empty there is pain.

Arbuthnot Lane would explain the relief of pain by food by invoking a reflex contraction of the duodenum caused by food and serving to empty that portion of the gut. The condition above described may go on for many years, periods of relief alternating with periods of pain, water brash, flatulence, etc. Usually, but by no

means always, there is hyperacidity. In some cases acidity is normal; in some, actually subnormal. It is probable that during painful attacks there is hyperacidity. We have stated that the pain occurs from two to six hours after a meal. If it occur very late, the ulcer is posterior; if it occur earlier than two hours, stenosis has begun or the ulcer is adherent to the liver or belly wall (Moynihan, Ibid.).

Hemorrhage occurs in about 40 per cent. of the cases. The blood may be passed by bowel only or it may be passed by bowel and also vomited. In most cases it is passed by bowel and not vomited. When there is a severe hemorrhage the patient first has a peculiarly severe attack of indigestion, he then grows deathly pale, presents the symptoms of internal hemorrhage, and passes a quantity of blood which is first tarry black and later red, and perhaps he also vomits blood. Just as chronic gastric ulcer may be latent, no symptoms ever being observed, so may chronic duodenal ulcer be latent. The pain is located in the epigastric or right hypochondriac region and may last until the next meal. If the digestion of the evening meal is delayed the pain rouses the patient from sleep, but a glass of milk will quiet it. The pain is less severe than is usual in gastric ulcer and in many cases does not radiate to the back, although in others it does radiate to the right scapular region. There may be tenderness on deep pressure in the right hypochondriac region. Symptoms of indigestion are not nearly so marked as in ulcer of the stomach. Vomiting is far less common than in gastric ulcer and it does not relieve pain. Vomiting occurred in one-fourth of Deaver's cases (Ibid.). The hemorrhage from the bowels may be so profuse as to kill or almost kill the patient. It may be so frequently repeated as to make him profoundly anemic. Unlike the bleeding from gastric ulcer, bleeding from duodenal ulcer is often fatal. In some cases the man bleeds insidiously, perhaps even without knowing it, losing some blood daily, and finally becoming extremely anemic. Probably in every case of duodenal ulcer occult blood is at times present in the stools. In many cases there is no visible blood in the feces, but the guaiac and aloin tests show occult blood. Vomiting of quantities of blood is much rarer than in gastric ulcer. In very rare cases of duodenal ulcer the first symptom is perforation. I have operated on two such cases. In other cases the first symptom is hemorrhage, or is due to stenosis or some other complication. Examination by *x*-rays after the taking of a meal containing bismuth or barium shows, if there be ulcer, greatly increased activity of the stomach. The viscus empties too rapidly. In some cases stenosis is demonstrated, in some, a pseudodiverticulum. Moynihan[1] mentions the following complications: severe hemorrhage; perforation; periduodenitis; cancer, and cicatricial contraction involving the bile-duct. Cancer is a rare result of ulcer. Jefferson reported 1 case, but could find only 30 cases in literature ("Brit. Jour. of Surgery," 1916, iv).

Acute perforation is more common than we once thought. Perforation is usually on the anterior wall. It is much less common on the posterior wall. It is extremely rare on the superior wall and practically never occurs on the inferior wall. Moynihan gathered 49 cases from literature and added 2 of his own. In the great majority of cases perforation of the duodenum cannot be differentiated from perforation of the stomach by a study of the symptoms. In most cases there is a sudden onset of violent abdominal pain which is general through the abdomen, but is most acute in the epigastric or right hypochondriac region; vomiting, rapid pulse, and tenderness are soon noted, and perhaps shock. The pain is apt to radiate to the right. The tenderness is most acute a little to the right side above the level of the umbilicus. There is intense board-like rigidity of the upper abdomen, especially of the upper half of the right rectus muscle. After a number of hours pain, tenderness, and rigidity may be noted in the right iliac region, the contents of the duodenum, which were expelled upon the transverse mesocolon, having been directed to the right side and having descended along the right of the ascending colon to the cecum or even to the pelvis. Such cases may be mistaken for appendicitis. Vomiting may occur. The pulse is usually rapid, but not invariably so, and there may be shock. Profound shock is rare. Often shock is trivial. Even if shock is severe the patient usually reacts after a few hours. Shield's case got better in four hours and walked some distance to the hospital.[2] Lucy's case got better a short time after the onset, walked home, and attended to a horse, but then became rapidly worse. The improvement is apparent, not real, and is only temporary. Peritonitis develops rapidly. The symptoms quickly become worse, and when they become worse, besides the pain, tenderness, and rapid pulse, there will be occasional vomiting, rigidity of the abdomen, usually an elevated or normal temperature, and

[1] "Lancet," Dec. 14, 1901.
[2] Ibid., March 29, 1902.

seldom diminution of the area of liver dulness. Just as in stomach ulcer, there may be acute, subacute, or chronic perforation.

Treatment.—In duodenal ulcer the risks of serious hemorrhage and of perforation are much greater than in gastric ulcer, and operation should always be recommended if the diagnosis is made. We used to say operate only if the symptoms are not amended by rigid diet and medication, if severe hemorrhage occurs or if cicatricial contraction interferes with the passage of food through the bowel or of bile into the duodenum. In some cases excision is practised; in others, excision with gastrojejunostomy; in still others, gastrojejunostomy alone.

If grave hemorrhage occurs and is repeated the surgeon should open the abdomen, ligate the bleeding vessels, bring the outer coats of the bowel together over the indurated area, and perform posterior gastrojejunostomy (William J. Mayo, in "Surg., Gynec., and Obstet.," May, 1908). In such a bleeding ulcer the vessels entering it are usually varicose. It would seem wiser in cases which are suitable to excise the ulcer by the knife or cautery and perform gastrojejunostomy.

In perforation operation is performed, as in gastric ulcer, as soon as possible. In these cases, as in perforated gastric ulcer, I believe operation should be immediate and that we should not wait for a possible reaction from shock. Personally, I do not practise excision of the ulcer, as I believe that closure is just as permanently useful and is safer. The first thing to do is to cleanse the peritoneum, cauterize the ulcer with the actual cautery and then to close the perforation. Do so by two rows of interrupted inversion stitches of silk. These stitches are inserted at right angles to the long axis of the duodenum. Overlie the stitch line by covers of gastrohepatic and gastrocolic omentum. In cases operated upon late nothing else is to be done. If the gap of the perforation be huge, it may be impossible to close it by inversion. It may then be closed by the gall-bladder (as was done by Downes) or by an omental plug. Failing in this, a gauze tampon may be used. If the operation is performed within twelve hours of the perforation, perform gastro-enterostomy as well as closure of the perforation, even if there is no stenosis. This additional operation aids in preventing recurrence of the ulceration and the stitches closing the perforation may narrow the duodenum more or less. Gastrojejunostomy is imperative if the suturing has narrowed the duodenum. It is valuable in any case because it removes irritants from the scar, allows of early administration of food, favors healing, and antagonizes recurrence. Some surgeons do not drain. I feel it safer to drain, if the operation was done six hours or more after the perforation. In perforated duodenal ulcer the extravasated fluid is apt to flow into the right iliac region. If an erroneous diagnosis of appendicitis has been made, an opening in the right iliac region, by giving vent to this fluid, might for a time confirm the surgeon in error, but the character of the fluid should make evident the condition of affairs. In cases in which fluid has flowed into the right iliac fossa and pelvis drainage must be inserted above the pubis. If a case is *in extremis* simply open the abdomen and drain. Later, if the patient reacts, a secondary operation may be done.

Gibson ("Annals of Surgery," Jan., 1924) in 59 cases of acute perforation of the stomach or duodenum had a mortality of 16.6 per cent. Those operated upon within twelve hours showed a mortality of 6.5 per cent—within twenty-four hours, 20 per cent.—over twenty-four hours, 66.6 per cent.

Gibson's mortality for duodenal cases is 12 per cent. McCreery's mortality for duodenal cases is 10 per cent. ("Annals of Surgery," Jan., 1924). The mortality for gastric cases is from 20 to 40 per cent.

In subacute perforation we may separate adhesions, find and close the perforation, and perform gastrojejunostomy, or follow Lund's advice ("Boston Med. and Surg. Jour.," 1905) and do gastrojejunostomy alone. Lund maintains that as the perforation is walled off it is not necessary to open it up in order that we may close it. The treatment for chronic perforation is that for an abscess about the duodenum. In every operation for duodenal ulcer Moynihan examines the appendix and often finds it diseased ("Lancet," Jan. 6, 1912).

Ulcer of the Jejunum After Gastro-enterostomy.—(See page 1073.)

Perforated Typhoid Ulcer.—Perforation occurs in 2 or possibly 3 cases out of 100. My colleague, Prof. John H. Gibbon, reported the experience of the Pennsylvania Hospital from 1901–1915 inclusive ("Annals of Surgery," Oct. and Nov., 1915). There were 5891 cases of typhoid fever and 139 perforations. Twenty-seven were not and 112 were operated upon. About 70 per cent. of perforations occur in the second, third, or fourth week. Whenever a typhoid patient develops pain a surgeon should be called

in consultation. Perforation in a typhoid ulcer is usually effected rapidly, a large opening is formed, and a considerable quantity of fecal matter is passed into the peritoneal cavity. In a few perforations very little fluid escapes. Severe pain and a nervous chill indicate that perforation is occurring or has occurred. Some maintain that the two above-named symptoms associated with marked leukocytosis indicate that perforation is about to occur, and they call this stage the *preperforative* stage. That distinct symptoms may in some cases point to impending perforation is, I believe, true, and in 1 case I operated on this conviction and found two areas almost perforated. In most cases, however, I do not believe that there is a distinct preperforative stage, but the perforation exists when the symptoms are first noted. The conviction that perforation was occurring would be strengthened by a progressive increase in the leukocyte count. But as leukocytosis cannot occur for eight or ten hours, never wait for it. It is to be remembered, however, that the leukocyte count is increased by sweating, cold bathing, vomiting, hemorrhage, severe diarrhea, or some positive complication. When perforation occurs, violent pain develops. As a rule, there are tenderness, rapid pulse, costal respiration, abdominal rigidity, vomiting, and shock. A sudden fall of temperature and increase of pulse rate may mean hemorrhage. Usually in perforation there is temporary reaction from shock, the subnormal temperature giving way to a normal or to an elevated temperature. The vomiting in some cases becomes stercoraceous. There is constipation and sometimes dulness on percussing the flanks. It should be the rule to make a digital examination of the rectum. The face is Hippocratic. The patient may die of the preliminary shock or may react and die subsequently of toxemia or lung complication. In a few hours after perforation distinct leukocytosis may be observed, but it may never take place at all. Even when leukocytosis arises, it may disappear as peritoneal infection spreads and systemic poisoning deepens. If the abdomen is distended diminution of liver dulness is not a reliable sign. Diminution of liver dulness with a flat abdomen is very significant. Micturition is usually painful and difficult. Le Conte points out that rupture of a mesenteric gland simulates intestinal perforation. A case of typhoid with lung complication or cholecystitis may be thought to have perforation. Whereas violent pain is the rule in perforation if the patient be stuporous, acute pain may not be manifested.

Treatment.—In 1884 Leyden suggested operation, and in the same year Mikulicz obtained the first operative success. In 1886 my colleague, Dr. James C. Wilson, published a paper in which he advocated operation. Death is practically certain without operation. Operation should save at least one-fourth of the cases. It should be done at once, proper means being adopted to combat shock. In many cases a general anesthetic should not be given as it increases the danger of pulmonary complications. Gas and oxygen or a local anesthetic should be employed. The incision should be made in the right iliac region and the colon should be first located and then the end of the ileum. By locating the colon we obtain a fixed point from which to begin our search for perforations, and by opening the abdomen in the right iliac region we come down at once onto the perforated gut in the vast majority of cases. When a perforation is found, it should, if possible, be inverted by two layers of Halsted sutures. It is not wise to excise the ulcer. If the bowel be very badly damaged, resection can be considered, but it is usually wiser to make a temporary artificial anus. In some cases the perforation can be used as the anus, a tube being inserted, or the bowel being stitched to the skin. Hayes ("Penn. Med. Jour.," 1908) advocates enterostomy in typhoid perforation and reports 38 cases, of which 36 per cent. recovered. After finding a perforation and closing it, examine to see if there are others. It is not very unusual to have from 2 to 5 perforations. In 26 autopsies reported by Gibbon there were secondary perforations in 14 (Gibbon, Ibid.). Close every perforation, and if a point is found where the thinning of the bowel wall indicates that perforation is liable to occur, protect this point by inverting the area of ulceration by sutures. Many surgeons cleanse the peritoneum by flushing with hot salt solution, others do not irrigate. Leave the wound open, insert strands of iodoform gauze, and establish tubular suprapubic drainage. Elevate the patient in bed if not too weak, and employ continuous proctoclysis of salt solution. Early death is due to shock or exhaustion. Death occurring later results from peritonitis or lung complication. I have operated ten times for typhoid perforation, with 3 recoveries; 3 cases died of shock. In 1 case the perforation was not found, but was discovered postmortem in the hepatic flexure of the colon, the gall-bladder being responsible for the ulcer of the bowel. One case improved greatly, lived for eight days, developed another perforation, and died of shock. The necropsy showed that the sutured perforation was soundly closed. One

case, a young man, brought to me by Dr. Godfrey, was operated upon twenty-four hours after perforation. There was one perforation in the ileum and considerable fecal extravasation. The opening was large and the stitches would not hold. The 6 inches of bowel between the ulcer and the ileocecal valve presented several ulcers almost perforated. The patient was too weak for a resection. After cleansing the abdomen an artificial anus was made proximal to the perforation. The patient recovered and subsequently the anus was successfully abolished by resection. In another case, that of a young woman, on opening the abdomen violent appendicitis was found, the appendix being swathed in lymph and in a state of gangrene. The appendix was removed. Search showed a perforation in a loop of gut 2 feet from the ileocecal valve. There was considerable extravasation. The perforation was closed. The peritoneum was cleansed, drainage was inserted, and the patient recovered. Cultures from the appendix and from the peritoneal cavity showed the colon bacillus only. In a third case, that of a young woman, impending perforation was diagnosticated by Dr. Kalteyer because of pain, tenderness, some rigidity, and definite and increasing leukocytosis. Two ulcers almost but not quite perforated were found. They were covered over by the use of inversion sutures, the wound was closed without drainage, and recovery followed. Culture from the peritoneal cavity was negative. These 3 successful cases were operated upon in the Jefferson College Hospital. Harte and Ashhurst collected the cases operated upon up to January, 1903. There were 362 cases, with a mortality of 74.03 per cent. Dr. F. D. Patterson ("Amer. Jour. Med. Sciences," May, 1909) collected 369 cases occurring since the paper of Harte and Ashhurst. Of these cases 242 died, a mortality of 65.58 per cent. The perforations were located as follows: stomach, 1; jejunum, 1; Meckel's diverticulum, 2; ileum, 279; cecum, 5; appendix, 15; colon, 12; not stated, 54. In Gibbon's 112 patients operated upon there were 27 recoveries, a mortality of 75.9 per cent. (Gibbon, Ibid.).

Primary Intestinal Tuberculosis.—Although intestinal tuberculosis is common in patients with chronic pulmonary tuberculosis, primary intestinal tuberculosis is a rare condition. The exact propriety of regarding rigidly such cases as *primary* is doubtful. Kocher's cases (reported before the Swiss Medical Congress in 1892) came from tuberculous stock, and suffered in infancy from enlarged glands, pleurisy, or bronchitis, and this surgeon said that, in all probability, there had for some time been somewhere in the body a latent tuberculous focus, and from this focus came the bacteria which attacked the intestine. Intestinal tuberculosis, in the victims of phthisis, begins with the formation of multiple ulcers, due to swallowing tuberculous sputum. Primary intestinal tuberculosis usually begins as one ulcer or several, or even many ulcers in the ileum or perhaps in the cecum. These ulcers when they heal tend to form strictures of the small bowel, seldom of the large. Primary tuberculosis is most common in the ileocecal region. It may exist as an ulcerative process with inflammation and abscess about the cecum or as enormous tumor-like thickening of the cecum. The first form is called by Hartmann *enteroperitoneal tuberculosis*. The second form is called *hyperplastic tuberculosis*. The cecum may be involved alone, but usually a portion of the ileum also suffers. The ulcers cause extensive sloughing. The appendix may be involved. All about the cecum a multitude of adhesions form containing masses of tuberculous matter, which may break into the intestine, through the skin of the abdomen, or in both directions. (See Hartmann in "Revue de Chirurgie," Feb., 1907.) Tuberculous areas suppurate. In tuberculosis of the small intestine there are bloody diarrhea, colicky pain, emaciation, and weakness. There is very active peristalsis and also gurgling. The abdomen may be tender. The bacilli may be found in the stools. As ulcers heal strictures develop and produce the usual symptoms. Peritonitis may arise or death may be due to pulmonary tuberculosis. In primary intestinal tuberculosis the urine is apt to show the diazo-reaction (Kocher).

In hyperplastic (conglomerate) tuberculosis the cecum and lower end of the ileum suffer as a rule. In some cases the colon participates in the process. Great fibromatosis with adiposis occurs simulating tumor and due to reaction of tissue *against infection*. Tuberculosis of the ileocecal region is most common between the ages of twenty and forty. There is seldom demonstrable phthisis.

The enteroperitoneal form of ileocecal tuberculosis simulates appendicitis. At first there may be diarrhea, the liquid stools containing blood. Pain in the right iliac fossa may be the first symptom. In any case pain becomes the permanent symptom. A lump can be palpated. After acute pain subsides the lump persists and increases. There may be attack after attack of pain. The symptoms of abscess arise. Spontaneous opening finally occurs, usually about Poupart's ligament. Several fistulæ

may form. Each fistula discharges pus with fecal matter. An abscess may open into the intestine only. When it does, pus appears in the stools. Bacilli may be found in the stools. In enteroperitoneal tuberculosis death occurs because of the development of pulmonary tuberculosis or, in a small number of cases, by peritonitis due to rupture of an abscess into the peritoneal cavity (Hartmann, Ibid.). The hyperplastic form develops slowly, the individual complaining of indigestion and annoying sensations in the right iliac fossa. During many months the patient feels at times better and at times worse. Then food begins to disagree radically. Several hours after a meal the patient suffers from colicky pain in the right iliac region and distention of the abdomen. Severe pain simulating appendicitis may occur intermittently. Constipation may be severe or may alternate with diarrhea. Gradually a tumor mass forms, evidences of obstruction become obvious, the patient becomes weak and emaciated. The lungs are involved very late, if at all. In some cases ulceration occurs. Conrath's study of 77 cases led him to believe that death occurs in from two and one-half to three years.

Treatment of Primary Intestinal Tuberculosis.—In the first stage the proper treatment is excision of ulcerated areas, possibly excision of the cecum. Later, if stricture is causing chronic obstruction, an operation may be performed to give relief. Laparotomy, careful separation of adhesions which are not fused with the gut, and the introduction of iodoform into the peritoneal cavity may prove of value. Hartmann ("Revue de Chirurgie," Feb., 1907) collected 229 operations for ileocecal tuberculosis, viz., partial excisions of the cecum, resections (with end-to-end anastomosis, side-to-side anastomosis, or end-to-side implantation), resections in two séances, ileocolostomies, unilateral exclusions, bilateral exclusions, and other operations. There were 46 deaths in these 229 operations. He comments on the fact that there were 58 operations with 7 deaths since 1900, a mortality of 12 per cent.

Perforation in Intestinal Tuberculosis.—By this term we mean perforation into the peritoneal cavity, not into another segment of gut and not into a mass of adhesions. It is supposed to be a rare accident. Cruice estimates that it occurs in from 1 to 5 per cent. of phthisis cases ("Amer. Jour. Med. Sciences," Nov., 1911). It may occur in either the primary or secondary tuberculosis of the gut. It is very rare in ileocecal tuberculosis, commoner in tuberculosis of the small bowel. It causes sudden and severe pain, shock, and usually nausea and vomiting. The abdomen becomes rigid. Distention soon occurs. Death may be due to shock or peritonitis. Now and then a perforation causes no characteristic symptoms at all (Cruice, Ibid.).

Tuberculosis of the Mesenteric Glands in Children.—This condition is very common. Corner ("Lancet," Feb. 17, 1912) makes a statement exactly in accord with my own experience when he says that "tuberculous mesenteric glands will be found in practically every child patient submitted to an abdominal operation." They are often recovered from unrecognized. They may produce the well-known symptoms of *tabes mesenterica*, viz., greatly enlarged abdomen, constipation or constipation alternating with diarrhea, loss of flesh, anorexia, anemia, and perhaps a palpable mass. There are abdominal pains about the umbilicus, coming on after taking food and particularly common at night.

In some cases vomiting occurs and pain is in the right iliac region and the case is mistaken for appendicitis. In such a case the pulse and temperature are normal or only slightly elevated and there is no leukocytosis. In mesenteric tuberculosis the appendix is apt to be dilated, constricted, or kinked. Mesenteric tuberculosis may undergo cure, the glands becoming fibrosed and calcified. It may lead to tuberculosis of the intestine, tuberculous peritonitis, or tuberculosis in some distant part.

I agree with Corner that the abdomen should be opened, the appendix removed, and the patient placed a long time on full antituberculous treatment.

Tumors of the Intestine.—Innocent Tumors.—Adenoma, lipoma, fibroma, myoma, fibromyoma, papilloma, angioma, and chylangioma may occur. Such tumors are rare. If attached by a pedicle or stem the growth is called a polypus. Adenoma is the commonest tumor. It may or may not be a polyp. It arises from an intestinal gland. There may be one, several, or many. Adenomata may produce no symptoms, may cause hemorrhage, may produce blocking, or may lead to intussusception.

Malignant Tumors.—*Sarcoma* is very rare, but does sometimes arise, particularly in young persons, and it enlarges very rapidly. It is most prone to attack the large intestine. Jopson and White[1] reported 1 case and collected 22 others. The mesenteric glands frequently enlarge. *Cancer* is not uncommon, attacking especially the middle aged. Cancer of the small intestine is very rare. In 888 collected cases of cancer of

[1] "Amer. Jour. Med. Sciences," Dec., 1901.

the intestine, 798 were in the large intestine and 91 in the small intestine, less than 10 per cent. Out of the 91 cases in the small intestine 42 were of the duodenum. (Vickers in "Annals of Surgery," Feb., 1924.) According to Rolleston, the average age in duodenal cancer is fifty-two years; in jejunal and iliac cancer, forty-seven; in cancer of the cecum, nearly forty-eight, and in cancer of the rest of the large intestine, about forty-nine years. Vickers (Ibid.) pointed out that over half the cases of duodenal cancer involve the ampulla, having started perhaps in the common duct or the pancreatic duct. The symptoms of duodenal cancer resemble those of pyloric obstruction, although the patient may vomit bile. Metastasis is late. Cancer about the ampulla is rapid in progress, causes jaundice, and death is not long postponed. We cannot palpate a duodenal cancer. Cancer of the jejunum causes advancing obstruction. So does cancer of the ileum. It may be possible to palpate a cancer of the jejunum or ileum. There is pain at the seat of growth. In any growth of the small intestine the *x*-rays give most valuable information. Mr. Burgess ("Brit. Med. Jour.," Sept. 29, 1923) collected statistics of the Manchester Royal Infirmary for a period of ten years. In 1278 cases of acute intestinal obstruction, if intussusception is excluded, the colon was involved in 199 cases (17.87 per cent.) and 173 of these cases were cancer (87.9 per cent.). Over half of all malignant growths of the colon are in the sigmoid, and over 46 per cent. are in the rectum. Obstruction is much less common from rectal cancer than from cancer higher up. The symptoms of cancer of the rectum are given elsewhere. In cancer of the colon higher up there is pain at the seat of growth. After a time constipation is noted, or constipation alternating with diarrhea. Finally, intestinal obstruction occurs. In some cases the symptoms appear suddenly, acute obstruction taking place or intussusception occurring. It is usually possible to palpate the tumor, which is hard and immovable. The patient wastes rapidly and is apt occasionally to pass blood at stool. The growth does not enlarge very rapidly and glands are not involved early. In some cases the supraclavicular glands enlarge. In more than one-half of the cases which die of intestinal cancer there is no lymphatic involvement.[1]

Treatment.—Early in the case exploratory laparotomy should be performed, followed, if possible, by excision with end-to-end or side-to-side approximation. This is done for either cancer or sarcoma. It may be possible to remove enlarged glands. In cancer of the cecum extirpate the cecum and implant the end of the ileum into the side of the colon (Wm. J. Mayo). In operable cancer of the small intestine perform resection and end-to-end suturing. This is done even if there is acute obstruction, provided gangrene has not begun. Herschel successfully resected the duodenum for cancer of the ampulla ("Münch. med. Woch.," 1914). In inoperable cases of cancer of the ileum or jejunum anastomose a portion of the bowel above the growth to a portion of the bowel below the growth. If the growth is in the lower ileum it may be necessary to anastomose a portion of the ileum above the growth to the colon. In inoperable cancer of the ampulla gastrocholecystostomy or cholecysenterostomy may be performed for jaundice. Obstruction of the duodenum calls for gastro-enterostomy. Cancer of the colon calls for resection or anastomosis unless there is acute obstruction. If acute obstruction exists, resection with immediate anastomosis should not be done except perhaps in the cecum. Cecostomy should be performed and later resection and anastomosis (Burgess, Ibid.). In inoperable cases of rectal cancer or cancer of the descending colon make an artificial anus above. For inoperable cancer of the transverse colon or hepatic flexure do cecostomy. For inoperable cancer of the cecum or ascending colon perform ileosigmoidostomy.

Appendicitis.—The vermiform appendix is found in man, the higher anthropomorphous apes, the wombat, and rodents. Chimpanzees in captivity sometimes die of appendicitis. Some mammals "closely allied to the anthropomorphous apes possess very large ceca; and in some of these the terminal segment of the cecum resembles the vermiform appendix in that it possesses a very large proportion of the peculiar kind of tissue known as adenoid or lymphatic" ("Evolution and Disease," by Sir J. Bland-Sutton). Some observers believe that the appendix furnishes abundantly digestive ferments and an internal secretion which causes peristalsis. The appendix is usually regarded as a vestigial structure. Professor Berry, Dr. Arthur Keith, and some others regard the appendix as a specialized region of the cecum. The fact that the appendix of a newborn child is as long absolutely as the appendix of a full-grown man is regarded by Sir J. Bland-Sutton as proof "that the part was of great importance to the ancestors of the human species" (Ibid.). Appendicitis, which is an inflammation of the vermiform

[1] Wm. J. Mayo, "Jour. Amer. Med. Assoc.," Oct. 19, 1901.

appendix of the cecum, is almost invariably the primary lesion of all of those various conditions known as typhlitis, perityphlitis, paratyphlitis, etc.—terms which are seldom justified by pathologic entities, and are in most instances well relegated to obscurity. I say in most instances, not in all, because I believe there is such a condition as primary inflammation of the cecum, although it is extremely rare. This rare condition may cause perforation, perityphlitic abscess, or peritonitis when the appendix is sound. It is not to be distinguished clinically from appendicitis (McWilliams in "Annals of Surgery," June, 1907). Involvement of the cecum as a result of appendicitis is common. Such a condition should be expected because the mucous membrane is continuous. It was recognized by some observers many years ago that such a disease as inflammation of the appendix existed, but the majority of the profession did not grasp the fact. In 1753 Laurence Heister, of Helmstädt, in his book "Medical, Chirurgical, and Anatomical Cases and Observations" described an abscess about the vermiform appendix (this historic fact was pointed out by R. D. Rudolf in "The Canadian Med. Assoc. Jour.," May, 1913). In 1759 Mestevier, of France, reported a case of perforation of the appendix by a pin.[1] In 1812 a perforated appendix was shown to the Medico-Chirurgical Society of London[2] and in 1835 Southam reported an appendical abscess (Manley). In 1848 Hancock reported an appendical abscess ("Lancet," 1838, p. 380). It is interesting to note that this was a case of appendicitis in pregnancy. Ten days after a premature delivery an abscess was opened. About two weeks after operation two fecal concretions came out of the wound. In 1827 Dr. F. Mèlier described appendicitis, and named among its symptoms fixed pain in the right iliac fossa and colic. This brilliant and original young Frenchman was years ahead of his contemporaries. He reported cases of undoubted appendicitis verified by autopsy, described gangrene, perforation, associated peritonitis, and appendical concretions. His original article, Manley[3] tells us, is in the "Journal of Medicine, Surgery, and Pharmacy" for 1827, second series, 110. Howard Kelly quotes it from "Jour. gén. de méd.," 1827, vol. c, p. 317. Mêlier said: "If it were possible to establish with certainty the diagnosis of this affection, we could see the possibility of curing the patient by operation. We shall perhaps some day arrive at this result."[4] In spite of Mêlier's writings, the profession adhered for half a century to the view of Dupuytren, put forth in 1833, that abscesses in the iliac region take origin from the cecum and not from the appendix. Dr. Reginald Fitz, of Boston, in 1886 persuaded the world that the appendix was the real seat of most inflammations in the right iliac fossa, and introduced the term "appendicitis" ("Amer. Jour. Med. Sciences," 1886, vol. xcii). This structure is particularly liable to infection because of the large amount of lymphoid tissue in its make-up, because it is in a dependent position, is always full of bacteria, has a poor blood-supply, and is readily blocked by kinking or by swelling of its mucous membrane. Further, as a vestigial structure, it has a low resisting power. A functionless part, like a loafer in a city, is a dangerous element. Each is a menace. The loafer is apt to become a criminal; the appendix is apt to inflame and kill. The appendix is a long and narrow diverticulum (musculomembranous in structure), which comes from the posterior and internal part of the cecum, and which probably has no physiologic function. The structure of the appendix is similar to the structure of the colon, except that the muscular structure is ill developed and trivial in amount. Lockwood[5] points out that there is an extensive lymph system in the appendix, and that the submucous and subperitoneal tissues communicate by numerous gaps in the muscles. This structure has a poor blood-supply, and in consequence gangrene occurs from rather trivial causes. It is supplied by a branch from the superior mesenteric artery. In women there is sometimes an additional supply by a vessel running in the appendiculo-ovarian ligament. The nerves are derived from the superior mesenteric plexus. The appendix averages about 4½ inches in length, but varies in size between the limits of ⅓ inch and a little over 9 inches. In 641 autopsies the longest appendix was 9⅓ inches and the shortest was ⅓ inch (Monks and Blake). Its diameter is, as a rule, about equal to that of a No. 9 English bougie; its canal is narrow and is partly closed by the valve of Gerlach (Talamon). The appendix enters the cecum at its posterior internal part, which is usually the seat of the most intense pain in inflammation, and corresponds to a point on the surface 2

[1] "Jour. Méd. Chir. and Pharm.," vol. x, 1759.
[2] "Med. and Chir. Trans.," London, 1812, vol. iii.
[3] "Med. Record," July 19, 1902.
[4] See R. J. Lee Morrill's article in the "Amer. Med. Surg. Bull.," Dec. 19, 1896.
[5] "Brit. Med. Jour.," Jan. 27, 1900.

inches from the anterosuperior spine of the ilium, on a line drawn from the umbilicus to the iliac spine, which is known as *McBurney's point*. The free part of the appendix in one-third of all persons is in relation with the posterior surface of the cecum; in almost one-third of all persons it is fixed in the iliac fossa, so that if perforation occurs the contents will be voided into the retroperitoneal tissue (iliac abscess). In less than 2 per cent. of cases the appendix is extraperitoneal. In some cases it is external to the cecum; in some it passes downward, and in some inward. It is important to remember that the appendix may be met with in the most unexpected situations. When the ascending colon is displaced, the diverticulum may be upon the left side. It is not unusual to find its tip in the middle line, up toward or adherent to the gall-bladder, or in the pelvis. In about two-thirds of all cases the appendix is completely covered by peritoneum; in one-third of all cases it is in contact, in some part of its length, with cellular tissue (Talamon). Byron Robinson has called attention to the fact that the appendix in man is frequently in contact with the psoas muscle, and may be bruised by that muscle. The mesentery of the appendix (meso-appendix) is attached to one-half or two-thirds of the diverticulum but the tip is nearly always free. In 10,000 autopsies the appendix is said to have been absent five times. In most cases in which surgeons have been unable to find the appendix it was not absent, but was covered and hidden by peritoneum. Occasionally the appendix is found in a hernial sac, and often in a cecal fossa.

Etiology and Pathology.—Appendicitis is very rare in infants. I operated unsuccessfully on a male two years of age for gangrenous appendicitis. Savage operated unsuccessfully on a baby sixty-one days old, and Weiss operated unsuccessfully on a child twenty months old.[1] J. P. Crozer Griffith[2] has collected 15 cases in children under two years of age. One of these patients was three months old. Nine of the 15 were operated upon, with 7 recoveries. In 4 of the cases the appendix was in the scrotum. In 2 cases a diagnosis of intussusception was made. In children nine or ten years old the disease is by no means infrequent (see page 998). Appendicitis is common at any period beyond childhood, being more frequent in young and middle-aged people than in the aged. It is very rare in those over sixty years of age. A reason for this is that over half of all the appendix is obliterated or is being obliterated in people over sixty years of age.

Morris ("Annals of Surgery," Nov., 1917) believes that an appendix in a condition of fibroid degeneration is saved from infection by the destruction of structures very liable to infection and by the irritation productive of local hyperleukocytosis. It is for this reason that Morris refers to appendicitis obliterans or irritans as *protective appendicitis*. Appendicitis is about four times commoner in males than in females. It is more common in summer than in other seasons, and in warm countries than in cold or temperate climes. Appendicitis is a bacterial disease. It is produced in many cases by pus cocci, but most commonly by the action of the Bacterium coli commune of Escherich. The colon bacilli, which normally inhabit the appendix, are harmless when the appendix is healthy, but become active for harm when the diverticulum is bruised, obstructed, irritated by the presence of uric acid, congested because of chilling of the cutaneous surface of the body, or distended by the ingress of colonic fluid (C. Van Zwulenburg in "Annals of Surgery," March, 1905). It seems probable that flatulent distention of the colon may be responsible for forcing fecal matter in quantity into the appendix and may lead to plugging of the opening (Rubin in "Jour. Amer. Med. Assoc.," vol. xliii, No. 1). It has been shown by Rosenau that certain toxins which enter the circulation have a selective action for the appendix. Such toxins may come from a distant focus of infection. When inflammation occurs, swelling of the mucous membrane may occlude the opening into the colon. If this occurs, the lumen of the appendix will dilate, fill up, and become distended by a thick mucopurulent fluid. Ulcers sometimes form which may only involve the mucous membrane, may pass deeply into the coats, or may even perforate. Dieulafoy[3] maintains forcefully that appendicitis is due *always* to the conversion of the appendix into a *closed* cavity, but cases are met with which disprove this assertion. Various conditions may bring about this transformation. Partial obstruction may be caused by calculi, which are composed of stercoral material and hordes of bacteria mixed with salts of lime and magnesia. These calculi are not formed in the colon, but are formed in the appendix. The theory that concretions form in the colon and are forced

[1] Manley in "Med. Record," July 9, 1092.
[2] "University of Penna. Med. Bull.," Oct., 1902.
[3] "Progrès médicale," No. 11, 1896.

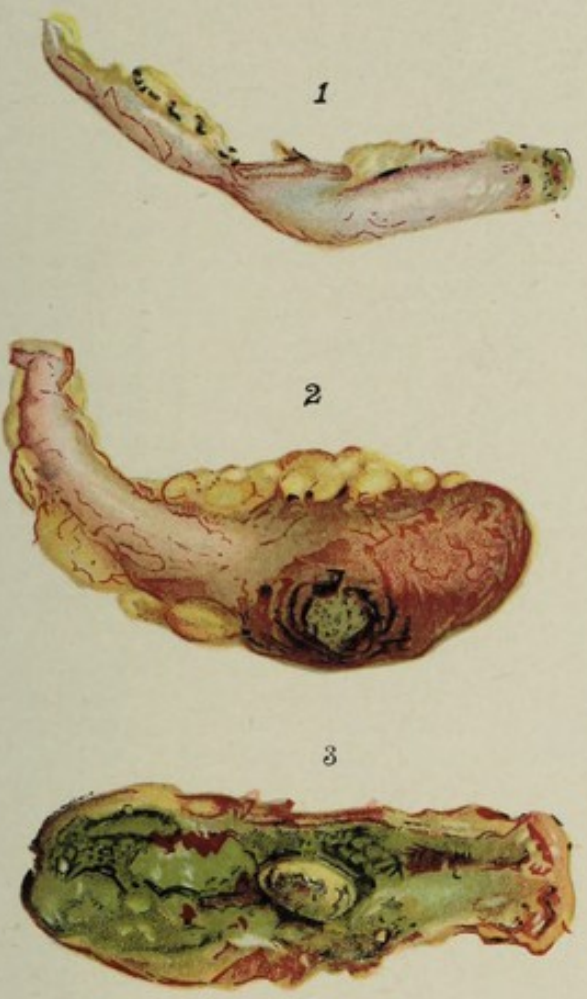
into the appendix by peristalsis has been very largely abandoned. Dieulafoy speaks of the condition as *appendicular lithiasis*, and says it has a tendency to run in family lines, and has a kinship to gout and rheumatism. Obstruction may be caused by local infection of a catarrhal area, by the formation of a fibrous stricture, or by several causes acting in unison. The presence of a concretion is always dangerous. It is frequently associated with ulceration, either as cause or effect. It is a mass of virulent bacteria. It may lead to perforation or gangrene. Talamon taught that the appendix resents the presence of the concretion, reflex contraction of the muscular coat taking place, with violent pain (*appendicular colic*). The muscular structure is so rudimentary that it does not seem probable that attempts at contraction, even should they arise, would produce violent pain and distant symptoms. Pozzi[1] believes that appendicular colic may be caused by torsion or bending of the appendix or malposition of the diverticulum, and holds that pain may arise when there is no lesion in the appendix and no inflammation of the peritoneum or pericecal structures. What is called appendicular colic is really inflammation of the appendix without involvement of the peritoneum. The term "appendicular colic" has led to much injudicious conservatism, and, as Lockwood shows, if an appendix is removed from an individual who suffers from attacks of appendicular colic, it will usually be found that the diverticulum is inflamed or the lumen contains a concretion. Foreign bodies, such as pins, fish-bones, nails, buttons, date-stones, cherry-stones, and grape-seeds, may enter the appendix, but they do so far less often than is generally supposed, most alleged grape-seeds from the appendix being fecal concretions. Fitz found concretions in 15 cases out of 300. Ranvier collected the records of 459 postmortems, and found reported 179 fecal concretions and 16 foreign bodies. In Burgess's 500 cases fecal concretions were found in 21 per cent. ("Brit. Med. Jour.," Feb. 24, 1912). Appendicitis due to a foreign body, such as a grape-seed or a pin, is known as *foreign-body appendicitis;* appendicitis in which a concretion is the assumed cause is known as *stercoral*. A foreign body may produce instant perforation. If impaction of a foreign body or concretion occurs, the orifice of the appendix is closed, the circulation is soon cut off, the secretions are retained, the coats become congested, the diverticulum enlarges enormously, microbes multiply with great rapidity, and the wall of the congested appendix inflames and may become gangrenous or ulcerated, and is finally perforated. Interference with the blood-supply of the appendix will predispose to appendicitis. This may be brought about by twists, bruises, adhesions, concretions, pressure, or bands; and the psoas muscle may play a part in the production of these conditions. In women appendicitis is occasionally secondary to tubo-ovarian disease. Appendicitis is rarer in women than in men, probably because in many females the appendix has a better blood-supply than in males, the additional supply coming through the folds of the appendiculo-ovarian ligament. In women disease of the uterus or adnexa frequently precedes or actually causes appendicitis. Catarrhal conditions of the intestine, habitual constipation, and indigestion with flatulence predispose to appendicitis. In fact, in a great many cases there has been a more or less prolonged history of diarrhea or constipation and flatulent indigestion before the development of acute appendicitis. An acute attack of appendicitis may arise after the eating of a large and indigestible meal, especially if such a meal has been taken late at night. Bolting the food and eating large meals at irregular hours predispose to an attack. It seems probable that catarrhal appendicitis may result from extension of catarrh of the colon, and possible that, in rare cases, appendicitis may arise from external traumatism (*traumatic appendicitis*). In most cases, however, in which appendicitis seems to have been produced by a blow, the injury at most simply "awakened a sleeping dog" and stirred into acute inflammation an appendix already diseased. It is well to be skeptical as to external force causing appendicitis. Sprengel ("Deut. med. Woch.," Dec. 14, 1911) says that no case in literature, ascribed to abdominal trauma as causal, can be confirmed by scientific evidence. If before perforation the appendix adheres to the cellular tissue behind the cecum, cellulitis or abscess without peritonitis may result. When appendicitis goes on to perforation, there is always some peritonitis; but if the steps to perforation are gradual, and if the causative organism is the colon bacillus, the peritonitis may be local. Sometimes, by formation of adhesions, a barrier is made between the appendix and the peritoneal cavity before perforation occurs. When perforation takes place suddenly peritonitis is inevitable. When the causative organism is the streptococcus, general peritonitis is very apt to arise. Peritonitis may arise without perforation by contiguity of structure or by migration of bacteria through the con-

[1] "Progrès médicale," No. 19, 1896.

gested walls of an obstructed appendix. In some cases perforation takes place into the peritoneal cavity, yet pus is circumscribed by matting together of the intestines with plastic exudate. The appendix may become gangrenous very rapidly or after some time. A case of appendicitis in which gangrene and perforation come on very quickly is spoken of as *fulminating appendicitis*. In some cases, if a perforation is very small and the appendix is swathed in lymph, or if perforation does not occur, the inflammation may subside. Perforation rarely occurs from liquid pressure or from the pressure of a concretion; it is generally due to ulceration produced by the action of micro-organisms. Appendicitis which subsides may at any time recur, and the life of such a patient is under constant menace. An enormous number of people have had appendicitis. Toft recorded 500 autopsies, and in 36 per cent. of them there were positive signs of past attacks. The disease is occasionally unsuspected during life. These facts prove that the disease may subside without the aid of surgery.

Forms of Appendicitis.—In what is known as *appendicular colic* the appendix is temporarily obstructed because of transitory inflammatory swelling of the mucous membrane of the outlet, and the stercoral contents are retained in the diverticulum. The peritoneal covering is not involved in the inflammation. This condition is called by Fergusson *constipation of the appendix*. If not relieved, it will eventuate in appendicitis with involvement of the peritoneal coat. It is an unfortunate term, sometimes used as an excuse for avoiding operation. In such cases a concretion is frequently or usually present.

Simple parietal or *catarrhal appendicitis* does not remain limited to the mucous membrane; hence the term *catarrhal* is not strictly correct. The vessels of the appendix are distended with blood, the lumen at the intestinal end becomes partially or completely obstructed, the epithelium desquamates from numerous glands, the mucosa may ulcerate, and the lumen of the appendix becomes filled with a mixture of mucus, bacteria, and portions of organic matter. Bacteria enter the lymph-spaces of the wall of the appendix, and pass rapidly from the submucous to the subperitoneal tissues. In from twelve to thirty-six hours after the mucous coat begins to inflame the peritoneal coat will probably be involved. The inflammation may undergo resolution and the patient get well, or a wait for improvement may result disastrously. The appendix may thicken, ulceration may take place, and peritonitis may arise. Suppuration or gangrene may occur, perforation may take place, or pyemia, with abscess of the liver, may arise. The acute condition may pass into chronic appendicitis or ulcerations of the mucosa may remain; the mucous crypts may be filled with bacteria; a concretion may exist; cicatricial contractions may occur. In any of these conditions the patient is in danger of a fresh attack at any time. In a catarrhal inflammation secondary to catarrh of the colon the case may be chronic from the beginning, but most cases of chronic appendicitis follow acute attacks. If the lumen of the appendix is gradually and finally, it may be, completely obliterated the condition is denominated *obliterative appendicitis* (Senn in "Jour. Amer. Med. Assoc.," 1894). It is present in more than half of all appendices in people over sixty years of age. Senn was of the opinion that the condition resulted from mild but prolonged relapsing infection. Eight years before Senn's paper Fitz claimed that obliteration of the appendix was the result of inflammation. One year before Senn's paper Ribbert asserted that obliteration was the result of non-pathologic involution. Robert T. Morris ("Annals of Surgery," Nov., 1917) believes appendicitis obliterans is "a normal involutional process belonging to a vestigial structure," nerve structures persisting in the midst of contracting hyperplastic connective tissue. It is an area of irritation occurring in those undergoing physical decline and is most common in neurasthenics. *Recurrent appendicitis*, it was once said, may be due to the inordinate size of the mouth of the appendix, making of this diverticulum a drag-net for foreign bodies; but we now know that it is more probably due to the fact that the opening is so small that even slight swelling serves to close it, and convert the appendix into a closed vase filled with septic material. *Suppurative appendicitis* is due to purulent infiltration of the walls. Pus in the lumen is not purulent appendicitis. Pus may form about the appendix, a condition known as *appendical* or *appendicular abscess*. *Gangrenous appendicitis* is a moist or septic gangrene, due to interference with the circulation and to tissue destruction by the action of micro-organisms. Perforation occurs and multiple perforations are common. The entire appendix may slough off. Interference with circulation may be caused by an obstruction, by a bend or twist or bruise of the appendix, by a concretion, or by the action of virulent organisms on an appendix the tissue resistance of which is lowered by injury or disease. In gangrenous cases the vessels of the meso-appendix are usually



Various forms of appendicitis (from drawings by Dr. M. H. Richardson): 1. Obstruction from stenosis of appendix. 2. Dilatation of distal end of appendix; perforation by a fecal concretion. 3. Gangrene of nearly the whole of the appendix; fecal concretion in lumen.

obstructed by thrombi in the veins or arteries. In rare instances appendicitis is due to tuberculous ulceration, in other cases to typhoid ulceration, and genuine appendicitis may arise during typhoid fever.

By the term *syncongestive appendicitis* Morris means a congested appendix, the congestion being synchronous with "obstruction to the blood and lymph circulation of the cecum and ascending colon. For example, it is a common complication of general enteroptosis" ("Annals of Surgery," Nov., 1917).

Fowler suggested the following classification of cases of appendicitis: Endo-appendicitis; parietal appendicitis; peri-appendicitis; para-appendicitis.

As a matter of fact genuine appendicitis, that is, actual inflammation of the appendix, is always one disease which varies in intensity and complication. It is useless to divide it into a great number of symptomatic groups.

Symptoms and Signs.—In what is known as *appendicular colic* the patient suffers from disorder of digestion and occasionally has a brief attack of abdominal pain associated with trivial and temporary tenderness in the right iliac fossa. The colicky pain is about the umbilicus and right iliac fossa; there is often nausea and usually constipation. This condition, if not soon relieved, is followed by the evidences of peritoneal inflammation. The symptoms of genuine acute appendicitis are as follows: In some cases the disease seems to begin suddenly, but in most of the cases there are noted for a few hours or even for a day or two distinct *premonitory symptoms*, among which are constipation or diarrhea, flatulence, nausea, anorexia, dyspepsia, coated tongue, weakness, general gastro-intestinal uneasiness, colicky pain about the umbilicus, and, perhaps soon, tenderness, a sense of weight, soreness, or uneasiness in the right iliac fossa. The acute symptoms suddenly appear after the premonitory symptoms have lasted a variable time, and the acute symptoms very frequently appear in the early hours of the morning. The first definite symptom is severe colicky pain. The tongue is coated and usually dry. Great thirst is often complained of. The face is expressive of pain or, later, in a fatal case, becomes Hippocratic. The posture assumed for greater ease is one of recumbency, with the right thigh and knee or both thighs and knees partly flexed. Respirations in acute appendicitis are shallow and thoracic. The development of acute pain is usually the most prominent symptom. The pain is at first colicky and located about the umbilicus or through the abdomen in general, this distant, primary, or generalized pain, according to Treves, corresponding to the distribution of the superior mesenteric plexus. Mr. Burgess ("Brit. Med. Jour.," Feb. 24, 1912) states the present view when he says that the primary pain is referred to "the peripheral distribution of the spinal nerves arising from those segments of the spinal cord with which the appendix and small intestine are connected through their sympathetic nerve supply—eighth to eleventh dorsal." In 5 per cent. of cases of appendicitis in the male there is pain or uneasiness in the right testicle. This is explained by the fact that both the testicle and the appendix obtain nerve supply from the same segment of the cord (Cope in "Brit. Jour. of Surg.," Oct., 1921). This primary pain may subside if the appendix succeeds in emptying its contents into the colon, but it may also subside if the appendix becomes gangrenous or ruptures (Murphy). Usually in from twelve to thirty-six hours the pain becomes localized in the right iliac fossa, and associated with tenderness and hyperesthesia of the skin—in other words, true inflammatory pain develops. It is due to peritoneal inflammation. "Thus, the closer the situation of the appendix to the parietal peritoneum, the earlier will the latter be irritated and the sooner will the pain be localized" (Burgess, Ibid.). The usual location of the pain in the right iliac fossa depends on the fact that the appendix is usually placed in that region. Occasionally, when the appendix crosses the belly, the pain is located on the left side, and occasionally, for like reasons, in the gall-bladder region, the right loin, or the pelvis. "If the appendix lies among coils of small intestine or in the pelvis there may at no time be local pain, the initial umbilical pain becoming steadily generalized" (Burgess, "Brit. Med. Jour.," Feb. 24, 1912). If the pain of appendicitis is violent the patient presents some evidences of shock. Nausea is the rule in appendicitis; vomiting usually occurs early—about three or four hours after the beginning of pain. In children vomiting is often early, violent, and persistent, but in adults, after the early hours of the attack, vomiting occurs, as a rule, occasionally or not at all, although nausea is complained of. Early vomiting is a reflex symptom due to distention of the appendix (Murphy). If vomiting persists, it points to peritonitis, to pus formation, or to intestinal obstruction unless it results from the administration of morphin. There is usually constipation in acute appendicitis, although diarrhea occasionally occurs. In appendicitis there is always

some elevation of temperature, although it may be very slight and of brief duration. The fever is very seldom ushered in by a chill, but the temperature mounts in the course of a few hours to 102° or 103° F., or even higher. The fever does not begin until several hours or a number of hours after the onset of pain. In a very mild case the temperature remains elevated for a day or two and then falls to normal. In severe cases it is apt to remain elevated for a longer period, but it is always to be borne in mind that in very grave appendicitis the surgeon may find very little elevation of temperature, no elevation, or actually a subnormal temperature. In gangrenous cases, and in cases in which a large perforation suddenly takes place, and when general peritonitis develops, there is usually, for a time at least, a subnormal temperature. A *sudden* drop of temperature indicates, as a rule, a calamity, particularly gangrene of the mucosa of the appendix, which prevents absorption of toxin (Murphy), or perforation of the appendix. Leukocytosis is usually present (see Diagnosis). The pulse in appendicitis is in most cases rapid. A very rapid pulse (well over 100) is significant usually of a severe case, and the auguries are especially ominous if the pulse is rapid, but the temperature is normal or subnormal. Occasionally, however, a slow pulse exists, even in the worst cases.

Examination of the abdomen may discover, early in the case, general abdominal rigidity; but usually in the course of twenty-four hours or more the general rigidity passes away, the abdomen distends more or less, and rigidity of the lower half of the right rectus muscle becomes evident and persists. If general peritonitis begins early, general abdominal rigidity does not abate or pass away. If general peritonitis begins later, general abdominal rigidity, which was present at first but which passed away, returns. Rigidity may not exist in the very beginning of appendicitis, in a case in which the appendix is retrocecal or pelvic, in some abscess cases, or in a case with relaxed belly walls.

A symptom almost invariably present in appendicitis is tenderness. In some cases the tenderness is diffuse; in most it is localized, or at least most acute, in the right iliac fossa. The point where tenderness is usually most acute is a spot about 2 inches internal to the anterosuperior spine of the ilium, on a line drawn from that bony point to the umbilicus (*omphalospinous line*). This is known as *McBurney's point*, and overlies the usual point of origin of the appendix. In some cases, however, the greatest point of tenderness is nearer the gall-bladder; in others, in the loin; in others, toward the umbilicus, in the midline, or on the opposite side; in others, in the rectum. The seat of greatest tenderness depends on the situation of the appendix, and it is usually at McBurney's point, because this usually overlies the origin of the appendix. The lesson is that in appendicitis there is a point of tenderness or of greatest tenderness in a region which the appendix can occupy. If tenderness exists on the right side and then develops in the left side, severe spreading peritonitis usually exists (W. Meyer). When the appendix becomes gangrenous, local tenderness may for a time disappear, because the peritoneum of the involved region has become anesthetic; later, however, it returns, spreads, and may become general. In view of the fact that tenderness in the right iliac fossa is often demonstrable in tubal and ovarian disease, the sign in males "is of greater significance than in females" (A. H. Tubby on "Appendicitis," in "Medical Monograph Series"). Pressure upon the left side will, in some cases, cause pain in the right iliac region. When rigidity abates or disappears the case may go on to cure, but sometimes a mass becomes evident in the right iliac fossa. The mass, of variable shape, is at first hard, and if of any considerable size, is dull on percussion. In some cases when no mass is palpable through the abdominal wall, rectal examination detects one. This mass may be agglutinated bowel and omentum or a collection of coagulated inflammatory exudate. It may gradually disappear or an abscess may form. The evidences of general peritonitis are: general abdominal rigidity, then great distention because of intestinal paresis, general abdominal tenderness, rectal tenderness, very rapid pulse, hiccup, persistent vomiting which may become regurgitative, and, as Meyer points out, percussion dulness over the right iliac region or entire lower abdomen.

In some cases the symptoms, at first trivial, become grave. In some all the symptoms are violent from the beginning, the attack tends to linger, and is followed by persistent soreness of the appendix and harassing digestive disturbances. Any case of appendicitis may become suddenly desperately grave because of perforation or gangrene, and in any case general peritonitis may develop. After sudden perforation or rapid gangrene the temperature falls, vomiting is noted, hiccup begins, abdominal distention, pain, and tenderness become marked and general, and the pulse becomes very rapid. In some cases these grave symptoms are present almost from the start (fulminating cases).

A sudden perforation produces collapse and, if reaction takes place, general peritonitis arises. Peritonitis, be it remembered, may arise without either perforation or gangrene. If pus forms, it may be unlimited by adhesions. In such cases there is the rapid onset of fatal peritonitis and septicemia. Pus may be limited by adhesions and be practically extraperitoneal. In such a case a lump is felt in the right iliac region, but dusky discoloration and edema of skin very seldom exist. The surgeon does not wait for fluctuation before he makes a diagnosis. In an abscess case there are usually irregular fever and sweating, but rigors do not occur. Hawkins says we should always suspect pus if the symptoms continue after the sixth day, and particularly when the symptoms abate and suddenly increase between the seventh and tenth days. A limited collection of pus may be liberated into the peritoneal cavity by rupture of the abscess wall. Such a rupture may be caused by pressure or muscular effort; rupture is followed at once by shock and later by diffused peritonitis. An abscess may rupture externally or into the vagina, intestinal tract, or bladder. It is desirable, if possible, to locate the situation of the appendix, and this is usually determined by locating the seat of swelling and of greatest tenderness. The surgeon should not lose sight of the fact that the appendix may be found in the most unexpected situations. In every case a rectal or vaginal examination should be made in order to detect swelling and tenderness, and thus determine if the inflammation took origin in or now involves the pelvic region. Pain at the end of micturition points to involvement of the vesical peritoneum.[1] In cases in which there is no *localized* swelling and no local tenderness—for instance, in gangrenous or perforative appendicitis with general peritonitis—"diagnostic localization" is impossible (Van Hook).

Terminations and Prognosis.—Acute appendicitis may terminate in death, in complete recovery, or in a condition of lowered vitality during the existence of which acute attacks are almost certain to recur. Sometimes after and sometimes without an antecedent acute attack the patient develops persistent soreness and tenderness in the right iliac region. Between the attacks of recurrent appendicitis there may be soreness, tenderness, and gastro-intestinal disturbance, or there may be no evident trouble whatever; yet, even in the latter case, there may be an ulcer or ulcers of the mucous lining. If a patient has once had appendicitis he will always be liable to suffer from another attack if the appendix has not been removed. The liability becomes almost a certainty if the intestinal end of the appendix is narrowed or if the lumen is obstructed at any point, if a concretion exists, or if there is an area of ulceration or of desquamating epithelium. After an attack the appendix may remain enlarged and tender; exercise or indiscretion in diet may cause it to become tender, or the patient may have occasional attacks of colicky pain. If any of the above conditions exist, another attack may be confidently anticipated if operation is not performed. In such cases the appendix can usually be palpated. The method of palpation in an interval proposed by Robert T. Morris[2] is very useful. It is applied as follows:

The surgeon stands to the right of the patient and uses three fingers of the right hand to feel with and three fingers of the left hand to press with. Morris insists that no muscular effort should be used by the hand which feels. The feeling fingers are pressed by the other fingers beneath the margin of the right rectus muscle on a level with the umbilicus, and are drawn toward the patient's right side, and the colon will be felt to roll under the fingers. The process is repeated several times until the end of the cecum is reached. The appendix is sought for by rolling the cecum from side to side with the finger-tips, and working toward the proximal end of the appendix.

Adhesions may form as a result of appendicitis, general peritonitis may arise, the appendix may slough or become perforated, or abscess may ensue upon local peritonitis. Lymphangitis of the appendix may accompany, and septic lymphangitis or phlebitis and secondary hepatic and lymphatic infections may follow, appendicitis. They are thought to be most common after mild attacks of appendicitis. The secondary *lymphatic* and *hepatic infections* are of the greatest importance. There may be abscess of the liver, subphrenic abscess, or retroperitoneal lymphangitis.

A subphrenic abscess may result from infection carried from the appendix by the lymphatics, from pus ascending along the posterior cellular spaces, or from direct invasion via the peritoneal cavity (John C. Munro in "Annals of Surgery," Nov., 1905); such an abscess is usually on the right side, but may be upon the left.

Lymphangitis is the rule in appendicitis, and when we open the abdomen there

[1] Van Hook in "Jour. Amer. Med. Assoc.," Feb. 20, 1897.
[2] "Medical Record," Sept. 17, 1898.

is usually evidence of it in the lymph-glands of the mesentery, and in children particularly these glands are apt to be enlarged. One lymph path from the appendix is through the ileocecal glands, another is posterior to the cecum and is retroperitoneal, and the latter reaches the liver and diaphragm (Munro). In lymphatic infection an abscess may form anywhere in the course of the lymphatics. Abscess of the liver usually results from portal invasion, but may result from lymphatic infection.

Sometimes jaundice arises. Jaundice is due to toxins which enter the portal vein and reach the liver. It is ushered in by a chill and the chill is apt to be repeated daily, every other day or every third day. Such a patient may die in two or three days or may live a week or two. In these cases the liver is small, the liver-cells are degenerating and there is acute nephritis. The red blood-cells are destroyed in immense numbers and these dead cells add to the jaundice. A similar jaundice may happen after anesthesia by chloroform or ether (Lenzmann in "Zentralb. für Chir.," Feb. 14, 1914) and in fatty degeneration of the liver cells as a complication of pregnancy.

Among other possible consequences of appendicitis may be mentioned pyemia, empyema, inflammation of the parotid gland, and thrombosis of the right iliac vein. A positive prognosis of any case of appendicitis is an absolute impossibility. The future of every case is clouded with uncertainty, and the most that can be attained in the field of prediction is a scientific guess of more or less probability. All surgeons have seen apparently hopeless cases recover, and have observed cases with the most trivial symptoms grow progressively worse or suddenly develop a fatal complication. Further, after one attack other attacks are very apt to arise. The medical man who estimates that 80 or 90 per cent. of cases get well without operation has probably dealt with many catarrhal cases, and he certainly is optimistic as to freedom from future attacks, because, as stated before, recovery from an attack does not of necessity mean freedom from the disease. In appendicitis there may be delusive evidences of improvement; for instance, the abatement of pain and the lessening of fever, being regarded by the patient himself as indubitable signs of improvement, may, in reality, be indicative of gangrene. In spite of the previously mentioned difficulties and obscurities we can in the majority of cases decide with a reasonable probability of accuracy whether or not the patient is becoming worse. In a delusive improvement some signs and symptoms improve, but all do not; and in endeavoring to form a prognosis, *all* the signs and symptoms must be noted and weighed: pain, tenderness, rigidity, distention, nausea and vomiting, delirium, intestinal obstruction, shock, the temperature, the rapidity of the pulse, the blood examination, etc. If *all* these elements, not only some of them, point to improvement, we may be reasonably confident that improvement is really taking place. If only some of them point to improvement we will in many cases be altogether uncertain as to the significance of the change.

The **diagnosis** is not invariably so easy, as many light-hearted operators seem to believe. It is frequently far from easy and is sometimes altogether impossible without exploratory operation. Sonnenburg maintains that we can diagnosticate the pathologic condition of the inflamed appendix. Personally, I am unable to do this with any certainty, although I always try, and am often right and just as often wrong.

In attempting to make a diagnosis, besides the ordinary examination of the abdomen, a rectal or vaginal examination should be made, associated in many cases with bimanual palpation. If an appendix is enlarged and an individual has a thin abdomen which is not rigid, it may be possible to palpate the appendix. Sometimes it can be felt after the administration of ether when it could not be detected before. In an acute case forcible or prolonged palpation is always unjustifiable, as it may force an ulcer to perforate, or may rupture an abscess, and the information gained is not of sufficient importance to justify the risk. In a chronic case information of great value may be obtained and there is no real risk in the maneuver. I am persuaded John B. Murphy is correct in attaching the greatest possible importance to the order in which symptoms appear in acute appendicitis. Pain *precedes* nausea and vomiting, elevated temperature, and abdominal tenderness. If fever precedes pain the condition is not appendicitis. If vomiting precedes pain the condition is probably not appendicitis.

The disease may be confused with a number of different conditions. It sometimes is confused with typhoid fever; in fact, early typhoid fever associated with marked abdominal pain gives a picture very similar to that furnished by appendicitis.

In typhoid fever the temperature is usually distinctly higher than that commonly encountered in appendicitis and fever precedes pain. Maurice H. Richardson[1] tells us

[1] "Boston Med. and Surg. Jour.," Jan. 9, 1902.

that in every case in which typhoid is suspected, operation is not justifiable on the hypothesis of existing appendicitis, unless there are local pain and localized tenderness in the appendix region, associated with definite muscular resistance or distinct rigidity; and that operation should be postponed in a case in which the constitutional signs are severe and the local signs are difficult to detect; but when there are pain, tenderness, and rigidity with or without distention, operation must be performed, even when one recognizes the possibility of the existence of typhoid fever. Richardson lays down the following rule: Soft abdomen plus high temperature suggests typhoid, even if there are pain and tenderness. In appendicitis there is usually leukocytosis; in typhoid, leukocytosis is absent, except when perforation is imminent or has occurred, or when some other complication exists. I have seen the operation performed twice for supposed appendicitis when the condition in each case was found to be early typhoid fever.

Acute intestinal obstruction is sometimes confused with acute appendicitis, and the mistake is particularly likely to occur if the obstruction is due to intussusception. In acute obstruction, as in appendicitis, the pain is first appreciated about the umbilicus; but in acute obstruction it remains in that region, does not pass to and localize itself in the right iliac fossa, and is not associated with tenderness of the right iliac fossa. In obstruction the vomiting is persistent; in appendicitis, except in the beginning, it is usually trivial and often absent, although in children it may be violent and persistent. In acute obstruction shock is much more pronounced than in appendicitis, and early and great distention of the abdomen is noted. The temperature in obstruction is seldom elevated and is usually subnormal; while in appendicitis, at least in the majority of cases, the temperature is distinctly elevated. Further, in acute intestinal obstruction the constipation is absolute, not even gas passing. In children intussusception is capable of particularly confusing the diagnosis, because, after the first day, it is by no means unusual to have distinct fever in this condition, and occasionally a tumor-like mass is found in the right iliac fossa; but in intussusception the tumor does not remain fixed, but alters its position; it is movable; and the patient usually suffers from tenesmus and the passage of bloody mucus. One should bear in mind that in acute appendicitis associated with septic peritonitis acute obstruction may exist; and that the diagnosis of obstruction may be made without recognizing the appendicitis.

In those rare cases of typhlitis occasionally encountered the symptoms are much milder than in appendicitis: the temperature is not much elevated, the pulse-rate is only slightly accelerated, the leukocytosis is not marked, there is seldom rigidity, there may be tenderness, but seldom pain. Pain when present is colicky rather than continuous. There may be a doughy mass or a mass feeling "like an air-cushion" in the right iliac fossa (Raymond Russ in "Surg., Gyn., and Obstet.," Oct., 1912). Chronic typhlitis causes muscular atony and intestinal stasis (Russ, Ibid.).

Lesions of the kidney are sometimes mistaken for appendicitis, but in renal colic the pain runs into the groin and testicle of that side, and occasionally passes down the front of the thigh or into the rectum; and if any tenderness exists, it is found in the loin or in the groin rather than in the right iliac fossa. Besides, there are other symptoms of kidney trouble. The urine may contain blood or pus, and there may be a history of difficult or of frequent urination, though one should bear in mind that in appendicitis with inflammation of the vesical peritoneum there may also be a record of urinary difficulties. An *x*-ray picture may exhibit a calculus in the ureter or kidney, and a movable kidney is distinctly palpable. In ordinary renal colic there is vomiting in the beginning, just as in the beginning of appendicitis. In movable kidney and renal colic the vomiting is often more violent and prolonged than is common in appendicitis. Movable kidney and appendicitis may exist coincidentally. Very confusing cases are those in which *hematuria accompanies appendicitis*. I have seen it twice, and in neither case was there any apparent connection between the appendix and the kidney, ureter, or bladder. The hematuria must have been due to acute nephritis which is known to occur in some cases of appendicitis, the nephritis resulting from the toxins of a bacterial disease. This form of nephritis Dieulafoy calls "nephrite toxique appendiculaire." As pointed out by M. G. Seelig ("Annals of Surgery," Sept., 1908), hematuria may also be due to direct involvement of the kidney, ureter, or bladder. When the tip of an inflamed appendix is adherent in the region of the right ureter there may be symptoms inseparable from those of renal colic.

Gall-bladder difficulties, too, may be confounded with appendicitis. I have operated upon 2 cases of cholecystitis under the supposition that they were cases of

appendicitis; and upon several cases of appendicitis in the belief that the condition in each case was cholecystitis. In an inflammation of the gall-bladder, with a distended gall-bladder hanging low down, and with muscular rigidity, the distinction between appendicitis and cholecystitis is always difficult and sometimes impossible. The same is true when the cecum has not descended and the appendix is in the gall-bladder region. So it is when the tip of the appendix is adherent to the gall-bladder. In ordinary gall-stone colic the condition is generally sudden in onset; it is characterized by pain in the epigastric region, passing toward the right shoulder-blade and the shoulder, the pain being most acute and becoming more or less localized in the region of the gall-bladder; and there is always tenderness over the gall-bladder region. In gall-bladder colic the vomiting is usually violent and often almost continuous.

The perforation of a gastric or of a duodenal ulcer may be diagnosticated as appendicitis. In perforation of a gastric ulcer there is usually a history of previous difficulty with the stomach, though this is not always the case. The onset of acute perforation is more sudden than is characteristic of the onset of appendicitis. The pain is violent, the rigidity intense, and the pain, rigidity, and tenderness are in the epigastric region.

Among other conditions that may be confused with appendicitis may be mentioned malignant disease of the cecum, tuberculosis of the cecum, acute tuberculous peritonitis, twisting of the pedicle of an ovarian tumor, tubal disease, extra-uterine pregnancy, membranous colitis, perinephric abscess, tuberculous abscess of the loin or of the groin, and abscess from hip-joint disease. I have operated on 3 cases in which sciatica was caused by appendicitis. In each case the appendix was adherent posteriorly. All were promptly cured. One had been bedridden for many months before the operation.

Pneumonia of the right base and pleurisy may cause abdominal pain and be mistaken for appendicitis. The pain may be due to inflammation of the diaphragmatic pleura or may be reflected along the lower six intercostal nerves which supply the lower part of the pleura and the abdominal wall. Irritation of the eleventh thoracic nerve causes pain in the iliac region. There may even be superficial tenderness in the abdomen, but deep pressure is well tolerated (Donald W. Hood, "Brit. Med. Jour.," Dec. 30, 1905). There may be abdominal rigidity. The abdominal pain seldom persists more than a few hours. It is intensified by deep respiration and is accompanied by high fever. As Hood says, whenever a patient suffers from vomiting, abdominal pain, and high fever, examine the chest. Sir Thomas Oliver has described what he calls "the abdominal type of pneumonia." It is characterized by the sudden onset of severe abdominal pain. Vomiting often occurs. There is then a chill, usually a rise of temperature, and in some cases collapse. The pain is accompanied by tenderness, and both these phenomena may be in the right iliac region. Early there are no physical signs of pneumonia. In a few hours the patient reacts from collapse, the abdominal pain and tenderness subside, the temperature rises, and signs of pneumonia become evident. In young children pneumonia is particularly apt to cause abdominal pain and rigidity. Beyond a doubt, more than one abdomen has been opened for supposed appendicitis when the real condition was pneumonia.

In *chronic appendicitis* there is no rigidity. The diagnosis of chronic appendicitis is usually lightly and sometimes wrongly made. The conditions which lead to confusion are many; among them may be mentioned Lane's kink, enteroptosis, movable kidney, adhesions, Jackson's membrane, twisted cecum, gall-bladder disease, pelvic disease, etc. F. Gregory Connell speaks of cases which he calls *pseudo-appendicitis* ("Jour. Amer. Med. Assoc.," July 29, 1916). They occur particularly in young, thin adults and in females. Attack after attack of pain may occur. The pain is aggravated by exercise and relieved by recumbency. During the attack there is muscle spasm, there may or may not be tenderness, the intestine is inflated with gas, the temperature is normal or subnormal, there is no leukocytosis, rarely vomiting, and the patient is seldom driven to bed. Connell (Ibid.) believes the condition to be due to "a lack of balance between the vagus and sympathetic divisions of the autonomic nervous system." Removal of the appendix does not cure such a case. Robert T. Morris ("Annals of Surgery," Nov., 1917) points out a fact of great importance in regard to chronic appendicitis. In all forms of chronic appendicitis there is tenderness about 1½ inches to the right of the navel. This tenderness is due to hypersensitiveness of the right lumbar sympathetic ganglion. A striking fact is the difference in the location of the tenderness between acute and chronic appendicitis. In the latter condition the tenderness is not over the appendix. In chronic appendicitis, in addition to tenderness of the ganglion, we note gaseous distention of the ascending colon. These two

symptoms pointed out by Morris are undoubtedly realities, and I have been able to confirm their genuineness many times. The explanation of them will be found in the study of appendicitis obliterans. Robert T. Morris ("Annals of Surgery," Nov., 1917) discusses the diagnosis of *appendicitis obliterans*, which he designates *appendicitis irritans*. He points out that it occurs most frequently in neurasthenics with relaxation of peritoneal supports and who show other stigmata of physical decline ("narrow costal angles, crowded teeth, gunstock scapulæ, or a defective helix of the ear"). An advanced degree of atrophy of the appendix does not occur in the very young, but more or less of the atrophy exists in one-third of all appendices in people over twenty years of age. The chief symptoms are those of chronic appendicitis. Morris (Ibid.) sums them up as follows:

1. Hyperesthesia of the second and third right lumbar sympathetic ganglia. The tenderness is 1½ inches to the right of the navel and "a trifle caudad" and is near the spinal column. There is no direct nerve route from the appendix to the ganglion and the hyperesthesia is probably due to an efferent impulse from the spinal cord to the ganglia. The impulse having originated in the appendix, passes first to the cord center and then to both the ganglia and the skin, the skin becoming hyperesthetic, and pressure over the ganglia causing pain.

2. Distention of the flaccid colon with gas. This is due to overstimulation of the innervation of the ascending colon by irritation from the appendix. As Morris puts it, "the muscularis of this part of the colon becomes more or less exhausted from persistent nagging." Morris says in his graphic style: "The percussion note of the right side of the abdomen in these cases is suggestive of the percussion note of a cider barrel in January. The percussion note of the left side of the abdomen in these cases is suggestive of the percussion note of a cider barrel in October."

3. Transitory pains in the appendix region which are not sufficiently severe to send the patient to bed.

The *Bastedo sign* in chronic appendicitis was suggested by Bastedo in 1911 ("Amer. Jour. Med. Sciences," 1911, cxliii) and is of service. A tube is passed as high as possible into the rectum and air is forced in by the bulb of an atomizer. Distention causes pain and tenderness over the appendix (see Rosenbloom in "Surgery, Gynecology, and Obstetrics," Oct., 1916). Contraction of the psoas parvus muscle may be mistaken for chronic appendicitis and may result from appendicitis. It causes pain in the inguinal region and leg and flexion of the thigh which may persist under ether (Cremer in "Lancet," 1914, xxxiv; Macdonald in "Surgery, Gynecology, and Obstetrics," 1914, xix; White, "Annals of Surgery," 1913, lviii).

In reaching a diagnosis in doubtful cases of appendicitis I believe that the blood-count is often of service. It is, of course, not to be maintained that the diagnosis of appendicitis may be made by counting the blood; but the blood-count may furnish evidence that, when added to the other signs and symptoms, may be of great importance. In nearly every case of acute appendicitis the hemoglobin is diminished by at least 30 per cent. In a catarrhal appendicitis or in an interstitial appendicitis the *leukocytosis* is trivial; but in cases of abscess or of gangrene of the appendix the leukocytes, as a rule, rise from 15,000 to 20,000. It is to be remembered, however, that when the patient is profoundly septic the systemic condition is so depressed that leukocytosis is impossible; hence leukocytosis may be absent in trivial catarrhal cases or in grave cases with overwhelming general sepsis. This latter condition, however, is extremely rare. The blood-count will not help one in making the differentiation between appendicitis and an inflammatory disorder of the pelvis or abdomen, but will aid one in making a diagnosis from typhoid fever, intra-abdominal or pelvic neuralgia, and movable kidney (see J. C. DaCosta, Jr., study of 118 cases, "Amer. Jour. Med. Sciences," Nov., 1901).

Appendical Dyspepsia.—Indigestion may, for a longer or shorter time, precede an attack of acute appendicitis. A like condition may follow an attack.

In chronic recurrent appendicitis dyspepsia may so dominate the clinical picture as to lead the physician to regard the case as one of gastric disease. Such a patient has prolonged attacks of epigastric pain aggravated by food. The pain radiates downward toward the appendix and is not so severe as the pain of duodenal ulcer. There may or may not be tenderness in the appendix region, but in most cases there is tenderness to the right of the navel and the ascending colon is distended with gas (page 996). The condition may be due to hypersecretion of the gastric juice resulting reflexly from appendix inflammation. Fenwick regards chronic hypersecretion as a direct cause of this form of dyspepsia. The epigastric pain may be due to pyloric spasm or gastritis

(Eusterman, "Jour. Missouri State Med. Assoc.," May, 1913). At times, however, during some of the attacks appendical tenderness is demonstrable and perhaps there is pain in the right iliac fossa. The epigastric or abdominal uneasiness may be constant. Food may immediately cause pain. Nausea and flatulence are common. "As a rule there is not the regularity of onset of pain after food—the periodicity of attack—which characterizes gastric ulcer" (Eusterman, Ibid.). Food does not relieve pain except in the less common cases in which there is hyperacidity.

Appendicitis in Children.—The disease is much more common than was once thought (see page 988). Russel S. Fowler ("Amer. Jour. Dis. of Child.," Aug., 1912) collected 183 cases occurring in children under twelve years of age and brought to the German Hospital of Brooklyn. During the same period (1900–1912) the total number of cases was 1115, the proportion of children being 16.41 per cent. The youngest patient in this series was two years and nine months old. Morf of the Cook County Hospital in Chicago reports 822 cases of appendicitis and 150 of them were under fifteen years of age ("Jour. Amer. Med. Assoc.," March 24, 1917). There is usually a history of antecedent attacks of gastro-intestinal disorder. The onset is apt to be sudden, but may be insidious, the symptoms as a general thing are violent, and the progress of the disease is rapid. Vomiting is usually more violent and prolonged than in adults. There is a great likelihood of pus formation and general peritonitis and gangrene are more common than in adults. Marked leukocytosis usually exists. Occasionally in young children pneumonia begins with so much pain and rigidity in the lower abdomen that the signs seem to point to appendicitis, and an attack of appendicitis may begin coincidently with or arise soon after a pulmonary inflammation. I have seen 4 cases in children in which pneumonia was ushered in by abdominal pain and rigidity. The surgeon should be awake to the possibility of typhoid fever, indigestion, fecal impaction, intussusception, and tuberculous peritonitis. In children the appendix occupies a lower position than in adults, the point of abdominal tenderness is usually lower than in adults, the inflammation usually reaches the right side of the pelvis, a painful point can generally be discovered by a finger in the rectum, hence a digital rectal examination must always be made. This usual involvement of the pelvis is responsible for the frequent and painful micturition which is very common (Karewski). Sometimes when the bladder symptoms are very prominent they dominate the clinical picture and the bladder is thought to be the real seat of disease. An attack of peritonitis in a child is more apt to result in general peritonitis than is the same disease in an adult (Selter). I agree with Springer ("Prag. med. Woch.," 1909, xxxiv, Nos. 7, 8) that operation in children should invariably be prompt and that purgatives should never be given; nor should they be given adult victims of the disease. In Fowler's series of cases ("Amer. Jour. Dis. of Child., "Aug., 1912) the operative mortality was 3 per cent. Clopton's mortality was 4 per cent. ("Pediatrics," 1915, xxvii).

Appendicitis in Pregnant Women.—Appendicitis is a very dangerous, but, fortunately, is a very rare complication of pregnancy. In 731 women operated on for appendicitis in the Mount Sinai Hospital of New York, from 1898 to 1907, only 7 were pregnant (Cooke in "New York Med. Jour.," May 1, 1909). Lobenstine states that in 30,000 cases under the care of the New York Lying-in Hospital there were but 5 cases of acute appendicitis (Cooke, Ibid.). Most of the patients who develop appendicitis during pregnancy have had previous attacks.

The condition may arise at any stage of pregnancy. It is usually violent, rapid in progress, and accompanied by vomiting. Early in pregnancy the pain and tenderness are significant and are located regionally, as when pregnancy is absent. Cooke points out that later in pregnancy the pains may be so spasmodic as to cause them to be attributed to beginning labor, and they are often located in the region of the liver or even on the left side of the belly (Ibid.). Two hundred and fifty cases have been reported and over 100 have been operated on (Renvall).

Appendicitis in the pregnant is far more dangerous than in the non-pregnant. In from 20 to 40 per cent. of cases abortion occurs, and usually the child dies from infection. In some cases of successful operation pregnancy continues to term. In only 10 per cent. of Morf's 22 operations did abortion occur ("Jour. Amer. Med. Assoc.," March 24, 1917). The diagnosis is often very difficult because of the enlarged uterus. Early in pregnancy the diagnosis is easy, later it is obscure. In early cases of appendicitis operate in every case. The more prompt the operation and the earlier the pregnancy, the less the mortality. Always operate. Drainage greatly increases the risk of abortion. Abortion is rare in early operations and especially rare when drainage is not indicated. In late cases consider the advisability of Cesarean section. (See Cocke

and Mason in "Jour. Amer. Med. Assoc.," July 10, 1920). In early cases of appendicitis the mortality is under 0.8 of 1 per cent. Operation at forty-eight hours gives a mortality of nearly 7 per cent. (Findley in "Jour. Amer. Med. Assoc.," Aug. 24, 1912).

Appendicitis Following Childbirth.—Hilton collected reports of 29 cases and added 1 of his own ("Surg., Gynec., and Obstet.," Oct., 1907). Hilton demonstrates that childbirth and the puerperium may be causal of appendicitis. The signs and symptoms are apt to be masked or are thought to be due to the puerperal state. The prognosis is grave. In cases developing within ten days of labor 45.5 per cent. died (Hilton, Ibid.).

Acute Appendicitis in Typhoid Fever.—An ordinary acute appendicitis may arise during or soon after typhoid fever. In some of these cases a chronic appendicitis has been driven into violence by the fever. I have operated on two ordinary cases of gangrenous appendicitis and one of acute suppurative appendicitis occurring during typhoid fever. During the fever a typhoid ulcer may form in the appendix and this ulcer may perforate or the appendicitis may be secondary to typhoid infection of the lymph-follicles. Undoubted cases due to the typhoid bacillus have been reported

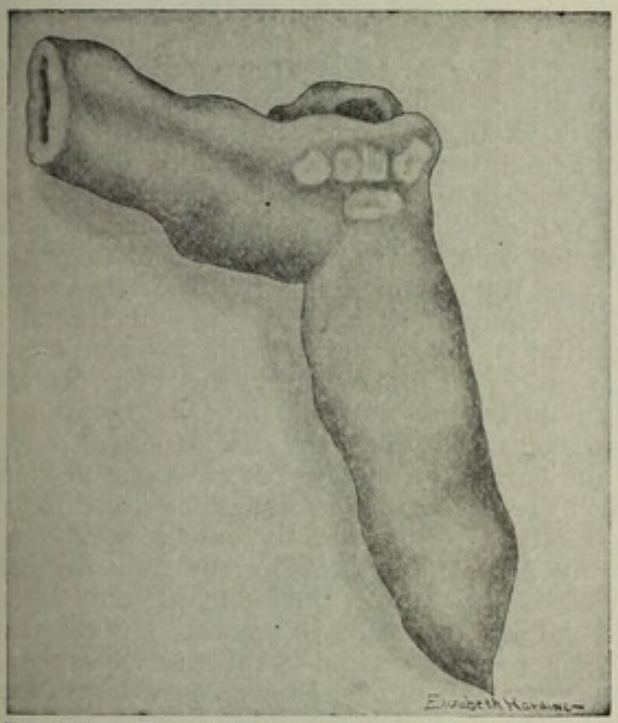


FIG. 769.—Tuberculous appendix with perforation and abscess.



FIG. 770.—Carcinoma of bowel and belly wall after appendix operation. Appendix removed by English Army Surgeon in Burmah. Portion of bowel removed at Heidelberg.

(Homer Gage in "Annals of Surgery," Aug., 1915). In such cases the typhoid bacilli are lodged in the lining of the appendix. Pus cocci or colon bacilli may cause appendicitis in a victim of typhoid. The appearance of leukocytosis during typhoid fever should lead us to investigate for some inflammatory complication, especially appendicitis and perforation. Pain and diarrhea usually exist. Rigidity may be absent.

Tuberculous Appendicitis (Fig. 769).—Acute symptoms may develop resembling those of acute appendicitis. There is usually a history pointing to intestinal stenosis, the stenosis existing at the ileocecal valve.[1] There is always great thickening, and an abscess of large size is apt to form. The cecum usually, but not always, is involved in the tuberculous process. Chronic cases, with palpable enlargement, are sometimes mistaken for cancer of the cecum.

Appendicitis in the Victims of Pulmonary Tuberculosis.—Many cases present the well-known symptoms of appendicitis but they may be very mild. Appendical dyspepsia (page 997) may exist. Dieulafoy described a form of appendicitis in the tuberculous which is characterized by pain and diarrhea. Most cases show no tuberculous lesions of the appendix. One-fourth of the cases show such lesions. Lesions

[1] Andrews, "Annals of Surgery," Dec., 1901.

are found when the pulmonary tuberculosis is advanced rather than when it is incipient (Kinghorn in "Jour. Amer. Med. Assoc.," 1916, lxvii). Kinghorn (Ibid.) operated upon 28 patients and 3 of them died.

Malignant Disease of the Appendix (Fig. 770).—This is a very rare condition (less than $\frac{1}{2}$ of 1 per cent. of appendices removed for supposed inflammation). It is impossible of recognition clinically, but is sometimes discovered postmortem or during operation for supposed acute or chronic appendicitis or pelvic disease. Inflammation does not cause the malignant disease, but the malignant disease is apt to block the appendix and so cause inflammation. The condition may be carcinoma, sarcoma, or endothelioma, and usually there are distinct inflammatory changes. It is more common in women than in men. Rolleston and Jones collected 42 cases. McWilliams reported 3 cases and collected 45 not in Rolleston's table. This makes 90 reported cases ("Amer. Jour. Med. Sciences," June, 1908). Since writing his article McWilliams has found 15 more cases reported. No case is counted in which the colon is diseased. The combined statistics show the average age of the patients to be only twenty-nine years. Two patients were only eight. In most cases the appendix alone is diseased; in some the colon or glands of the mesentery are also involved. In three-fourths of the cases the growth was distal to the middle of the appendix. Glands are involved late. Out of 90 cases in McWilliams' table only 8 had enlarged glands, and in 4 of these it was proved that the glands were not cancerous. In about 5 per cent. of cases concretions were found. The chance for permanent cure after removal of an appendix the seat of malignant disease is very good if the disease is limited to the appendix, and is particularly good if the growth is spheroidal-celled carcinoma (Rolleston and Jones). Metastasis is rarely noted. The growth is seldom larger than an almond.

Treatment.—If the diagnosis were always certain from the beginning, and if the case were seen by a surgeon in its early hours, immediate operation in every case would be eminently proper. If this plan could be followed, the mortality from appendicitis would be extremely small. At this early stage the peritoneum is free from infection, and the appendix can be rapidly and easily removed without risk of infecting the peritoneum. Whenever I see a case early, that is, during the first thirty-six hours of the attack, I practically always advise operation. Unfortunately, this plan cannot be habitually followed. As a rule, when the physician first sees the case the appendicular peritoneum is inflamed, and the surgeon usually sees the case at even a later period than the physician. At this time the barriers of leukocytes are being heaped up to limit the spread of infection, and delicate encompassing adhesions are usually being formed. Even in these later cases I often, in fact, usually, advise operation. Operation at this stage may be imperatively necessary because of the rapid spread and dangerous nature of the process; but when operation is not done, in some cases at least, a temporary limitation will be secured and the case will go on to an interval. Operation in the acute period is always dangerous; operation in an interval is safe. In some instances, when the case is not seen early, it is wiser to avoid operating at the time, and it is proper to wait for an interval. The period in which the surgeon usually sees the case for the first time was said by Maurice Richardson to be "too late for an early operation and too early for a late operation." Those who say "operate as soon as the diagnosis is made," operate, often, in this dangerous period, and in this period I do not believe that every case should be promptly cut. Most cases, it is true, must be operated on as soon as seen, irrespective of the duration of the disease. We must operate promptly if the pulse is small, tense, and well above 100; if there is persistent vomiting; if there is delirium; if intestinal obstruction exists; if a chill has occurred; if the pain and rigidity are very marked; if a mass can be felt in the right iliac fossa or by rectal examination; if there is marked abdominal distention; if there are evidences of pus formation; if the patient is growing worse; if there is or has been shock; or if the pain suddenly passes away without the use of opiates.

In an ordinary mild case, not seen early, in which none of the above-named conditions or symptoms exist, it is best to defer operation. Those who advocate operating upon every case consider such delay reprehensible and dangerous, point out that even in apparently mild cases gangrene or perforation may quickly occur, and cite striking cases to emphasize their belief. There is much force in this view, and it must not be hastily rejected. The choice, however, is not between a dangerous delay and a safe operation, but rather between a dangerous delay and a dangerous operation. It is a question of two dangers, and each side chooses the danger which seems to it the least. Richardson's elaborate study of 750 cases, showing a mortality of 18 per cent. in operations for acute appendicitis, determined us in the practice of the more conserva-

tive plan. General peritonitis is the most common complication and more than half the deaths are due to it. It may arise in abscess cases from spontaneous rupture, from rupture due to rough handling, from digging out an appendix from an abscess wall or from removing drainage too early.

The mortality of abscess cases is not half that of gangrenous cases. Coffey collected 13,445 reports of operations for acute appendicitis. The mortality was 7.4 per cent. ("New York Med. Jour.," Aug., 1906).

In an ordinary case of appendicitis in which operation was refused, it was once a common custom to purge by means of castor oil, Epsom or Rochelle salt. This practice was begun because of the belief that inflammation of the appendix is associated with fecal impaction in the head of the colon. This belief has been exploded, but the treatment is still used by some who regard it as beneficial. As a matter of fact, it is highly dangerous and should not be practised. A purgative may cause rupture of a badly diseased appendix. My own belief is that if operation is refused, or if the surgeon determines to wait for an interval, he should not give a purgative, but should follow the plan of treatment suggested by Ochsner to control peristalsis and favor limitation of infection. The patient is kept perfectly quiet, is placed in the Fowler position, no cathartics are given, no food or drink is administered by the mouth, and thirst is allayed by enemata of salt solution. Nutritive enemata may be given. It is also my custom to place a hot-water bag instead of an ice-bag over the appendix region.

To permit peristalsis favors diffusion of the infection; to prevent peristalsis is to favor the formation of encompassing and defensive adhesions. A purgative is very dangerous and may be fatal. It may cause rupture of the appendix. By causing peristalsis it diffuses the infection.

Many surgeons use the ice-bag, but I do not believe in it in these cases. We have already shown (see page 32) that cold as a remedy for inflammation is useful only in the brief stage of hyperemia, and when a surgeon sees a case of appendicitis there is certainly more or less stasis. Cold adds to stasis and does harm, and I am persuaded that the routine use of the ice-bag is responsible for some cases of gangrene. Again, cold actually antagonizes the migration and gathering of leukocytes and the formation of adhesions. For a number of years I have believed and taught that the ice-bag weakened resistance in appendicitis. These views seem to find confirmation in the article of Dr. A. M. Fauntleroy, U. S. N. ("The Ice-bag and Appendicitis," "Med. Record," Aug. 3, 1912). The study of a number of cases led him to the conclusion that the ice-bag is often responsible for "a noticeable lack of effort on the part of nature to wall off from the rest of the abdominal cavity the appendix." Further: "It was also noted in the ice-bag cases that there was a surprisingly low white count when one took into consideration the condition." These reports are most significant. They are in strict accord with my own results. It is my belief that the use of the ice-bag antagonizes the limitation of the infection and favors dissemination of toxins and bacteria. I believe that its employment is a grave mistake.

Heat is a remedy which favors limitation of the process. It relieves stasis, draws leukocytes to the part and stimulates their activity, favors the formation of an encompassing barrier of phagocytic cells, and aids the cellular proliferation which leads to the formation of adhesions. Hence I prefer the hot-water bag.

The ice-bag, when applied before the diagnosis has been made, that is, in the earliest hours of the attack, when it might be thought to be most serviceable, allays pain and lessens rigidity in some cases almost like a full dose of opium, and hence masks the symptoms as does that drug.

Opium should never be given until the diagnosis has been made. In the first place, it is not needed, for if the pain is so violent as absolutely to demand opium, operation should be performed. In the second place, opium masks the symptoms, makes the patient feel comfortable, and gives the physician an unfortunate and ill-founded sense of security. The pain about the umbilicus, if severe, can be distinctly and safely relieved by the administration of 30 min. of spirits of chloroform every half-hour until three doses have been taken. Opium should not be given if the surgeon, having decided not to operate at once, is awaiting an interval, because it may prevent or delay the recognition of some disastrous change. If a patient refuses operation, it can be given.

When we are inclined to wait for an interval, the case should be seen again within six hours. We are accustomed to follow McBurney's rule, which is as follows: If on seeing the patient again, six hours after the first visit, the patient is worse, operate at once. If he is no worse there is no pressing danger.

If in twelve hours after the beginning of the attack the symptoms are not intensified, they will soon begin to abate; if the symptoms have become worse during this time, operate. If in twenty-four hours after the beginning of the attack the severity of the symptoms lessens, it is usually possible to wait for an interval; but if during the second twenty-four hours there has been no abatement in the severity of the symptoms and there is doubt as to the condition, operate at once.[1] When the attack has subsided, and about three weeks or more have passed, the appendix can be removed with remarkable safety. After a patient has had two or more attacks of appendicitis all surgeons agree that the appendix should be removed.

If pus is present some surgeons delay operation in the hope that firm adhesions will form around the pus, and that the necessary operation will simply be the opening of an abscess. I do not believe it is safe to delay operation in a pus case. The pus may become limited, but it may instead pass up toward the liver or down into the pelvis. Delay is fraught with peril.

If only one attack has occurred, there may never be another, and the question arises, "Should the appendix be removed after one attack?" We do not know that a man has really recovered after purely medical treatment. Many cases reported as cured by medical means have subsequently required operation. As Lockwood[2] puts it, "To say that a man with appendicitis has been cured by medical means is in many cases equivalent to saying that a man with a stone in his bladder has recovered from calculus after the cure of a cystitis by rest in bed."

Even after a first attack, if the appendix remain tender or become tender after exercise, or if attacks of colicky pain occur, or if there be tenderness to the right of the navel and gaseous distention of the ascending colon, operate.

In some cases even a single attack of appendicitis is followed by persistent dyspepsia and ill health, and in such cases operation should be performed. In the majority of cases, even after one well-marked attack, operation is necessary. It is always necessary after two attacks. (See Operation for Appendicitis.)

Appendicitis cases which are far advanced in general peritonitis when seen by the surgeon some operators decline to touch. If we make a custom of operating on such cases we will lose very many, but will save some few, and these few would have died if we had not operated. To operate spoils statistics, but occasionally saves lives. The operation should consist of a simple incision to relieve tension and afford exit to infected fluids—rapid removal of the appendix if it is easily accessible, otherwise leaving it alone—and drainage of the pelvis. After such an operation the patient is placed in Fowler's position and a continuous stream of salt solution at low pressure is caused to trickle into the rectum. (See Murphy's Treatment for Peritonitis, page 1010.)

Appendicitis in a child is treated exactly as in an adult. Appendicitis in the pregnant woman is treated as in the non-pregnant. Early operation is particularly indicated, and it is not proper to induce premature labor in a patient far advanced in pregnancy unless there is general peritonitis. Then it is proper to empty the uterus—primarily, to obtain drainage and to give the patient a chance for life, and secondarily, to obtain a living child (page 998).

When operating upon a woman for appendicitis, bear in mind that ovarian, tubal, or uterine disease may have preceded, actually caused, or resulted from the appendicitis; examine the adnexa and remove them if necessary.

An operation for tuberculous appendicitis is rather apt to be followed by a fecal fistula. An ordinary laparotomy is sometimes followed by cure, but the rule of an operator should be, when possible, to remove the appendix and resect the diseased bowel. Andrews[3] mentions as expedients suited to special cases of tuberculous disease: total exclusion; partial exclusion; lateral anastomosis, and the formation of an artificial anus. If, in any operation for appendicitis, the psoas parvus muscle is found to be contracted, the peritoneum should be stripped up and the tendon should be bared and divided.

Intestinal Diverticula.—Congenital diverticula sometimes exist in the duodenum. Pressure diverticula may arise in the small intestine; they are, as a rule, small and multiple. The descending colon and the pelvic colon are the most common seats of diverticula. They occur at any portion of the circumference of the tube, are usually multiple, and vary much in size. Occasionally a diverticulum becomes enormous. A diverticulum contains fecal matter and, perhaps, fecal concretions. When free from

[1] For McBurney's views see "New York Polyclinic," Jan. 15, 1897.
[2] "Brit. Med. Jour.," Jan. 27, 1900.
[3] "Annals of Surgery," Dec., 1901.

acute inflammation and when unobstructed a diverticulum may cause fecal stasis or may cause no symptoms whatever. A diverticulum may inflame, suppurate, cause pericolonic suppuration, perforate, or become the focus of a great fibrous area (fibromatosis), which is usually mistaken for cancer. The *x*-rays are invaluable in diagnosis.

Acute diverticulitis occurs in "adults, mostly in males in midlife and given to obesity" (Joseph Ransohoff in "Annals of Surgery," Aug., 1913). There may be catarrhal inflammation. An abscess may form about the diverticulum. Perforation may occur, followed by abscess or general peritonitis, or the diverticulum may become gangrenous. When perforation occurs it is apt to take place into the mesocolon or through an epiploic appendix. Diverticulitis may cause the formation of scar tissue in the wall of the gut. The scar can be mistaken easily for a malignant growth. As most diverticula are in the lower colon the symptoms are usually left sided, otherwise they strongly resemble those of appendicitis. Occasionally the condition is found in the cecum or ascending colon. Suppuration about the sigmoid does not of necessity arise from acute diverticulitis. Acquired diverticula do not arise in children, and yet Ransohoff (Ibid.) reported cases of acute perforating sigmoiditis in children.

Chronic Diverticulitis.—This occurs particularly in the sigmoid, produces pain, hemorrhoids, constipation and great thickening, and is commonly mistaken for carcinoma.

Meckel's Diverticulum.—(See page 967.)

Treatment of Acute Diverticulitis and of Perforating Sigmoiditis.—As for appendicitis.

Fibromatosis of the Colon.—This condition produces symptoms strongly resembling those caused by carcinoma, and many cases have been operated upon under this conviction, the truth having been discovered by microscopic examination of the specimen. It is an inflammatory condition most often met with in the pelvic colon. A large, hard mass forms and constriction occurs. The mucous membrane is thrown into deep folds and ulceration occurs between these folds.

The fibromatosis is a reaction to infection. The infecting agent gains entrance through a desquamating area, a wound of the mucous membrane, an ulcer, or an inflamed diverticulum. Even when cancer exists there may be extensive fibromatosis about it, the area of real malignancy being much less than the induration suggests.

Fibromatosis may arise at any age, but is most common during and beyond middle age. There is continuous abdominal uneasiness now and then rising to pain. The general health deteriorates. The victim suffers from habitual constipation, but occasional attacks of diarrhea occur. Blood and mucus are at times found in the stools. If the constricting mass is within reach of the finger, it will be found that the induration is beneath thick and soft mucous membrane. If it can be seen by the sigmoidoscope, the folds of mucous membrane will be obvious. Abdominal palpation often detects the mass, which is sausage shaped. (See Miles in "A System of Surgery," edited by C. C. Choyce.)

Treatment.—Resection and anastomosis if possible. If real obstruction exists, or if the mass seems irremovable, do colostomy. After colostomy the mass usually shrinks greatly and may actually disappear.

Congenital Idiopathic Dilatation of the Colon (Hirschsprung's Disease; True Megacolon) (Fig. 771).—This condition was described by Hirschsprung in 1886. In 1921 Ladd found 118 cases on record. It is of prenatal origin. The large intestine is chiefly involved. The condition occurs particularly in the sigmoid and descending colon "and in more than one-third of all the cases the sigmoid flexure is alone involved" (Finney in "Surg., Gynec., and Obstet.," June, 1908). It is seldom seen in adults. The hypertrophy is the initial condition, then come kinking, valve formation and perhaps twisting. Great dilatation occurs. There is no definite mechanical obstruction demonstrable at autopsy or operation. It is in this that Hirschsprung's disease (true megacolon) differs from pseudomegacolon (Finney, Ibid.). The diameter may reach 6 or 8 inches, and the colon may seem elongated and be in loops. Dilatation and hypertrophy produce marked changes in the wall of the gut. The condition may be obvious in early life or it may not become so until adult years, being aggravated and developed, but not caused by habitual atony of the bowel. The supposed cause is an anatomic anomaly (perhaps elongation) leading to looping of the colon, a muscular aplasia leading to dilatation and valve formation. Various causes have been suggested.

The victim of this condition is obstinately constipated and has a distended abdomen, usually from early infancy, although, as previously stated, the condition may not manifest itself until childhood, youth, or even adult life. It is most difficult to get the

bowels to move at all. Gay reported a case in which there was no bowel movement for three months. Periods of several weeks without a movement are by no means uncommon. Now and then an attack of diarrhea may cause the emptying out of great quantities of feces. The abdomen is enormously distended and the patient is emaciated.

The abdominal veins are distended and the rectus muscles may be separated. In Finney's cases (as in some other reported cases) the cords of distended gut could be seen or felt to be more prominent on one side than on the other. There is no decided abdominal tenderness and pain is absent unless there is diarrhea or sudden great distention. Borborygmus is often very loud. Vomiting is rare. The urine shows a marked increase of indican. The patient is liable to attacks of painful and aggravated distention.



FIG. 771.—Professor Nassau's case of Hirschsprung's disease (St. Joseph's Hospital).

The disease does not directly cause death, except occasionally by complete obstruction, but the ill-nourished condition lessens the chance for recovery from any attack of illness.

In 358 cases collected by Schneiderhöhn (Internat. Abstract, Oct., 1915, from "Zeits. f. Kinderh.," 1915, xii) the mortality was 43 per cent. Surgical treatment shows a less mortality than medical treatment. Schneiderhöhn (Ibid.) collected 143 cases treated surgically, with a mortality of 36 per cent. and with 46 per cent. of cures. (See Shâine in "Med. Jour. and Record," Feb. 20, 1924.)

Treatment.—Very early cases ought to be treated medically. Medical treatment consists in the ordinary plans for combating constipation. Surgery is more dangerous in young children than in older subjects. Some surgeons have removed almost the entire large intestine; others have performed ileosigmoidostomy; others, colopexy; others have established a permanent artificial anus; others have made an artificial anus preliminary to ileosigmoidostomy. Finney believes that the operation of choice is resection of the affected gut followed by ileosigmoidostomy.

Splanchnoptosis (Visceroptosis).—Coffey ("Surg., Gynec., and Obstet.," Oct., 1912) points out that in man special provisions have been made to keep the viscera from riding down because of the upright posture. He names four forms of support: (1) Peritoneal fusions before birth to the parietal peritoneum; (2) a shelf above each psoas muscle; (3) tone of the abdominal wall; (4) packing of subperitoneal fat which regulates intra-abdominal pressure. Visceroptosis is generally said to be due to relaxation of the abdominal walls and decrease of intra-abdominal tension, which lead to gradual stretching of suspensory ligaments and finally to movement of the viscera downward. The prolapse may involve all the abdominal viscera, one viscus, or several viscera. The heart, too, may droop. Fossier collected a number of cases of movable heart ("New Orleans Med. and Surg. Jour.," Nov., 1910). According to Coffey (Ibid.), when the intestine descends, kinks occur at the junctions of fixed and movable parts, and general ptosis is an attempt on the part of nature to prevent intestinal kinks. Prolapse of the stomach is known as gastroptosis (see page 961); prolapse of the liver, as hepatoptosis (see page 1023); prolapse of the spleen, as splenoptosis (see page 1046); prolapse of the kidney, as nephroptosis (see page 1273); and prolapse of the intestines, as enteroptosis or *Glénard's disease* (See below).

The causative relaxation of the abdominal walls is most common in women, but is by no means confined to that sex. It may be produced by ascites, pregnancy, muscular effort, febrile maladies, or wasting disease. In some cases no cause can be assigned. Such a relaxed abdomen may or may not be thin. The fascial strands and muscular fibers are stretched, and usually attenuated and separated, the belly bulges downward and forward, and a viscus or the viscera follow because of lack of support.

Enteroptosis, or Glénard's Disease.—This disease is a prolapse of the intestine. It may be but a part of ptosis or prolapse of all the abdominal viscera; it may exist alone; it may be associated with movable kidney, prolapse of the stomach, of the liver, or of the spleen. The recti are apt to be separated. Symptoms usually begin at

puberty, but may arise in childhood. It is much more common in females than in males.

In Glénard's disease the intestines occupy the lower portion of the abdomen, and the belly below the costal margins is flat, is dull on percussion, and the pulsations of the aorta are very evident. The right portion of the transverse colon begins to descend first, and other portions of the intestine follow. The splenic and hepatic flexures are elongated, and sometimes there is venous engorgement of dependent parts of the mesentery (Lambotte in "Presse Med. Belge," Nov. 24, 1901). The victims of this disease are irritable, dyspeptic, anemic, constipated, hysteric, and neurasthenic. Mucous colitis is common. They suffer from severe migraine, loss of flesh, weakness, pain in the back, the coccyx and in various parts of the body, attacks of pseudo-angina, vasomotor disturbances, variable temperature which tends to become subnormal and, whereas there is seldom tenderness, pressure may induce cramps (Lerch in "New York Med. Jour.," Dec. 19, 1914). Most of the victims of enteroptosis are emaciated, but there is a type of case in which the stature is short, the patient is fat with a pendulous belly and has an enlarged thymus (Lerch, Ibid.). Normally the tenth rib is firmly attached by fibrous tissue to the ninth costal cartilage. In enteroptosis the tip of the tenth rib is freely movable and obviously separated from the ninth costal cartilage (*Stiller's sign*). The *x*-rays used after a bismuth or barium meal are of the greatest help in diagnosis. The ptosis may arise without apparent cause, but may follow the wearing of ill-fitting corsets, falls, blows, lifting heavy weights, or prolonged vomiting. Lerch thinks an abnormal form of the spine is responsible ("New York Med. Jour.," Dec. 19, 1914). In one type there is no lumbar curve, in another type there is an extreme lumbar curve. The dyspepsia is due to dragging on the duodenum, the tube becoming flattened out (A. K. Stone). The flattening of the duodenum may be followed by kinking of the pylorus, and in such a case the stomach dilates, otherwise it does not dilate. Where a movable portion of the gut has a junction with a fixed portion a kink may form and chronic intestinal stasis may ensue.

Treatment of Visceroptosis.—In many cases medical treatment is of benefit. The following is the usual plan: Employ lavage, abdominal massage, and electricity. Fresh air and tonics are of benefit. Laxatives and sedatives are required. Mineral oil is the most useful laxative. Insist on regular exercise, and treat the anemia and dyspepsia. Abdominal support is of great importance. It sustains the viscera in place and saves them from congestion. Support is obtained as in movable kidney by a well-fitting, straight-front corset. This corset takes a bearing as low as the great trochanters. It laces in front and is applied while the patient is recumbent, pillows beneath the buttocks making the pelvis higher than the head. It is to be laced tighter below than above. Pads are harmful. We strive to support the organs by intra-abdominal pressure. Lerch (Ibid.) says the patient should go to bed for an hour or two after the midday meal and should sleep on the face without a pillow. Surgery is resorted to if intestinal stasis exists and cannot be relieved by medical and dietary treatment. The surgical methods applicable to special organs are discussed under those headings. When the intestines are ptosed and there is stasis there are two commonly employed surgical plans, and each has its advocates: (1) The suture of the prolapsed intestine to some adjacent structure or shortening its supporting ligaments. (2) Plastic operation to lessen the area of the abdominal wall and thus increase intra-abdominal tension. Depage makes the abdominal wall less in both directions (*laparectomy*). Webster, in cases of separation of the recti, resects and sutures the fascia of the muscles. I believe that Depage's method of shortening the diameters of the abdominal wall cannot permanently succeed, because the viscera, hanging to relaxed ligaments, will eventually stretch the wall; it will be stretched easily because of damage done to its nerve supply by operation, and hernia will be apt to occur; and if it should, the patient will be worse off than before operation. Of course, whatever operation is done, diastasis of the recti muscles must be corrected by approximation and suture. For ptosis of the small intestine the mesentery may be shortened, as suggested and performed by Davis, of Omaha, in 1897.

In prolapse of the transverse colon good results are said to have been obtained by attaching the splenic and hepatic flexures to the abdominal wall (*Lambotte's operation*). The surgical treatment of ptosis of the stomach is considered on page 962; of the liver, on page 1023; of the spleen, on page 1046; of the kidney, on page 1276.

The Peritoneum

Acute Peritonitis.—Peritonitis, or inflammation of the peritoneum, is a common and usually a very dangerous disease.

Aseptic irritation by a traumatism or a chemical irritant produces *aseptic peritonitis*, a condition which is strictly limited; which may produce local pain and tenderness; which may cause aseptic fever from the absorption of aseptic pyrogenous elements and the products of tissue change; which leads to the formation of temporary or permanent adhesions, and which is, in reality, a process of repair.

"Peritonitis," as the term is used by the surgeon, is always due to bacteria. Bacteria may reach the peritoneal cavity by means of an abdominal wound or the entrance of foreign bodies; by extravasations from the stomach, bowel, vermiform appendix, gall-bladder, urinary bladder, kidney, Fallopian tube or uterus, or by the passage of micro-organisms through the damaged walls of any of these viscera or structures; by way of an open Fallopian tube; from the breaking of an abscess into the peritoneal cavity; from rupture of an infected mesenteric gland; from perforation of a diverticulitis of the bowel; from areas of necrosis due to volvulus, strangulation, or intussusception of the intestine; twisting of the pedicle of an ovarian tumor, a floating kidney, or a floating spleen; blocking of a mesenteric vessel by a thrombus or an embolism; gangrene of the pancreas or spleen, and fat necrosis.[1] In some cases the peritoneum may contain a point of least resistance, and bacteria contained in the blood reach this point and produce infection. Infection may be brought to the peritoneum by the lymphatics during childbirth. It was once taught that cold could produce peritonitis, but it seems probable that it can only act by producing an area of least resistance. The capacity of the rheumatic poison to produce peritonitis is doubtful.

The peritoneum, as Byron Robinson pointed out and Fowler confirmed, is, in reality, a great lymph-sac, and peritonitis is lymphangitis. "When the peritoneum is infected the lymphatics furnish an exudate which clots in the lymph-channels, blocks them, and limits or prevents absorption. This blocking of the lymph-channels serves to preserve the life of the subject, on the one hand, while a failure in this respect, either because of the enormous and overwhelmingly rapid increase of septic material and the large size and number of channels necessary to destroy and obstruct, on the other hand, permits the destruction of the organism."[2] Absorption takes place most actively from the region of the diaphragm, hence peritonitis in this region is peculiarly fatal. Absorption takes place very rapidly from the intestinal region, although not quite so quickly as from the diaphragmatic area. Absorption takes place slowly from the pelvic region, hence peritonitis of this region is much less dangerous than is the disease in the intestinal region, and vastly less dangerous than is the disease in the diaphragmatic region (Fowler).

When severe bacterial infection of the peritoneum occurs, exudation of blood-liquor takes place, leukocytes migrate from the blood-vessels beneath the endothelial layer, and particularly into the peritoneal cavity, and the causative bacteria rapidly spread about the cavity. The fibrinous exudate, in many infections, coagulates in masses on the free surface of the peritoneum, and thus serves a useful purpose by blocking the lymph-channels and hindering the absorption of toxins and bacteria. The fibrinous exudate may break down into a wide-spread suppuration or may be organized into adhesions. In very virulent streptococcic infections a patient may die and there may be scarcely any coagulated exudation or may be none at all. Exudation and migration take place also into the subserous tissues and into the muscular coat of the bowel, and the segment of bowel which is attacked becomes paralyzed and distended with gas, the gas within causes it to rise up, and, as peristalsis is absent, obstruction occurs (James P. Warbasse in "Amer. Jour. Med. Sciences," July, 1905). Absorption of poison in peritonitis takes place in part from the peritoneal cavity and in part from the subserous tissues. Warbasse believes that the inflamed peritoneum is scarcely an absorbing surface, but in cases in which coagulated exudate has not formed or has been destroyed, it seems probable that it is an active absorbing surface, and absorption may occur from some regions, but not from others.

Various bacteria may be responsible for peritonitis, especially staphylococci, streptococci, pneumococci, and colon bacilli. The infections which spread most rapidly and widely are due to streptococci. In streptococcus infection the protective exudate does not coagulate, barriers of leukocytes are not heaped up, encompassing

[1] See Park's "Surgery by American Authors."

[2] George R. Fowler, "Diffuse Septic Peritonitis," in "Medical Record," April 14, 1900.

adhesions do not form, there is rapid absorption of toxins, and overwhelming systemic poisoning. Colon bacilli cause a very grave form of peritonitis, but less rapid and diffuse than that caused by streptococci—in fact, the process is often encompassed for a time by coagulated lymph, leukocytes, and adhesions. The omentum particularly is thickened, and is apt to be drawn to and to adhere about the area of infection. Staphylococci and pneumococci produce peritonitis which is more apt to be limited than that produced by colon bacilli. In most cases of peritonitis a mixed infection exists; for instance, colon bacilli and staphylococci or colon bacilli and streptococci. Gas-forming bacilli cause a form of peritonitis in which gas gathers in the abdominal cavity (*pneumoperitonitis*). It may arise after a stab wound or a gunshot wound. In some apparently severe cases of acute peritonitis cultures have remained sterile.

Forms of Peritonitis.—An accurate bacteriologic classification is not as yet possible.

Peritonitis can be named, according to regions, *pelvic*, *subdiaphragmatic*, etc.; it can be divided pathologically into *diffuse septic*, *putrid*, *hemorrhagic*, *suppurative*, *serous*, and *fibrinoplastic* (Senn); it can be classified, etiologically, into *traumatic*, *puerperal*, *perforative*, *metastatic*, *scarlatinal*, etc.; and it can be divided, clinically, into *circumscribed suppurative*, *diffuse suppurative*, and *diffuse septic*.

Circumscribed Suppurative Peritonitis.—In this condition, which is frequently met with in appendicitis, the area of infection is circumscribed by omentum, by glued intestine, by coagulated exudate, leukocytes, and adhesions, and an abscess forms. After a time distinct localization becomes evident.

The *symptoms* of circumscribed peritonitis are pain, at first general and then local, tenderness in a particular region, muscular rigidity, distention, vomiting, rapid and often wiry pulse, constipation, fever, great weakness, and dorsal decubitus with the thighs flexed. After a time a distinct mass can usually be detected by palpation, and there may be dulness on percussion, local rigidity, irregular temperature, sweats, and possibly edema of the belly wall. An abscess, though limited for a time, is always liable to break through its walls and produce general peritonitis. Such an accident may be produced by muscular effort on the part of the patient, by injudicious palpation on the part of the surgeon, or by rough handling of the patient while transporting him from place to place; its occurrence is announced by shock, and the symptoms of general peritonitis quickly arise.

Diffuse or **general septic peritonitis** may destroy life even before the peritoneum presents any marked change. Death ensues from the absorption of virulent toxins. Septic peritonitis may arise during the puerperium, through lymphatic infection; it may be due to infection from without by an operation or an accident; to perforation of an ulcer of the stomach or gut; to appendicitis; to gangrene of a portion of the intestine; to rupture of an abscess into the peritoneal cavity; to rupture of a mesenteric gland; to perforation of a diverticulitis of the bowel; or to migration of micro-organisms through a damaged wall of the bowel. Peritonitis due to perforation is called *perforative peritonitis*. Perforation is made manifest by pain, a chill, it may be by shock, or perhaps collapse. Gas may pass into the peritoneal cavity, and if it does so, the area of liver dulness may be lessened or abolished. Symptoms and signs of hemorrhage may arise. Diffuse septic peritonitis is announced by a very rapid pulse, which is at first wiry and later gaseous; a temperature which may at times be highly febrile, but which may be normal or subnormal or which soon becomes so; general abdominal pain and tenderness, dry tongue, delirium, persistent vomiting, constipation, and collapse. Rigidity exists, and also intestinal obstruction due to paralysis of the gut. Usually, but not invariably, there is distention. In puerperal peritonitis or septic peritonitis from operation there is often no severe pain. In perforative peritonitis there is acute pain. Victims of general septic peritonitis if unoperated upon usually die within five or six days at most.

Diffuse or **general suppurative peritonitis** differs clinically from diffuse septic peritonitis in the fact that it is less apt to be fatal and wide-spread. In fact, adhesions may form about an area representing a considerable portion of the peritoneal cavity. The causes of both are identical. In septic peritonitis death occurs from absorption of toxins and perhaps before obvious pathologic changes occur in the peritoneum; in suppurative peritonitis the microbes are fewer, are less virulent, or vital resistance is more decided, and suppuration follows marked changes in the peritoneum. In suppurative peritonitis the pyogenic bacteria are always present, and there exists in the peritoneum a wound or damaged area to constitute a point of least resistance.

Symptoms.—Chilliness or a rigor is common, followed by fever, the temperature rising to 102° or 104° F.; pain is intense, and is accentuated by motion and pressure; the attitude of the patient is assumed to relieve pain (he lies upon his back, with the shoulders raised and the thighs drawn up); there are vomiting, obstinate constipation, and rigidity of the abdominal walls, followed by distention when the intestine becomes paretic from septic poisoning. The pulse is rapid; is at first wiry, but may become gaseous. The constipation may be due either to tympanitic distention or to the shock and toxemia inhibiting intestinal peristalsis. Obstruction arises. Vomiting is frequent. In perforation gas often passes into the peritoneal cavity, and it may obscure the liver dulness; in tympanites without perforation the liver is apt to be pushed up and its dulness remains, but on a higher level. Pus unconfined by adhesions will gravitate to the most dependent part of the peritoneal cavity. In some rare cases of suppurative peritonitis there is no tympanitic distention or rigidity; in some cases there is no elevation of temperature, in fact, the temperature may be actually subnormal.

Treatment of Peritonitis.—After an abdominal operation the patient may have pain, slight rigidity, constipation, nausea, flatulence, etc., and the surgeon is in doubt if peritonitis is beginning or about to begin. The old-time remedy was opium, but Tait denounced it as inefficient, and showed that it masked the symptoms and often created a false sense of security in the very midst of imminent dangers. Atropin, eserin, and pituitrin may be useful (see page 978). Saline purgatives may abolish



FIG. 772.—Murphy treatment for suppurative peritonitis.

pain and distention and will perhaps prevent peritonitis after an abdominal operation, but if, however, genuine peritonitis is thought to exist, no purgative should be given. In doubtful cases give an enema. It is a deadly dangerous thing to give a purgative, as it diffuses infection. Operation is required. Prompt operation is the only hope in genuine postoperative peritonitis and any delay means certain death. When diffuse septic or suppurative peritonitis exists from any cause and the surgeon sees the case early (within thirty-six hours) the abdomen should be opened. In a perforative case operate even if the case is first seen later than thirty-six hours. If a non-perforative case is seen later it may be wise to use Ochsner's treatment and wait for localization (Stanton in "New York Med. Jour.," Aug. 27, 1910). We all agree that if a perforation exists, it should be closed. A perforated or inflamed appendix should be removed. Until recently it was surgical custom to break up adhesions, eviscerate, wash the belly with gallons of very warm salt solution, wipe out the space between the liver and diaphragm, wipe out the pelvis, wipe off the intestines, and remove masses of adherent coagulated exudate. We thus produced dreadful shock, tried to cleanse the peritoneal cavity when it is impossible thoroughly to cleanse it, carefully removed the exudate which was doing good by plugging the lymph-spaces, and yet we did not reach the infection inside of the lymphatics, which is, after all, the greatest source of danger. Then we drained through two or more incisions and put the patient recumbent in bed, and thus permitted infected material to flow up to the diaphragm, where it was quickly absorbed. The mortality from this procedure was dreadful. John B. Murphy has taught us wisdom and has combined some of the conservative views of Ochsner with

the use of the semi-erect position of Fowler, and with the continuous rectal irrigations that several advocated.

There is great discussion among surgeons as to the proper plan of treatment. In the first place, there is no agreement as to exactly what general peritonitis is. Some consider it to be a condition in which there is absolutely no tendency to limitation of spread, there being dissemination throughout the whole abdomen. Others maintain that the abdomen may be full or nearly full of pus and yet only a very limited area of the peritoneum may show an involvement or a tendency to necrosis. It is a well-known fact that inflammatory fluid seldom occupies the entire cavity and, fortunately, even when it appears to do so there is usually here and there a tendency to limiting adhesions.

The very foundation of successful treatment is early diagnosis, and operation after forty-eight hours will probably prove futile. Some surgeons operate on all cases; others refrain from operation if the patient's temperature is high, his pulse very rapid, his abdomen greatly distended, if the face shows the peculiarities of the Hippocratic countenance and if delirium exists.

Some use a large incision, some, a small one. The objection to a large incision is that the intestines tend to protrude and must inevitably be handled, and thus shock is greatly increased. Some irrigate with wiping, some irrigate without wiping, and some do not irrigate at all. Some drain, some do not drain. Some use the semi-erect or erect position of Fowler after operation, others regard it as useless, and so on.

I think in the vast majority of cases peritonitis is secondary and not primary. It is seldom before operation that we can be sure of the bacterial cause of appendicitis (except in gonococcic and pneumococcic peritonitis). A large number of surgeons, after the operation, employ the postural position of Fowler. Others oppose it. We never think of giving opium before inaugurating operative treatment. We never dare to give a cathartic before operative treatment. Probably catharsis has been responsible for more peritonitis deaths than has anything else. A cathartic causes peristalsis and hence disseminates infection, especially in the small intestinal region. A cathartic may precipitate a perforation and may lead to the development of acute intestinal obstruction.

Personally I operate on nearly every case of diffuse peritonitis if I see it within forty-eight hours of the beginning of the symptoms. Before operation the stomach should be washed out. If the patient is in a desperate condition it may be necessary to open the abdomen under local anesthesia. If the condition justifies it I believe that ether or ether with oxygen is the best anesthetic. I think we can generally assume that if a patient can stand ether the operation will not prove fatal. A small incision should be made down to the suspected focus of infection (stomach, duodenum, pancreas, gall-bladder, appendix, etc.). If necessary, this incision can be enlarged to any extent. In some desperate cases, for instance, after perforation of the stomach or duodenum, we must follow the plan of Morris, of New York, and simply insert a drainage-tube, but, whenever possible, we close the perforation and remove an infected structure like the appendix or the gall-bladder. If the perforation is due to malignant disease, a coffer-dam of gauze must be built around it.

Shall we irrigate? Blake and other eminent surgeons have warmly advocated irrigation. I believe it should be used after a recent perforation of the stomach or intestines in order to remove foreign bodies. I don't believe it should be used if we are dealing merely with pus. Blake uses a return-flow irrigator through which siphonage takes place.

Murphy and others taught that irrigation might destroy adhesions and remove exudate. It seems to me that if there is the possibility of foreign bodies being present within the peritoneal cavity irrigation must be used.

Shall we drain? Some surgeons only drain when the pus is circumscribed into an abscess and when an area of peritoneum is necrotic or certain to become so. If the peritoneal wall glistens, if the fluid is not bloody or like dish-water, if there are no masses of lymph, if the initial focus was removed, if the toxemia is not profound, if purulent matter is homogeneous they do not drain. They rest the whole case in the power of the peritoneum to save the person from being overcome by infection. When we reflect, however, that the moment the peritoneum is opened by incision there is a squirt of purulent matter, it would seem that drainage must be attempted to relieve the intra-abdominal tension. High tension must favor absorption. It is claimed by some that tubal drainage is only efficient for a few hours, the tube being blocked by the omentum or intestinal wall and by the formation of adhesions. The less the tendency to the formation of adhesions, the longer the blocking will be

deferred, and it is precisely during the first few hours of drainage that a tube may do good by lessening tension, freeing the cavity of much poisonous material, and favoring the formation of adhesions at the outskirts of the purulent process.

The wound should be closed up to the drainage-tube with a very few through-and-through stitches of silkworm-gut. Those of us who believe in the Fowler position after operation make also a suprapubic incision to carry the drainage-tube into the depths of the pelvis. During the progress of the operation the patient must be kept warm by means of blankets and hot-water bottles and should be given, if necessary, salt solution by hypodermoclysis or by intravenous infusion. On his return to bed from the operating-table he is kept warm and proctoclysis is inaugurated. Some give it intermittently, 6 ounces every three hours; others give it continuously by the Murphy drip. I prefer the Murphy drip. We place the patient in the Fowler position, accomplishing it gradually so as not to make an undue strain upon the heart. At the present time we do not use the angle of 45 degrees as formerly employed, but place the patient a little more nearly erect. Coffey has shown us that in order to empty the right kidney pouch the patient must be placed at an angle to the horizon of 51 degrees. We call this the exaggerated Fowler position. It is, of course, founded on the belief that there is a natural current in the peritoneum toward the pelvis and that the tube placed in the pelvis will, once the patient is elevated, remove quantities of fluid. The value of this position has been disputed. It gives the heart more to do and the patient is apt to slip down over and over again, but it certainly gives decided relief to tympanites. Whether or not there is a stream of fluid flowing toward the pelvis, I believe the treatment is of value, although if I found that the blood-pressure was constantly falling I would abandon it, first trying to see if the man could get along with less elevation, but, if driven by necessity, placing him upon his side or upon his back. When we give the Murphy plan of treatment we utilize various things that are set forth above. It is the plan I follow. It is based upon the following principles:

First, that the initial lesion of the peritonitis should be removed as quickly as possible and with the slightest possible amount of handling. For instance, we should remove a gangrenous appendix; we should close a perforation in the bowel, etc. Flushing of the peritoneal cavity with gallons of salt solution is inadvisable. It cannot thoroughly cleanse the peritoneum; it may diffuse the infection to regions that it had not previously reached, and it may tear up adhesions. Inflammatory exudate should not be removed from the intraperitoneal structures. It is nature's method of sealing the lymph-spaces, and if we remove it we open thousands of channels, previously sealed, for the dissemination of the infection. A drainage-tube should be introduced through the operation wound, and a suprapubic incision should also be made and a drainage-tube be carried through this to the depths of the pelvis. When the operation is completed the patient should be placed in the semi-erect position, which is commonly called *Fowler's position* (Fig. 772). This is done in order that the intraperitoneal fluids may gravitate away from the diaphragm, where absorption is extremely rapid, and into the pelvis, where absorption is much slower.

When the patient has been placed in the bed quantities of warm salt solution are passed slowly into the rectum. The mucous membrane of the large intestine absorbs fluid with great rapidity when that portion of the gut is in its normal condition of moderate distention. Overdistention leads to spasm, which expels the fluid. Hence the fluid must be given at low pressure and administration should be continuous. The simplest sort of apparatus is shown in Fig. 773. It consists of a fountain syringe, a large rubber tube, and a rectal tip of hard rubber. The nozzle that is used is angled, has one opening on the end and several openings on the side, and this nozzle is passed so that the angle fits the sphincter (see Fig. 775). The tube is strapped to the thighs by adhesive plaster. The hose that comes from the nozzle is attached to a reservoir, the base of which is hung from 4 to 6 inches above the level of the patient's buttocks; and the fluid, therefore, enters the rectum only about as fast as the rectum will absorb it. The reservoir is kept warm by bags of hot water hung about it or by a special apparatus (Figs. 772, 774). The fluid is allowed to enter continuously, unless it should run out from the side of the tube; if this happens, the flow may be cut off for a short time and then allowed to begin again. Gas from the bowel passes into the openings of the tube, and every now and then bubbles up through the reservoir. By this continuous, low-pressure instillation (*proctoclysis*) an enormous quantity of fluid is absorbed by the rectum. In some cases a number of quarts are taken up in twenty-four hours. The absorption of this fluid greatly increases the amount of urine eliminated, removes toxins, and stimulates the heart. The reservoir must not be high. Increase

of pressure will cause expulsion of fluid and defeat the possibility of continuous administration. The plan so often followed of keeping the reservoir high and limiting the flow by a clip on the tube is a mistake. Murphy says: "It should never have a headway of more than 15 inches hydrostatic pressure, and it gives the best and most uniform results at 4 to 7 inches" ("Jour. Amer. Med. Assoc.," April 17, 1909). A

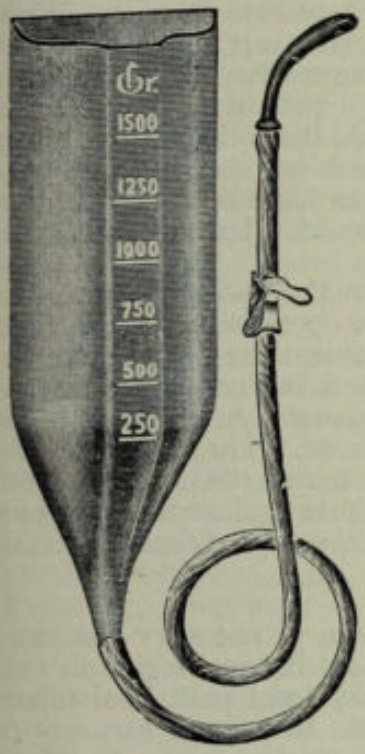


FIG. 773.—Proctoclysis apparatus consisting of fountain syringe, large rubber tube, and hard-rubber or glass tip (Murphy).

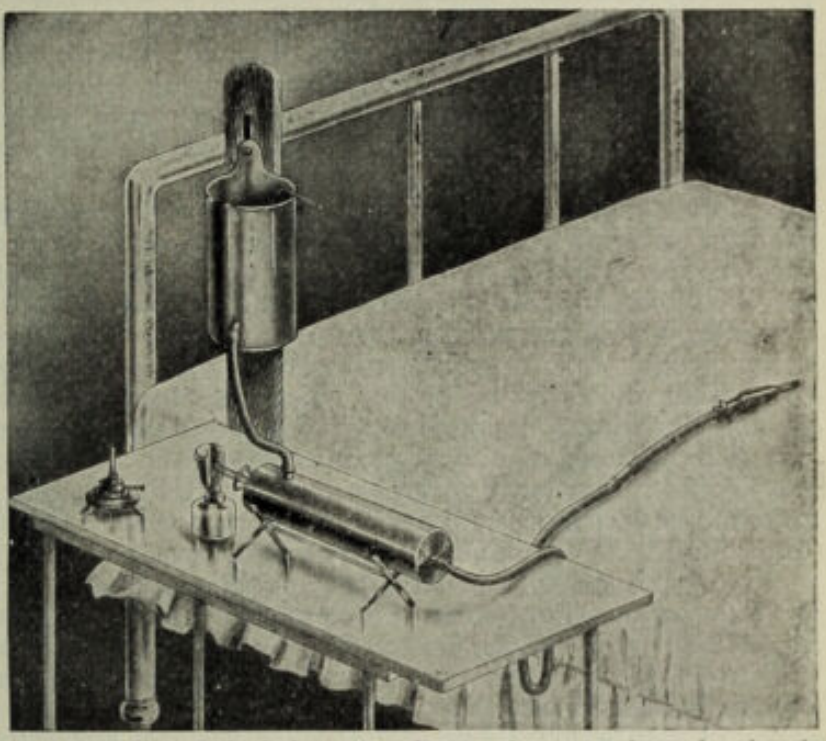


FIG. 774.—Alcohol or gas heater in operation, showing it properly connected. A short glass tube connects catheter to rubber tubing (Murphy).

straight tube is sometimes responsible for expulsion of the fluid, because it touches the posterior rectal wall of a patient in Fowler's position. Figure 774 shows a more elaborate apparatus than that just described.

After the salt solution has been entering the rectum for some time a profuse discharge of sour-smelling material comes from the drainage-tube. This discharge may be profuse for one day, two days, or longer, when its sour smell disappears from it and it greatly lessens in quantity. The outflow of this fluid from the wound means that saline fluid from the rectum has entered the lymph-spaces and run into the peritoneal cavity. Murphy thinks the lymph-current has been reversed. Whether this be true or not the peritoneum certainly seems to become a secreting instead of an absorbing surface, and the lymphatics are washed out. During the time that this treatment is pursued the patient has no food or water given him by the mouth. Stomach feeding is rigidly forbidden in order to prevent peristaltic movements. Small amounts of morphin may be given to prevent peristalsis. If the patient is in a weak condition, stimulants or food can be given by the rectum, the solution in the reservoir being allowed to reach a low level, and then the material that it is desired to give being

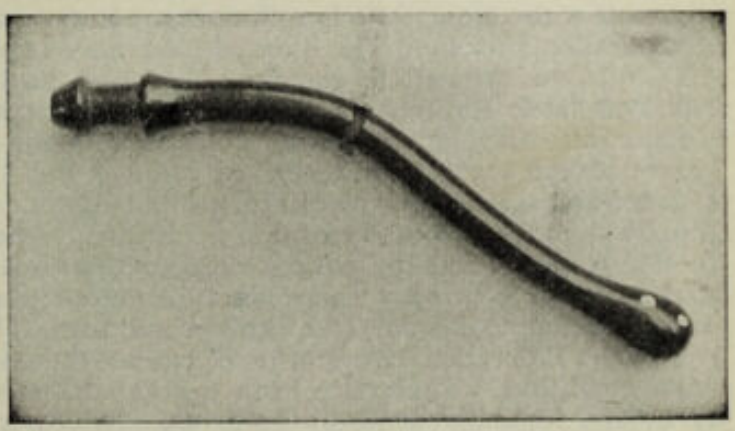


FIG. 775.—Tube with orifices filled with chalk in order to show openings better.

poured into the receptacle. Besides the above method of treatment antistreptococcic serum is usually given (see page 129).

I am convinced that this method of treatment is of the greatest value, and that the principles upon which it rests are entirely sound, and I have had a number of striking successes from its employment.

If a case of diffuse peritonitis has lasted for three or four days and the patient is profoundly toxic and no sign points to localization, do not operate at once. Wash out the stomach, place the patient in Fowler's position, give salt solution by the rectum, and withhold purgatives and food. Possibly inflammation may subside or may localize into a circumscribed suppuration. When in a patient with peritonitis the skin is blue, cold, and moist, the pulse very rapid and weak, the abdomen immensely distended, and the temperature subnormal death is almost certain, and the only chance is the conservative plan set forth above. We wait in hope that the infection may localize in an abscess. (See Buchanan in "Med. Record," Jan. 28, 1911, and Stanton in "New York Med. Jour.," Aug. 27, 1910.)

A *circumscribed suppuration* is treated as follows: Open the abscess. It will be possible, if the abscess is adherent to the abdominal wall, to open the abscess directly without opening the peritoneal cavity. If this be not possible, after opening the abdominal cavity pack gauze pads carefully about the abscess in such a manner as to prevent the diffusion of pus when the abscess is evacuated. After opening the abscess the primary lesion is sought for and, if possible, removed. The surgeon should not, in most cases, tear away the abscess walls in an attempt to find the primary lesion, but should rather let it go undiscovered. Pack iodoform gauze against the intestines to reinforce the barrier of lymph and insert a tube. It is frequently advisable to leave the wound wide open and drain by means of gauze.

Every patient with peritonitis requires stimulants.

Tuberculous Peritonitis.—Tuberculosis of the peritoneum is not very common. In 1170 autopsies in the Boston City Hospital tubercle existed in some region in 197, and in 14 of these the peritoneum was involved.[1] Primary local peritoneal tuberculosis is occasionally, though rarely, seen by the surgeon. In a great majority of cases of peritoneal tuberculosis other distant structures are involved. In about half of the cases the lungs are involved. In 28 cases reported by Bottomley[2] not one was primary. In every one of his cases the diagnosis was confirmed by the microscope, by the tuberculin test, or by autopsy. In most supposed cases of primary peritoneal tuberculosis another focus of disease exists, but is not demonstrable by clinical methods or has been overlooked. The disease sometimes exists as a part of general tuberculosis. Tuberculous peritonitis may be only a part of acute miliary tuberculosis. Bacteria may be swallowed with tuberculous food or a tuberculous patient may swallow tuberculous sputum and intestinal tuberculosis may result, the peritoneum being involved later. Fried ("Boston Med. and Surg. Jour.," May 10, 1923) examined the stools of 126 patients with pulmonary tuberculosis and found the bacilli in 101 of them. Peritoneal infection may follow a tuberculous lesion of the intestine or the mesenteric lymph-nodes. In a woman the bacteria may enter by way of the Fallopian tube. The initial lesion may be tuberculous appendicitis or tuberculosis of the mesenteric glands. The germ may lodge from the blood or lymph. The lymphatic form most commonly attacks the cecum. Tuberculous peritonitis is four times as common among women as among men, and most frequently attacks those between twenty and forty years of age, but I have seen it in a child of two and in a colored man of sixty. In all probability it is more common in childhood and infancy than we suspected formerly. Probably the diagnosis is not unusually missed in such subjects and the patient dies, or the disease makes great advances before it is recognized. In very early life tuberculous peritonitis may be confounded with rickets, pseudoleukemia, and other conditions (H. R. Sheffield in "Amer. Med.," 1916, xi). There are two groups of cases—the common chronic form and the rarer acute condition. The acute form begins suddenly, and such cases, as pointed out by Lejars, resemble acute appendicitis. In either the acute or chronic condition it is frequently the case that pulmonary phthisis exists. Cirrhosis of the liver is sometimes found with tuberculous peritonitis. There are three forms of chronic tuberculous peritonitis: the *ascitic*, the *fibrinoplastic*, and the *caseous*,[3] although, as a matter of fact, these so-called forms are only stages of the same disease. Tuberculous infec-

[1] Bottomley in "Amer. Med.," Feb. 15, 1902.
[2] Ibid.
[3] Parker Syms in "Medical Record," April 2, 1898.

tion may exist for some time without causing symptoms, acute symptoms may suddenly arise, or intestinal obstruction may take place. Symptoms sometimes develop quickly after pregnancy. In other cases the symptoms appear gradually and progressively grow more positive.

Symptoms of the Chronic Form.—Usually the disease begins insidiously. The digestion is found to be disturbed, there is nausea, the bowels are out of order, the abdomen is distended and tender, there is occasional colicky pain, and the patient is weak, loses flesh rapidly, and becomes very anemic. Frequently pain is the symptom which leads the patient to seek advice. The pain may be present from the very beginning, it may arise after malaise and gastro-intestinal disorder have existed for some time, but sooner or later it will develop.

In many cases there is ascites, but the amount of fluid is rarely very great. In some cases the fluid is serous, in some seropurulent, in some purulent, and in some bloody. Chylous fluid occasionally exists because of fatty degeneration of tuberculous masses. Ascites may be either unconfined or sacculated by adhesions. In some cases, and especially in early youth, there is little or no ascites, and the condition is characterized by the production of a quantity of adhesions which bind coils of intestine to each other, to the omentum, to the stomach, liver, and other viscera. In this condition, which develops very slowly, small cavities are formed between adhesions and the spaces contain fluid and bacteria. This is the most chronic form of the disease. In any case of tuberculous peritonitis the mesenteric glands may enlarge. There is usually moderate fever, but there may be episodes of high fever and protracted periods of subnormal temperature, or the temperature may be slightly elevated in the evening and subnormal in the morning. When the temperature becomes markedly elevated, pain, tenderness, and distention notably increase. In some cases there is a continued fever resembling typhoid. Tumor-like formations may be detected. These formations may consist of indurated omentum, encysted exudate, or enlarged mesenteric glands. If diarrhea exists for a long period there is probably tuberculous ulceration of the gut.

In every suspected case a bimanual examination should be made under an anesthetic, in order to discover whether or not there are any matted masses of intestine (Thomson). In young children the tuberculin reaction is of high diagnostic value, but it is of far less use in older persons.

In many cases a careful examination will detect tuberculous disease of other regions of the body, particularly of the lungs. If tuberculous disease of the lungs or pleura is detected, if tuberculous glands exist or have been present, if a nodule not due to gonorrheal inflammation is palpable in an epididymis, or if there are indurations in the prostate, the probability of the presence of tuberculous peritonitis is much enhanced. In many cases there is dilatation of the superficial abdominal veins. In some cases tuberculous peritonitis undergoes spontaneous cure. In the majority of cases death ensues from the tuberculous peritonitis directly or from associated or secondary disease in other organs.

If an intraperitoneal tuberculous area caseates, a large cold abscess may form, and such an abscess may break into the intestine or may be opened externally, and may be responsible for the formation of a fecal fistula.

In a case of tuberculous peritonitis intestinal obstruction may occur, the gut getting caught by bands or adhesions, or a part of it becoming a rigid tube because of the formation of tubercles.

Symptoms of the Acute Form.—This is sometimes mistaken for appendicitis. It comes on rather suddenly, but a carefully elicited history will usually show the previous existence of malaise, gastro-intestinal disturbance, loss of flesh, and anemia. The symptoms are not so strictly localized to the right iliac fossa as in appendicitis. There are abdominal distention, a certain amount of rigidity, nausea and vomiting, colicky pain which may be very severe, general abdominal tenderness, fever, and exhaustion. It may be possible to palpate masses like tumors, or to feel nodules in the prostate or epididymis, or to detect tuberculosis in some other part. In young children the tuberculin reaction is of decided value.

Treatment of Tuberculous Peritonitis.—In some cases there is a tendency to spontaneous cure, and in them medical treatment is of great service. The patient should be placed under antituberculous conditions, nutritious food and tonics should be administered (see page 162), the abdomen should be counterirritated and massaged, and purgatives should be given frequently. Guaiacol applied daily to the abdomen is thought by some to be of service, but I doubt it. A mixture is made of 1 part of guaiacol

and 5 parts of olive oil; 1 dram of this mixture is rubbed into the abdomen, and the part is covered with a piece of flannel held in place by means of a binder. If medical treatment is not soon productive of benefit, the advisability of operating must be considered. It is a curious fact, but one confirmed by ample evidence, that after simple abdominal section, without the introduction of germicides and without drainage, at least 30 per cent. of the cases recover from the disease in from six months to one year. Some surgeons doubt the curative effect of operation. For instance, the late Professor Fenger was strongly of the opinion that many patients recover after operation, but not as a result of operation. In his opinion they recover because they are strong, free from fever, and well nourished, and because the disease tends to spontaneous cure. He further believed that some die from operation because the traumatism lessens the already lowered tissue resistance. The majority of surgeons, however, believe that operation in many cases tends to cure. Ochsner, in a paper before the American Surgical Association in 1902, apparently proved that simple incision and evacuation of fluid tends to cure. It is uncertain how an operation tends to cure. It has been thought that the ascitic fluid is a culture-medium for bacilli, and when it is withdrawn the bacilli die, but opposed to this view is the fact that aspiration is rarely curative. It has been suggested that the operation brings numerous phagocytes to the peritoneum; that it stimulates vital resistance; and that it leads to the exudation of antitoxic serum. The entrance of air seems to play a definite and important part in effecting a cure.

The ascitic cases are most frequently benefited by operation. If there be encysted fluid operation often cures.

In cases in which there are numerous adhesions operation is not so likely to produce a cure. Great care should be exercised in separating adhesions, because the bowel is apt to be torn and a fecal fistula may result. It may be necessary to separate adhesions or short-circuit a portion of gut to relieve obstruction. Drainage should not be used unless a cold abscess exists. Not only is drainage of no service, but it is dangerous; death is more apt to ensue in a drained case and a fecal fistula will arise in nearly one-fourth of the drained cases. If operation is performed for cold abscess, tube drainage must be used for some days. In a woman with tuberculous peritonitis the abdomen should be opened in the midline, and if the Fallopian tubes are tuberculous they should be removed. Always examine the appendix and remove it if it is diseased. In a man the incision should be made over the appendix, and if this is tuberculous it should be removed. In either sex it may be necessary to resect tuberculous intestine or perform anastomosis because of stricture. (In confirmation of these views see W. J. Mayo in "Jour. Amer. Med. Assoc.," April 15, 1905.) The Mayos have performed 26 radical tubal operations on cases of tuberculous peritonitis and 25 recovered. Of these, 7 had previously been operated on from one to four times by simple laparotomy ("Jour. Amer. Med. Assoc.," April 15, 1905). In a very advanced case, in a case with notably high temperature, or in a case with marked and advancing tuberculosis in another region, an operation should not be performed except to relieve obstruction or drain an abscess. If a patient does not die within a few months after an operation, he will probably recover, and in most cases operation secures at least temporary improvement (Bottomley, "Amer. Med.," Feb. 15, 1902). The mortality from operation is 1 or 2 per cent. (Fenger).

Pneumococcus Peritonitis.—This condition is an unusual one. It is most apt to arise during the progress or after the termination of pneumonia or some other pneumococcic lesion, but is sometimes primary—is far commoner in females than in males and in children than in adults. Out of 74 reported cases, 57 were children under five years of age (Brunn in "Beiträge zur klinischen Chirurgie," Bd. xxxix, Heft i). In primary cases the bacteria may enter by way of the blood-stream or, perhaps, in some cases through the bowel wall or Fallopian tube. In secondary cases infection may arise from an adjacent pneumococcic area (pleura) or be carried by the blood from a distant point (*pneumococcic septicemia*). The condition may appear in a sufferer from otitis media. The symptoms in children are sudden in onset. The first symptoms are general abdominal pain, usually a continuous pain with colicky exacerbations, tenderness, rigidity, vomiting, elevated temperature, distention, and diarrhea. In a few days the symptoms abate and some of them disappear, although pain, tenderness, and rigidity are apt to localize at some point, particularly about the umbilicus, and may remain for a number of weeks. In such a chronic case physical signs of a fluid collection are usually demonstrable. In the chronic stage, as Brunn points out, there is seldom severe tenderness and there may be no fever at all, and a

septic temperature is very rarely observed. Pus may form, and if it does, it contains pneumococci. Adhesions practically always form. These adhesions glue the intestines together and often encompass pus. Rapid emaciation and progressive weakness are always noted. In adults the symptoms are irregular and less characteristic than in children (Brunn). The prognosis is excellent.

Treatment.—Incision and drainage.

A **subphrenic abscess** is a collection of pus beneath the diaphragm. It is a rare condition. The pus may occupy a part of the lesser peritoneal cavity; it may be extraperitoneal (when it is of **renal origin**); in some cases it is contained in the area between the diaphragm, cardiac end of the stomach, and liver or spleen. It is impossible to classify accurately these abscesses by anatomic position. George A. Ross ("Jour. Amer. Med. Assoc.," Aug. 12, 1911) classifies them as right, left, anterior, and posterior. Most are on the right side, but even an abscess due to appendicitis may be on the left side. It is an unusual thing for such an abscess to break into the general cavity of the peritoneum, but it may break into the pleural sac (Maydl).

Causes.—Perforation of a gastric ulcer, perforation of the gall-bladder or gall-ducts, ulceration of the duodenum, disease of the liver, spleen, pancreas, intestine, appendix, or kidney, hydatid disease, internal injury, metastasis, external injury, caries of rib, disease of the pleura, general peritonitis, or portal infection may be responsible for a subphrenic abscess. We have abandoned the notion that the infecting source must be in the upper abdomen. Appendicitis is the most common cause. Charles A. Elsberg[1] has collected 73 cases of subphrenic abscess after appendicitis. He points out that the condition may arise from direct extension or by way of the lymph-channels, and may be either intraperitoneal or extraperitoneal, although in the majority of cases it is intraperitoneal. In rare cases extension is by way of the portal vein. Ross claims that in most cases due to appendicitis the infection extends by cellular tissue directly upward from the lower peritoneal fossæ. In some cases infection ascends between the colon and the parietal peritoneum (the *parietocolic sinus* of our French colleagues). In all but 7 of Elsberg's cases there was suppuration about the appendix. The pus was thick and foul in all the cases. In 15 per cent. of them gas was also present, and in 25 per cent. of these cases the diaphragm was perforated. Gas may come from a hollow viscus (perforated stomach) or be produced by gas-forming bacteria. In 3391 consecutive cases of appendicitis operated on in the Lankenau Hospital of Philadelphia there were 30 cases of subphrenic abscess (Ross, "Jour. Amer. Med. Assoc.," Aug. 12, 1911). Subphrenic abscess may develop soon after an appendicitis, it may develop extraordinarily late. Ashhurst's case arose four years after appendicitis ("Trans. Phila. Acad. of Surg.," 1910), 1 of Ross's cases, one year after (Loc. cit.). If ascending retroperitoneal infection exists during appendicitis, removal of the appendix does not arrest it (Lance in "Gaz. d. Hôp.," 1909, lxxxvii). In 2 cases on which I operated the abscess developed after cholecystitis; in 2 others, after suppurative appendicitis.

The **symptoms** usually come on suddenly, but may do so gradually. There may or may not be abdominal symptoms. A patient with subphrenic abscess usually complains of pain in the lower part of the chest on the right side. Usually there is high temperature and often delirium, but, as Jopson ("Annals of Surgery," July, 1910) says, the temperature may be only moderately elevated and the pulse may be nearly normal. The area of liver dulness is, in many cases, distinctly enlarged, and there is tenderness in the lower part of the right chest when pressure is made through one or through several intercostal spaces. Frequently friction sounds may be heard about the region of the dome of the liver. Breath sounds and vocal fremitus are lessened. The signs are usually best heard posterior, but may be lateral or anterior. There is cough and also bulging of the chest wall. Jaundice is absent in uncomplicated cases. There may be hiccough. Sometimes the symptoms are obscure or indefinite, and not accompanied by particular pain. If the abscess happens to contain not only fluid but also a considerable amount of gas—and about 15 per cent. of such abscesses do contain gas—not only will there be no increase in the area of liver dulness, but the normal area of dulness may be diminished or obliterated. The presence of gas may be due to some connection with an organ which contains gas or to gas-forming bacteria. A pleural effusion may be associated with a subphrenic abscess. A pleural effusion will be preceded by or accompanied by symptoms pointing to the lung or pleura; and it is to be remembered that the area of percussion dulness found in the pleural effusion shifts its position whenever the position of the patient is changed,

[1] "Annals of Surgery," Dec., 1901.

which is not true of the area of dulness found in subphrenic abscess. When the abscess breaks through the diaphragm the patient collapses, cough and other thoracic symptoms develop; and if the abscess breaks into a bronchus the patient will expectorate pus. In subphrenic abscess the diaphragm of the diseased side is paralyzed—a condition rarely met with in liver abscess. There are general symptoms of suppuration and a swelling in the subdiaphragmatic region following some recognized causative condition. The history of chills with recurrent fever and sweats is rather indicative of abscess of the liver; but in abscess of the liver there is usually pain in the shoulder-blade of the right side, and this is rarely encountered in subphrenic abscess. The *x*-rays show that the diaphragm is elevated on the side of the lesion. The proof of the diagnosis is not, however, obtained until an exploratory incision has been made and the purulent matter has been found. Empyema and subphrenic abscess resemble each other. In empyema the upper limit of the fluid is concave; in subphrenic abscess it is convex. In empyema the flow of pus through an aspirating needle will be most marked during expiration; in abscess, during inspiration. The same is true of a rush of gas. In empyema the needle does not oscillate; in abscess it does.[1] If an abscess contains gas, percussion elicits a tympanitic note over a part of the cavity, and there is an alteration in the area of tympany with an alteration in the position of the patient. An abscess of the liver almost never contains gas and decidedly changes the outlines of the organ.[2] Empyema may follow subphrenic abscess.

Treatment.—Incision and drainage. The incision is made in the lumbar region if the abscess points there. In some cases it is made through the abdominal wall (epigastric region, iliac region, hypochondrium). In other cases the chest wall is incised, the ninth or tenth rib is resected, and the abscess is opened below the pleura or the pleura is opened, the parietal and diaphragmatic layers are sutured together, if possible, and the diaphragm is incised. If the condition was caused by appendicitis do not be satisfied with draining the subphrenic abscess, drain an appendical abscess if one is found and usually remove the appendix. If it be necessary to open the pleural sac, first try to stitch the parietal to the diaphragmatic layer of the pleura, or, if this be impossible, protect the cavity with iodoform gauze to prevent infection.

The Liver, Gall-bladder, and Bile-ducts

Rupture and Wounds of the Liver.—Rupture of the liver is due to very great force, and is usually accompanied by injury of other viscera. It may be produced by a blow, by a fall, or by the end of a broken rib. The superior surface or margin most often suffers. It is a very fatal accident. Out of 543 reported cases over one-half died of hemorrhage within twenty-four hours of the accident.[3] At least 80 per cent. will die if not operated upon. Wilms[4] collected 19 cases, and only 3 recovered after operation. Eisendrath[5] has collected 37 cases of suture of the liver for rupture, and 22 of them recovered (59.5 per cent.). The first operation was performed by Willette in 1888. Out of Kraussine's 13 stab wounds of the liver, 7 died (Murphy in "Practical Medicine Series," 1910, vol. ii). An attempt should certainly be made to save the patient by opening the abdomen and arresting hemorrhage, and in a suspected case an exploratory operation should be performed. A wound of the liver causes violent hemorrhage, which is usually rapidly fatal. Such a wound is apt to divide bile-ducts and allow bile to escape into the peritoneal cavity, and perhaps externally. Bile, if sterile, will do little harm to the peritoneum, but if it contains bacteria it will produce diffuse peritonitis. Even sterile bile is corrosive and may cause fibroplastic peritonitis. The symptoms of a rupture or wound of the liver are those of severe intra-abdominal hemorrhage, with collapse, accompanied by hepatic tenderness and respiratory embarrassment. Soon after the injury the abdomen is soft and flat, but it quickly becomes rigid and ultimately distended. The diagnosis becomes more probable when it is known that violence was applied to the hepatic region. Usually there is abdominal pain and often pain in the back. Sugar may appear in the urine. In about 5 per cent. of cases after several days jaundice and skin itching

[1] Wharton and Curtis, "Practice of Surgery."

[2] In a case of abscess of the liver secondary to appendicitis operated upon in the Jefferson Hospital the abscess did contain gas produced by gas-forming bacteria.

[3] Mercade in "Rev. de Chir.," Jan. 10, 1902.

[4] "Deut. med. Woch.," Nos. 34 and 35, 1901.

[5] "Jour. Amer. Med. Assoc.," Nov. 1, 1902.

have been noted. The area of liver dulness is usually increased. Patients do not always die from a serious traumatism of the liver. Some recover because operation has saved them. Some few recover without operation (see page 938). This last fact is proved by reports of autopsies in which scars were found in the liver parenchyma (Nussbaum). The fatality which usually ensues after a liver injury may be due to hemorrhage or peritonitis. If a surgeon is called to a patient suffering from wound of the liver, he must open the abdomen to arrest hemorrhage. If a penetrating wound is suspected, it may be desirable to enlarge the wound in the abdominal wall layer by layer, in order to determine if the liver be wounded. If the left lobe of the liver be wounded, or if it be uncertain which lobe is wounded, the incision should be median. If the right lobe be wounded, a curved incision is made along the line of the costal cartilages. In some cases these two incisions are joined.[1] The convex surface of the liver can be reached by Lannelongue's plan. Lannelongue resects the eighth, ninth, tenth, and eleventh costal cartilages and draws the ends of the ribs well out. It can also be reached by Langenbuch's plan, that is, by cutting the coronary ligament and the right lateral ligament. This allows the liver to be pulled well up into the wound in the belly wall. The site of the wound can be discovered if the hepatic vessels are grasped between the thumb and a finger (the finger in the foramen of Winslow and the thumb in front on the gastrohepatic omentum). This completely arrests hemorrhage, and the blood that has gathered may be sponged out and the wound sought for in a clear field. (See Pringle, of Glasgow, in "Annals of Surgery," Oct., 1908.) When the wound in the liver is discovered and well exposed, deep sutures of catgut should be inserted in the liver and the capsule should be stitched with fine silk (Schlatter). Round and blunt needles are used. If sutures fail to arrest hemorrhage, the organ should be sutured to the belly wall and the wound in the liver packed with iodoform gauze. It is useless to try packing without first attaching the liver to the abdominal wall, because pressure will simply push the liver away and will not arrest the bleeding. The cautery is a very useful means of arresting bleeding. It should be avoided if possible in a large wound, because, even if it arrests primary hemorrhage, secondary hemorrhage may occur. After arresting hemorrhage, wash out the abdomen with hot saline fluid, insert drainage, and close the abdominal wound. In a case of the author's in the Philadelphia Hospital the liver was wounded by the sharp ends of fractured ribs. The abdomen was opened, a wound was found, and bleeding was arrested by suturing the liver to the belly wall and packing the wound. The patient died, and necropsy showed another wound on the posterior portion of the organ. The possibility of such an occurrence should not be lost sight of.

Tumors and Cysts of the Liver.—The liver may be the seat of primary carcinoma, sarcoma, endothelioma, angioma, cavernous hemangioma, lymphangioma, adenoma, fibroma, myxoma, or lipoma. Many tumors called adenomata are really adenocarcinomata. Secondary malignant growths are far more common than primary neoplasms—in fact, 96 per cent. of liver tumors are secondary. Primary cancer of the liver is found once in every 2000 autopsies (Eggel). The commonest variety is nodular, but the diffuse form, known as *cancerous cirrhosis*, may occur. The nodular form is most often encountered in the right lobe, and it has been found in persons under the age of twenty. Metastases occur early. "There is always more or less coexisting cirrhosis of the liver" (Leonard Freeman in "Trans. Amer. Surg. Assoc.," 1904). It takes origin from the hepatic cells. The frequency of cancer of the liver secondary to cancer of the stomach has already been alluded to. Cancer of the liver may cause irregular fever. The commonest primary tumor of the liver is cavernous hemangioma. It is especially apt to take origin in the atrophying liver of an elderly individual. Primary sarcoma may arise at any age and may even be congenital. The growth is rapid and emaciation is soon noted. The liver enlarges, often greatly. Jaundice and ascites are rather rare. The patient soon becomes very weak. There is always pain. As Knott ("Surg., Gynec., and Obstet.," Sept., 1908) points out, the condition may simulate abscess, and if it arises in a middle-aged or elderly person can scarcely be differentiated from carcinoma.

Knott ("Surg., Gynec., and Obstet.," Sept., 1908) collected 59 cases of primary sarcoma from literature, and adds 14 reported by personal communications and 1 of his own, 74 in all.

He shows that 28 cases have been operated upon. In 9 the operation was exploratory and no attempt was made to remove the growth. In 19 the growth was extirpated, with 10 recoveries and 9 deaths. One of these patients was well after nineteen

[1] See Schlatter, "Beiträge zür klinischen Chirurgie," Bd. xv, Heft ii, 1896.

months, 1 after two years, 1 after seven months. Operation is indicated for a circumscribed growth.

Cavernous hemangioma is most common in the left lobe, is met with more often in females than in males, and tends to grow to a large size. In Pfannenstiel's successful case of excision the tumor when empty of blood weighed 5 pounds and was thought to have weighed 10 pounds when full of blood (quoted by Peck in "Surg., Gynec., and Obstet.," Sept., 1921). Major and Black report a case in which the tumor weighed 37 pounds (Peck, Ibid.).

Among the cysts occurring in the liver are blood cysts, congenital cysts, bile cysts, and hydatid cysts. Terrier and Auvray in 1901 collected 52 operations for hepatic tumors.

Hemangiomata have been removed successfully by hepatotomy, a cautery knife at a red heat being used to cut through the normal liver tissue around the base of the tumor, the large vessels having been tied with catgut. Enucleation is not feasible because of excessive hemorrhage. If a tumor be pedunculated, the base may be encircled by an elastic ligature held in place by a steel needle, and five or six days later the tumor may be cut across by the cautery.[1] In 1897 I assisted Professor W. W. Keen in such an operation. He made a pedicle by incising the liver on each side of the growth and then sunk his elastic ligature into the furrows. The patient recovered.

Peck successfully extirpated the left lobe of the liver for a cavernous hemangioma weighing 3 pounds and 14 ounces ("Surg., Gynec., and Obstet.," Sept., 1921). Peck collected records of 21 cases operated upon. In 17 of them the tumor was excised. There were 2 deaths (Ibid.).

Carcinoma of the liver has been extirpated, but it is seldom that a growth is recognized early enough and is found to be sufficiently limited to justify such a procedure. Operation is proper only when there is a limited nodule of primary cancer. In 1901 Terrier and Auvray collected 9 operations for primary cancer. In most cases there has been rapid recurrence or secondary growth, but Schrader's case was well at the end of seven years and Leonard Freeman's at the end of sixteen months. (For operative methods see Leonard Freeman in "Trans. Amer. Surg. Assoc.," 1904.) Hunbald has collected 96 cases of resection of the liver, with a mortality rate of 26 per cent. Probably the best method for arresting hemorrhage is the use of suture ligatures of doubled catgut passed by round, blunt needles, as advised by Mikulicz.

A **hydatid cyst of the liver** (the *endocyst*) is usually surrounded by a capsule (the *ectocyst*) from which the parasite obtains its nourishment. A cyst may be of small size and productive of no signs or symptoms; or may be of large size and productive of the signs of tumor. In the epigastrium the mass may be prominent and fluctuate. In cyst of the right lobe the dulness is found in the axillary line and the growth encroaches on the pleura. In a large cyst fluctuation and hydatid fremitus may exist. Hydatid fremitus is a vibration imparted to the palpating fingers of one hand when the fingers of the other hand knock upon the cyst. There may be no discomfort produced by even a large cyst, but, as a rule, the patient suffers from a dragging sensation in the epigastrium and pressure symptoms. Suppuration in the cyst produces the symptoms of abscess of the liver and septicemia. Rupture of the cyst produces shock and even death. Rupture may take place into the pleural sac, the lung, the bile ducts, or the peritoneal cavity. If the shock is recovered from, inflammation arises, the area of which depends upon the structures damaged. The escape of even a small quantity of hydatid fluid into the peritoneal cavity produces urticaria (*hydatid toxemia*). Aspiration for diagnostic purposes is not advisable.

Treatment.—Exploratory incision may be necessary to confirm the diagnosis, and the operation is completed at this time. After exposing the liver over the cyst, gauze is packed around it and a trocar is introduced. A small amount of fluid, which is usually milky, is withdrawn. If there be a considerable thickness of liver tissue over the cyst, incise the liver by the cautery knife or tear through by forceps. When the fluid is evacuated the ectocyst is incised and the extraneous sac is drawn partly through the wound in the abdominal wall, and is attached to the wound margins (*marsupialization*). The endocyst can then be removed by the scoop, the hand, or by irrigation. A large drainage-tube is introduced. Small and superficial cysts have been excised entire. If no pus is found, we can remove the endocyst and fluid, suture the ectocyst to the abdominal incision, swab with peroxid of hydrogen, dry, close the abdominal incision,

[1] Russell S. Fowler, on "Tumors of the Liver," "Brooklyn Med. Jour.," Dec., 1900.

and make pressure by strips of plaster (plan of Stewart McKay. For the evolution of methods in the treatment of hydatid cyst see McKay's "Life of Lawson Tait").

Syphilis of the liver is a very able actor and often impersonates with surprising accuracy various other diseases. It may be congenital or acquired. The congenital condition may cause cirrhosis, miliary gummata, spots of fibrosis, and very seldom large gummata. Sometimes the liver manifestations of congenital or hereditary syphilis may be postponed for years (ten, fifteen, or more) and then appear as ordinary tertiary lesions. Acquired syphilis may cause hepatic disease in the secondary and tertiary stages.

In secondary syphilis there may be temporary jaundice due, Rolleston thinks, to catarrh of the smaller bile-ducts within the liver. It is possible, according to Rolleston, for temporary pericellular cirrhosis to exist in the secondary stage.

The tertiary lesions are the most common and important. Among these lesions are gummata and scars. They are most common ten years or more after the primary sore. Tertiary syphilis may appear as irregular patches of inflammation in Glisson's capsule (a condition apt to eventuate in hepatic sclerosis)—as a large solitary gumma (only one-eighth of cases of gumma present a solitary lesion)—or as multiple and usually small gummata. Gummata are most usual upon the anterior surface of the right lobe. A gumma adjacent to the common duct or the hepatic duct causes jaundice. A large gumma is often mistaken for cancer of the liver, and it is a curious fact that in many cases of hepatic gummata we are unable to obtain any history of syphilis. Syphilis may be mistaken for ordinary cirrhosis, but in the latter disease the general nutrition is more impaired than in the former, and vomiting of blood, dilated cutaneous veins, ascites, and indigestion are far more apt to be present (Archibald MacLaren in "Annals of Surgery," Aug., 1908). The victims of gumma are apt sooner or later to develop jaundice, colicky pain, moderate fever, and palpable enlargement of the liver. The spleen may enlarge. The fever may be continuous or may occur episodically. In some cases it continues for weeks. It may be intermittent, preceded by a chill and followed by a sweat. Such a fever may be due to Spirochæta cholangitis. It may be due to absorption of toxic material from a breaking-down gumma. The Wassermann reaction is a valuable aid to diagnosis. A gumma sometimes undergoes secondary infection and an abscess forms. A gumma may rupture into the pleural or peritoneal cavity or some viscus.

Treatment.—Mercury and iodid will cure most cases. If these drugs fail, it is proper to remove the tumor, if solitary, by resecting the involved area of the liver. MacLaren (Ibid.) collected 9 cases of resection for solitary gumma and added 1 of his own. There were 2 deaths in this series. MacLaren's 10 cases added to Keen's 12 ("Annals of Surgery," Sept., 1899) and Cumston's 15 (quoted by Rolleston in his work on "Diseases of the Liver") make 37 cases.

If an abdomen is opened for exploration and a solitary gumma is discovered, the abdomen should be closed and specific treatment be tried before resorting to resection, that is, if specific treatment has not been tried before.

Abscess of the Liver.—An abscess of the liver may be produced by bacteria, especially staphylococci and streptococci. These organisms reach the liver by the general circulation or, what is more frequent, are taken up from the intestinal tract and reach the liver by the portal circulation, or pass to the liver by the lymphatics. Appendicitis with lymphatic infection may result in hepatic abscess. A subphrenic abscess may break into the liver and thus induce a liver abscess. Liver abscess may result directly from peritoneal infection. The fact that abscess of the liver is, in hot countries, frequently preceded by amebic dysentery led to the presumption that the Amœba coli produces the abscess, and in a large majority of cases of tropical abscess amebæ exist in the pus or at least on the abscess walls. Habitual intemperance and constant overeating predispose to abscess of the liver. The disease may follow traumatism, dysentery, diarrhea, cholangitis, suppuration of a hydatid cyst, gall-stones, typhoid fever, appendicitis, and a chill to the surface of the body.[1] Abscess of the liver may be metastatic, and such abscesses are multiple. It may be caused by foreign bodies and parasites. A tropical abscess is an abscess of the liver in an inhabitant of a hot country.

There are three forms of abscess of the liver: traumatic, pyemic, and tropical.

Traumatic abscess may result from a wound of the liver or may follow a contusion without a break of the skin. In the latter case bacteria from the blood are arrested in the injured liver tissue. Such an abscess is usually solitary. Streptococci, staph-

[1] G. B. Johnston, "Annals of Surgery," Oct., 1897.

ylococci, or colon bacilli may be found. Traumatic abscesses are more common in children than in adults, are situated superficially, and the symptoms are usually acute. Recovery is usually rapid and permanent after incision unless the causal injury brings danger or fatality.

Pyemic Abscess.—Multiple abscesses exist, but they may fuse into one. They are frequently due to suppurative inflammation of radicles of the portal vein, infected emboli forming and reaching the liver; they may follow ulceration of the intestine, hemorrhoids, or appendicitis.

Occasionally abscess may arise from the extension of an infective process, such as pylephlebitis. It may arise from cholecystitis or cholelithiasis with obstruction. In these latter cases both the Bacillus typhosus and the pneumobacillus of Friedländer have been found as the direct bacterial agents. Colon bacilli are a common cause. Abscess of the liver following appendicitis may be due to portal infection (*portal pyemia*) or to lymphatic infection. It is usually multiple, but in a case of mine in the Jefferson Hospital it was solitary, several cavities having probably joined to form one. Echinococcus cyst of the liver may suppurate and form abscess. I operated unsuccessfully on 1 such case which was brought to me by Dr. Hultsizer. The round-worm, the liver fluke, and the Balantidium coli sometimes cause abscess, and, finally, it has been observed in measles, epidemic influenza, and perforating ulcer of the stomach.[1]

Tropical abscess of the liver is rare in temperate climates, but is extremely common in the tropics. Its usual antecedent in either climate is dysentery. The reason for the great frequency of the disease in tropical regions is that the chief causative agent, the Amœba coli, is found widely distributed in hot countries; and that passive congestion of the liver is a common condition among the white inhabitants of tropical regions. It has been pointed out that tropical abscess is particularly common among white persons who abuse alcohol, the condition of passive congestion of the liver making that organ a nutritious soil for a fruitful infection. Predisposing factors are protracted malaria and chilling of the surface of the body.

Major Charles F. Kieffer, U. S. A.,[2] in a lecture on tropical abscess of the liver, stated that in his own experience he found, in a series of 33 abscess cases in soldiers, that dysentery was present in every case; and that in a second series of 25 cases in natives and civilians he elicited a history of dysentery in 22 cases. Some observers—notably McLeod—state that dysentery is the antecedent factor in 97.5 per cent. of cases. Kieffer points out that in all the figures allowance must be made for a number of latent dysenteries, as well as for cases in which no effort has been made to elicit a history of dysentery one or two years previously. It is also to be remembered that a case of amebic infection of the colon may have been so mild in the beginning as to have caused but a transient diarrhea, which the patient may have forgotten. Amebæ occasionally exist in the colon without producing any dysenteric evidences. From 20 to 25 per cent. of severe amebic dysenteries lead to the formation of abscess of the liver, and at least 95 per cent. of all tropical abscesses are due to infection with the Amœba coli. Occasionally an abscess begins very soon after the dysentery, but, as a rule, it does not form for some time afterward—weeks, months, a year, or even two years.

When an abscess of this sort forms in the liver that organ becomes enlarged and congested, and an area or areas of necrosis form in it. But one abscess may be present; there may be an abscess with satellite abscesses about it; several abscesses may coalesce, making a very large cavity; or genuine multiple abscesses may exist. In about 70 per cent. of cases, however, the tropical abscess is solitary.

The right lobe of the liver is the region most frequently involved. The abscess is found in the right lobe in at least 90 per cent. of cases, and it is far more common toward the convexity of the liver than toward the base.

An abscess of the liver of this type contains characteristic and peculiar material; it is different from the pus found in true abscesses, and, in fact, is not pus, but is necrotic liver substance. Liver abscesses due to pyogenic organisms contain true pus; a tropical abscess, free from pyogenic infection, does not. Ordinary pus contains hordes of leukocytes, but the fluid of a tropical abscess contains very few. Riesman is of the opinion that the reason there are so few leukocytes is that the abscess contains a substance that, by chemotaxis, repels leukocytes. The matter is of a reddish-brown color, is thick, and frequently contains some blood. Occasionally it is offensive in

[1] Major Charles F. Kieffer, U. S. A., in "Phila. Med. Jour.," Feb. 21, 1903.
[2] Ibid.

odor. Microscopic examination shows it to contain portions of necrotic liver tissue, some liver cells that are not destroyed, elastic tissue, blood, some few leukocytes, and amebæ. On bacterial examination it may be found that the fluid is infected, containing staphylococci, streptococci, or pyogenic bacteria. Such infection is secondary. In about 20 per cent. of the cases the matter contains neither bacteria nor the Amœbæ coli. In over 60 per cent. of the cases the matter of a recently opened abscess is free from bacteria. In cases in which the fluid is sterile it is possible that bacteria were originally present, but have died. The reason for the death of micro-organisms in this matter is in great doubt, because, as Riesman points out, bile cannot kill them, as organisms may be grown in the bile. In the large majority of cases amebæ are readily demonstrable in the matter; but in some few cases it is necessary to rub a piece of gauze on an abscess wall in order to obtain amebæ, and in others they can be demonstrated only after the abscess has been discharging for some days. The causative rôle of the amebæ has been doubted by some observers, but most surgeons who have had experience in the tropics believe it to be a fact.

The *symptoms* may be very definite and positive; they are frequently misleading and obscure; and in some cases nothing whatever directs the surgeon's attention to the liver until the patient passes a huge quantity of puriform fluid at stool or coughs up an enormous amount of the characteristic material. If rupture takes place, death usually ensues. As a rule the symptoms of a tropical abscess are positive and marked, but naval surgeons of large experience (Spear, Fauntleroy) inform me that even when there is a large abscess there may be no increase in pulse-rate, elevation of temperature, or leukocytosis.

The chief symptoms may be set forth under four heads: *fever*, *sepsis*, *enlargement of the liver*, and *pain*. In about three-fourths of the patients fever and sweats are definitely present; in about one-fourth they are absent or are very trivial. The type of fever met with is what has been previously spoken of as hectic. Usually there is an evening rise, preceded by a chilly sensation or by a chill; and as the temperature begins to fall, toward morning, there is a profuse sweat. It is seldom that there is any violent chill, though there are frequently slight ones. The sweats are extremely exhausting. They may occur either during the night or in the daytime, according to the time in which the patient sleeps. Kieffer says that they should not be called night-sweats, but rather *sleeping sweats*. In very chronic cases there may be no pyrexia. As a rule the temperature resembles that of malaria, but it is not controlled by quinin and the blood is free from malarial parasites. Sometimes the temperature suggests typhoid, with the exception that from time to time there are episodes of subnormal temperature. The patient loses flesh and strength, the appetite fails completely, and the skin becomes pasty or dirty yellow.

The entire liver is usually enlarged, and the enlargement may be detected by percussion, and in some cases a hard, smooth area can be palpated. Sometimes the liver reaches as high as the third rib anteriorly, or to the spine of the scapula behind, and it may extend downward to the anterior superior spine of the ilium. It is rarely, however, that the enlargement takes place in a downward direction; it is usually upward. In many cases the right side of the chest appears to be rather full, and sometimes there is actual obliteration of several intercostal spaces. If an abscess becomes adherent to the parietes, there may be skin edema and dusky discoloration. In rare instances, if a very large abscess comes near the surface, fluctuation may be obtained. By auscultation it is frequently possible to obtain friction sounds in the region of the diaphragm and the superior surface of the liver.

The liver becomes tender. This tenderness may be developed particularly by pressure upon the lower edge of the organ, and sometimes by pressure through the intercostal spaces. There is not always, but, as a rule, there is pain. The pain may be dull and heavy, but as the abscess nears the surface of the organ the pain becomes sharp and lancinating. The pain is persistent and is not strictly localized, but radiates to the back, the right shoulder-blade, and the point of the shoulder. Pain is increased by pressure, coughing, sudden or violent movement, and is sometimes felt in the esophagus when food is swallowed. When the upper surface of the liver is involved the patient breathes as if he had pleurisy; and pleurisy frequently does develop, with marked effusion.

Paralysis of the diaphragm rarely occurs in abscess of the liver, and the respiration is not much affected unless the diaphragm of that side and the pleura become involved, though the patient frequently has a dry cough. A severe cough suggests that the abscess is on the convex surface of the organ. Such a cough is aggravated by recum-

bency. Kieffer points out that the patient lies on his right side, and almost on the right front aspect, the shoulder being drawn down and the right knee drawn up to relieve the tension of the abdominal muscles. In about one-fourth of the cases of tropical abscess of the liver jaundice occurs. It is most apt to occur when the abscess is on the inferior surface. Jaundice does not occur unless the common or hepatic ducts are compressed or cholangitis exists. The leukocyte count is of no particular help in the diagnosis, as there may or may not be leukocytosis. The urine is usually scanty. Diarrhea is a common accompaniment, but constipation may exist, and nausea and vomiting are by no means unusual.

Diagnosis.—With an antecedent history of dysentery the diagnosis is easy. Without such a history it is always difficult and may be impossible. In the tropics exploratory aspiration is freely used, but exploratory incision, if necessary, with subsequent exploratory aspiration of the liver after the organ is exposed, would seem to be safer and more certain to the inexperienced surgeon of the temperate zone. But experience must rule.

Symptoms of Traumatic Abscess.—Similar to those of tropical abscess.

Symptoms of Pyemic Abscess.—The liver is enlarged and tender, there is slight jaundice, and the general symptoms of pyemia are present (see page 130).

Treatment of Tropical Abscess.—If all cases of dysentery were treated thoroughly with emetine abscess of the liver would be rare. If in doubt as to the diagnosis, aspirate at the point where swelling is greatest and tenderness most marked, or make an exploratory incision, exposing enough liver surface to permit of exploration by finger and needle. If pus is not found, pack the wound with gauze to keep it open, and when adhesions form explore again. The operation for abscess is incision and drainage. The *abdominal route* is used when the liver bulges front or when it extends well below the costal margin (McGill in "Surg., Gynec., and Obstet.," Nov., 1911). If the abscess is adherent to the parietal peritoneum and is not covered by liver substance, open it at once. If it is not adherent, or is covered by a considerable layer of liver substance, make a ring of gauze about the periphery of the abscess cavity. The abscess may be opened at once within the ring, the gauze being a coffer-dam to protect the peritoneal cavity. It is safer to fasten the gauze to the parietal peritoneum by means of two or three fine catgut sutures and wait for forty-eight hours before opening. This is an easier plan and just as safe as attempting to stitch the liver to the parietal peritoneum. The operation consists in evacuating the pus by a trocar and cannula, incising the abscess, stitching its edges to the edges of the abdominal wound, irrigating, and inserting a drainage-tube. If the abscess be covered by a layer of liver tissue, after locating it by an aspirating cannula, open into it by means of a cautery knife and arrest hemorrhage by packing. When the parietal and visceral layers of peritoneum are adherent, packing will arrest bleeding; if they are not adherent, packing will only push away the movable liver (Sir John O'Connor, of Buenos Ayres). The *transpleural route* gives the best access to the right lobe, which is far and away the commonest region for liver abscess. The operation devised by McGill (Ibid.) may be at first exploratory; it avoids pneumothorax and empyema. It is performed as follows:

The ninth and tenth ribs are exposed by a curvilinear incision. The flap which goes down to but does not include the fascia of the muscle is dissected up. Four inches of the tenth rib are resected; the gutter left by the removal of the bone is closed by catgut suture. This gutter can be pushed against the diaphragm by two fingers of an assistant, and while the pressure is being made an incision is carried along near the upper border of the eleventh rib. The incision goes directly into the peritoneal cavity through the layers of chest wall and through the diaphragm, but, as the parietal pleura is being pressed directly against the diaphragmatic pleura, pneumothorax does not occur. The edges of the chest wall and diaphragm are clamped together and sutured, the pleural cavity being thus closed. The liver is exposed and may be aspirated for exploration, or an abscess can be drained at once or after causing adhesions by gauze, as previously described. The best record given for incision and drainage shows a death-rate of 10 per cent. (Ludlow in "The China Med. Jour.," Feb., 1924).

Rogers and Wilson ("Brit. Med. Jour.," June 16, 1906) advocate aspiration and examination of the pus. If amebæ only are present, they inject a solution of quinin, a material quickly fatal to amebæ. The dose is 30 gr. of bihydrochlorate of quinin in a sterile solution. If the abscess holds less than 10 oz. of matter the quinin is given in 2 oz. of fluid; if it holds more, in 4 oz. of fluid. The authors report 2 cases cured by this method.

Aspiration as a treatment is favored by a number of men of wide experience. A. I.

Ludlow, of Korea, proceeds as follows ("The China Medical Jour.," Feb., 1924): Aspirate at the point of most marked swelling and most severe tenderness. The usual spot selected is in the ninth interspace, anterior axillary line. A local anesthetic is employed. The needle may be passed to a depth of 3 or 4 inches. If pus is found a small skin incision is made and a trocar is inserted. The pus is aspirated by means of a glass syringe fixed to the cannula by means of a rubber tube. If the pus is too thick to run freely inject 20 to 30 c.c. of Dakin's fluid. Empty the cavity as well as possible. If tenderness and swelling recur, aspirate again. If the pus is too thick for aspiration, incision is demanded. All of Ludlow's 10 cases recovered. Manson-Bahr ("Lancet," 1923, vol. i) reported 15 cases cured by aspiration and medical treatment.

Treatment of Traumatic Abscess.—Same as for tropical abscess.

Treatment of Pyemic Abscess.—Surgery is usually futile, because multiple abscesses exist, but an operation should be performed in the hope that it may do good. In a case in the Jefferson Hospital in which abscess of the liver followed appendicitis the patient recovered after operation.

Hepatoptosis (Floating or Movable Liver).—Hepatoptosis may be congenital, but is usually acquired. In a congenital case certain ligamentous supports of the liver are absent. In the following discussion the acquired form is the variety referred to. This condition is rare. Ninety-eight cases had been reported over twenty years ago.[1] It is a form of splanchnoptosis and is due to relaxation of the abdominal wall and stretching of the supports of the liver. It may occur alone, but it is more often a part of a general abdominal relaxation or of Glénard's disease, and often a kidney is movable, or uterine displacement or hernia may exist. The liver may descend into the lower abdomen, may be upside down (Demarquay), may rotate on its transverse axis (Griffiths), the anterior surface may become posterior, or the organ may lie with the superior surface in the right flank and the inferior surface looking to the left,[2] may be movable, or may be anchored by adhesions. It is most common in women. The liver is supported by ligaments and also by the inferior vena cava (which is firmly adherent to the central tendon of the diaphragm—Faure), by the abdominal wall, and by the distended intestines (Glénard). The cause of the condition is in dispute. It can result from relaxation of the belly wall, relaxation of the ligaments, enteroptosis, great enlargement of the gall-bladder, increase in weight of the liver, atrophy of the connective tissue between the liver and diaphragm, pregnancy, the growth of a liver tumor, and tight lacing. Either a strain, cough, or the dragging of an adherent tumor may be the exciting cause.

Signs and Symptoms.—An abdominal mass may appear suddenly after a blow or a strain, and if it does appear suddenly there are always pain in the hepatic region, nausea, and weakness. When the condition comes on gradually there may be no symptoms for a long time, but, as a rule, there is some pain in the loin which becomes worse after exercise or effort. In rare cases jaundice appears, and occasionally there is ascites. The abdominal walls are relaxed and the signs of splanchnoptosis are manifest. When the patient stands, a transverse furrow of skin covers the lower part of the umbilicus (*Glénard's sign*). In most cases the shape, the movability, and the absence of the liver from its proper position are diagnostic. Even when the organ is dislocated and attached in its new situation, it is missed from its proper abode, and palpation outlines the characteristic shape. When the patient lies down the liver usually returns to place and in most cases it can be restored by manipulation. In some cases, however, it will not return to place and cannot be restored by manipulation. A floating liver causes a recognizable enlargement in the right loin, and the mass usually moves on respiration.

Treatment.—In many cases the patient can be kept comfortable by wearing an abdominal support, and can be distinctly improved by the application of massage and electricity to the abdominal wall, the administration of tonics, and a course of forced feeding. If these means fail and the patient suffers, an operation should be performed. The operation of *hepatopexy* was devised by Marchant. He opens the abdomen and tries to restore the liver to its proper position. This can usually be accomplished. In some cases it can be done after adhesions have been separated. In other cases it can be only partially accomplished. After the liver has been restored he sutures it by means of catgut or silk to the abdominal wall or costal cartialges, the stitches passing through the hepatic parenchyma and being carried through the liver by means of a round and blunt needle. The sutures attaching the liver to the belly wall are tied beneath the skin. Marchant scarified the dome of the liver in order to favor adhesions.

[1] J. H. Carstens, "Jour. Amer. Med. Assoc.," May 17, 1902.

[2] Terrier and Auvray, "Rev. de Chir.," Aug. and Sept., 1897.

Ramsay rubs the upper surface of the liver with gauze to promote adhesion and transfixes the round ligament with a suture which is carried around the cartilage of the seventh rib. In a severe case Depage advises us to associate hepatopexy with an excision of a portion of the abdominal wall to amend relaxation (*laparectomy*). If, in operating on a floating liver, it is found impossible to get the liver back into its normal position, fix it with sutures as near its proper abode as is possible. Terrier and Auvray report 11 cases of hepatopexy. One case died and 8 completely recovered.

Floating Hepatic Lobe (Partial Hepatoptosis).—This condition is not uncommon in cases of chronic disease of the gall-bladder and it may be found in cholelithiasis. It is believed that it can be caused by tight lacing. A tongue-like projection forms upon the right lobe of the liver (*linguiform lobe, lacing lobe*). It can be palpated below the costal margin and the dulness of the mass on percussion is continuous with liver dulness. A linguiform lobe can usually be moved laterally and forward and backward; it is always tender and is sometimes the seat of pain.

Treatment.—When this condition is associated with gall-bladder trouble, it may disappear, or at least cease to cause pain, after the gall-bladder has been removed or has been drained by cholecystostomy. Langenbuch has successfully removed a linguiform lobe.

Rupture of the Gall-bladder and Bile-ducts.—This is a very rare accident unless there is distention from blocking. It may be due to a blow, a kick, a fall, a squeeze, or a sudden muscular effort. Bile escapes either into the abdominal cavity, the intestine, or into a space surrounded by adhesions. In 70 per cent. of cases of rupture into the abdominal cavity jaundice arises, usually after a day or two, but in rare cases not for a week or more. If the common duct is ruptured the jaundice is intense and fecal motions contain no bile. In rupture of the gall-bladder the jaundice is moderate and there is bile in the movements (Courvoisier). In at least half of the cases a swelling forms beneath the liver. If bile is not infected symptoms may be slight and slow in development. If the bile is septic, symptoms are early and severe and the danger is great. The abdomen should be opened. A gall-bladder should be drained or, if there is no block in the common duct, removed. A duct may be sutured or, if suturing is not feasible, drained, or anastomosed to the duodenum.

Cholecystitis (Inflammation of the Gall-bladder).—Inflammation of the gall-bladder is produced by infection. Healthy bile is sterile; and when bacteria are found in the bile, the condition is one of disease. Micro-organisms may find entrance into the gall-bladder by way of the blood, the bile becoming infected secondarily to the infection of the gall-bladder; or they may enter by way of the ducts, from the intestine. The conditions that follow infection depend upon the characteristic tendency and the virulence of the infecting germs. A trivial infection produces mucous catarrh; a more active infection causes suppuration, and possibly ulceration; a very violent infection leads to gangrene. Torsion of the gall-bladder is in very rare cases a cause of gangrene.

In most cases of cholecystitis an inflammatory swelling blocks the cystic duct, and obstructs it so that the bile stagnates in the gall-bladder. In many cases this condition lasts but a short time, and when the obstruction is relieved, bile again flows down the duct. Occasionally, as a secondary consequence, cholangitis (infection of the bile-ducts) follows.[1] Occasionally, also, the obstruction of the duct is not relieved, and a quantity of clear, thin mucus gathers in the gall-bladder and overdistends it—the condition known as *hydrops*. The gall-bladder may likewise become distended with pus, constituting an *empyema* of the gall-bladder; and any overdistended gall-bladder may rupture. A gall-bladder may distend to a most enormous size. Terrier reported a case of distended gall-bladder in which the viscus contained 42 pints of fluid. F. W. Collinson ("Brit. Med. Jour.," May 29, 1909) reports the case of a woman thirty-one years of age who was tapped twice before operation and at each tapping 25 pints of fluid were withdrawn. At the operation 22 pints were obtained. Collinson's case arose from blocking of the common duct as a result of traumatism, followed by kinking of the cystic duct and subsequent opening of the common duct. In cases of very chronic inflammation of the gall-bladder this structure becomes fibrous and contracts, until it may become no larger than the thumb, in which condition it may contain a very small amount of thickened bile. In some inflammatory conditions due to infection the bile mixes with thickened mucus, and micro-organisms form the nucleus upon which bile salts are deposited to form gall-stones. Cholelithiasis may result from cholecystitis, and may maintain chronic cholecystitis because the stones existing in a gall-bladder are sources of irritation.

[1] Joseph McFarland, "Proceedings of the Phila. County Med. Soc.," Sept., 1902.

Bacteriology of Cholecystitis.—It has been proved by abundant observation that the fact that bile contains micro-organisms is no evidence that the gall-bladder is inflamed; but that when the gall-bladder is inflamed micro-organisms are demonstrable in the bile. We know that the bile is infected during the course of typhoid fever, and that it is frequently so in pneumonia. The colon bacillus is not unusually demonstrable in cholecystitis; and pus cocci, either in pure culture or mixed with other germs, constitute the most common cause of the inflammation. It is probable that bacteria entering the gall-bladder and not being particularly virulent produce no immediate harm when the flow of bile is unobstructed, though even then they may become the nuclei of gall-stones; but if the bacteria are very virulent they may actually lead to obstruction. Stagnation of the bile favors infection, and infection may be the cause of stagnation. Each influence reacts upon the other and aggravates the other, and it seems more than possible that infection of the gall-bladder is to be regarded as serious only when there is obstruction to the outflow of bile. The same variety of germ may, under some circumstances, cause catarrhal, and under others suppurative inflammation; that is, when bacteria are virulent and tissue resistance is slight, suppurative cholecystitis results; but when the bacteria are not virulent and the tissue resistance is powerful, the gall-bladder is not infected at all, or only catarrhal inflammation is produced. I operated upon a case of acute suppurative inflammation of the gall-bladder three weeks after the termination of an attack of typhoid fever. The culture taken from the gall-bladder showed an unidentified bacillus, which was not the colon bacillus or the paracolon bacillus, and which was not identifiable as the typhoid bacillus or the paratyphoid bacillus. It strongly resembled the typhoid bacillus, but possessed no agglutinative power (the author in "New York Med. Jour.," April 8, 1905).

A patient in the medical ward of the Jefferson Hospital was supposed to be developing a typhoid relapse, but no fresh spots appeared, and there were pain, tenderness, and rigidity in the region of the gall-bladder. I operated and found the gall-bladder full, dark colored, and surrounded by numerous recent adhesions. It could be emptied slowly by pressure. There was no pus. It was drained and the symptoms promptly passed away and the man recovered. The culture was reported sterile. I cannot understand this finding, as inflammation undoubtedly existed. It may have been peritonitis rather than cholecystitis, but from what cause is unknown. No culture was taken from the peritoneal cavity. The finding of sterile bile at the end of an attack of undoubted typhoid is of interest.

Catarrhal Inflammation of the Gall-bladder and Bile-ducts.—This condition is known as catarrhal jaundice, acute or chronic, and is usually treated by the physician; but, as A. W. Mayo-Robson points out, chronic catarrhal jaundice sometimes resembles the jaundice of organic disease, and is occasionally associated with gall-stones, malignant disease, or hydatid cyst. Chronic catarrhal jaundice may lead to catarrhal pancreatitis, and result from interstitial pancreatitis and duct obstruction. This condition usually comes on without pain. If there be pain it means some complication. Robson ("Surg., Gynec., and Obstet.," Jan., 1908) names among such complications catarrhal cholecystitis, cholangitis, gall-stone, and duodenal ulcer. The jaundice is striking. It is often accompanied by itching. There is loss of flesh and anemia, and the liver is enlarged and smooth. Robson tells us that if the gall-bladder is not shrunken from stone, and if there is great duct obstruction, the bladder will be distended. Chills and fever mean infective cholangitis. In a case of chronic catarrhal jaundice in which medical treatment fails surgical treatment must be considered (cholecystostomy, cholecystgastrostomy, or cholecystenterostomy).

Catarrhal Cholecystitis.—This is a catarrhal inflammation of the gall-bladder usually without jaundice. The gall-bladder becomes thick and its mucous membrane is frequently plicated. Very thick mucus is secreted, which gathers in masses, and the descent of these plugs causes pain that is sometimes indistinguishable from that produced by the passage of a gall-stone. Such a plug may temporarily block the cystic duct. In catarrhal cholecystitis the gall-bladder is frequently distended, but rarely admits of palpation; and there are no adhesions to surrounding structures unless gall-stones are or have been present (Robson). Catarrhal cholecystitis may lead to the formation of gall-stones; may result from the presence of gall-stones; or may be found in cases in which gall-stones have been present, but have passed. In 1 case upon which I operated the gall-bladder was enlarged, thick, and without adhesions; the mucous membrane was convoluted; and the viscus was filled with thick, tenacious mucus, and the mucous membrane of the gall-bladder contained many minute concretions. In this case stone formation was probably

beginning to follow upon catarrhal cholecystitis. In another case a woman had presented violent symptoms of gall-stone colic, and stones had been recovered from the feces; but on opening the gall-bladder no stones were found—only a condition of catarrhal cholecystitis. Jaundice is rare in catarrhal cholecystitis unless gall-stones are present; it is, however, occasionally noted. Even if jaundice does occur, it is slight and lasts but a short time. The painful attacks that occur during catarrhal cholecystitis are similar to gall-stone attacks, but the pain is less violent and of briefer duration, and jaundice is not apt to follow the passage of a plug of mucus and is apt to follow the passage of a gall-stone. Further, as Robson has shown, in catarrhal cholecystitis with gall-stones there may be tenderness, but there is rarely tenderness in uncomplicated catarrhal cholecystitis.

Treatment.—An *x*-ray should be taken. It may give valuable information. The majority of the cases recover under medical treatment. If a case fails to recover under medical treatment, one cannot be sure whether there are gall-stones or not, but an operation is indicated in either case. Cholecystostomy should be performed and the gall-bladder should be drained for a week or two. This treatment will almost always produce cure.

Croupous Inflammation of the Gall-bladder and the Bile-ducts.—This is an extremely rare condition, due to the formation in the bile-passages of a thick membrane which causes obstruction to the flow of bile and spasmodic contraction of the gall-bladder. The symptoms are identical with those of gall-stones. Robson points out that a study of the evacuations may discover membranous intestinal casts; and that, as membranous enteritis is usually associated with croupous inflammation of the gall-bladder and bile-ducts, a diagnosis may thus be reached. The same author says that one may, in some cases, even find a cast of the gall-bladder in the evacuations.

Treatment.—If medical treatment fails, cholecystostomy should be performed and drainage should be employed for a considerable time.

Suppurative Inflammation of the Gall-bladder and Bile-ducts.—Adopting the classification of Mr. Robson, we divide these suppurative inflammations into simple suppurative cholecystitis, suppurative and infective cholangitis, phlegmonous cholecystitis and gangrene of the gall-bladder, ulceration of the gall-bladder and bile-ducts, pericystic abscess with adhesions, and certain consequences of these conditions, such as stricture of the gall-bladder and bile-ducts, perforation of the gall-bladder and bile-ducts, and fistula of the gall-bladder and bile-ducts. Suppurative inflammations of the gall-bladder and the bile-passages are due to infection by virulent organisms or to infection when the tissue resistance is at a low ebb.

One fact must strike the physician in regard to these cases; that is, that there is a strong similarity between the possible changes of acute cholecystitis and the possible changes of acute appendicitis. In the gall-bladder, as in the appendix, there may be a catarrhal inflammation, which may not advance beyond this stage, or which may advance into a more dangerous form; in each structure blocking and stagnation favor infection and aggravate existing infection; in each there may be suppuration, ulceration, gangrene, and perforation; in each there may be grave complications and disastrous and fatal consequences; and in each prompt surgical operation is usually life-saving.[1]

Simple Suppurative Cholecystitis.—This condition is also spoken of as *suppurative catarrh* of the gall-bladder or *simple empyema* of the gall-bladder. It is a rare condition unless gall-stones exist or unless some infectious disease—especially typhoid fever—has antedated the condition. I operated for this condition upon a boy eleven years of age three weeks after the termination of an attack of typhoid fever. It is not only typhoid fever that may be causative, but also other continued fevers. No matter, however, what organism is primarily responsible—be it colon bacillus, typhoid bacillus, or what not—a mixed infection with pyogenic cocci usually takes place. Pyogenic cocci alone may be causative. In simple suppurative catarrh of the gall-bladder, when the duct becomes blocked, the condition known as simple empyema exists; and when hydrops of the gall-bladder undergoes suppuration simple empyema is produced.

In an ordinary case of suppurative catarrh associated with gall-stones one obtains the history of a number of attacks of biliary colic, the pain finally having become localized and persistent instead of radiating and intermittent, and a definite swelling being palpable in the gall-bladder region. This swelling is tender on pressure. There are usually constitutional symptoms, sometimes trivial, often severe. The trivial symptoms are a somewhat rapid pulse, sweating at night, and some elevation of temperature. The more severe symptoms are chills, a remittent fever, and profuse sweats.

[1] The author, "Proceedings of Phila. County Med. Soc.," Sept., 1902.

The development of severe symptoms indicates that a dangerous change is taking place —usually ulceration of the gall-bladder, occasionally phlegmonous cholecystitis. Distinct jaundice is rare in simple empyema, though the patient usually shows loss of flesh, has a very poor appetite, and suffers considerably from thirst.

To distinguish an enlarged gall-bladder from any other intra-abdominal mass is sometimes difficult. Very large gall-bladders, such as have been placed on record by Collinson, Terrier, Lawson Tait, Gersuny, and others, may be mistaken for ovarian cysts. Alban Doran discusses such cases in the "Brit. Med. Jour.," June 17, 1905. An enlarged gall-bladder moves on respiration unless the mass becomes adherent to the abdominal wall, when it will cease to do so. An enlarged gall-bladder is sometimes mistaken for a movable kidney, and the diagnosis between these conditions is discussed in the section on Movable Kidney (see page 1275).

Treatment.—The gall-bladder should be removed or should be opened and drained by the operation of cholecystostomy. After it has been exposed, gauze pads are packed about the viscus to prevent contamination of the peritoneum. A considerable portion of the bile is removed through an aspirator. If cholecystostomy is chosen, the gall-bladder is opened and irrigated with salt solution, and a search is made for any cause of obstruction in the cystic duct. This cause should be removed, and any gall-stones that are present should, of course, be taken away. The walls of the gall-bladder will frequently be found diseased and softened, so that it is impos-

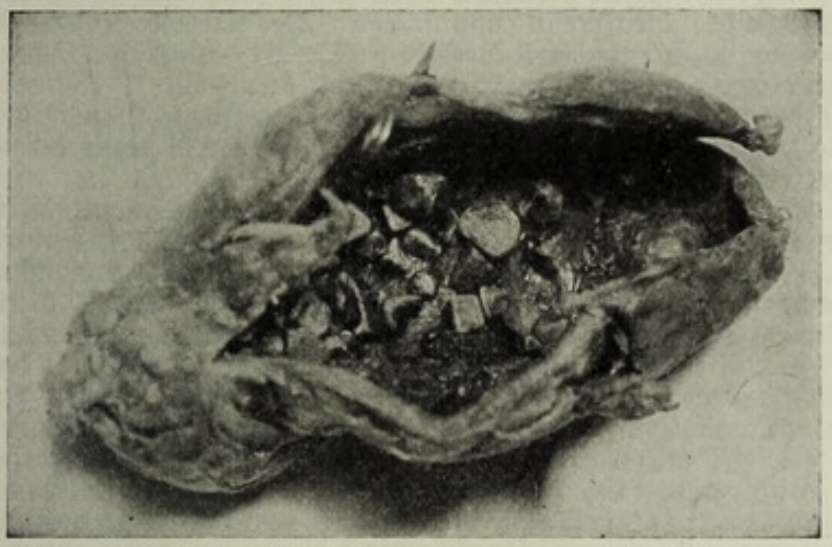


FIG. 776.—Gall-bladder filled with calculi. Removed by cholecystectomy.

sible to apply stitches. If the gall-bladder is badly diseased it should be removed, if the ducts are free. If the ducts are involved, incision with drainage is preferred, and secondary cholecystectomy is advised.

Recurrent Simple Empyema of the Gall-bladder.—In this condition a person develops, at intervals, pain, fever, tenderness, and enlargement of the gall-bladder. Then the symptoms clear up and he is well for a time, but they again become manifest; and at last they may become persistent or violent because of the development of some complication. In these cases it is impossible, after a number of attacks, to palpate any enlargement of the gall-bladder; and when an operation is performed the gall-bladder is found shrunken, thickened, and deeply placed, containing some purulent matter, and strongly fixed to the surrounding structures by adhesions.

Treatment.—Cholecystectomy is usually the proper operation.

Acute Phlegmonous Cholecystitis.—Some call this condition *acute empyema*. It is extremely dangerous, and is apt to cause gangrene of the gall-bladder. It is due to infection by extremely virulent organisms. It may, even without perforation, produce rapid peritonitis and death. As a rule, in advanced cases perforation takes place. It is generally associated with the presence of calculi, but sometimes none are found; and the condition sometimes develops during typhoid fever or septicemia.

This disease begins with sudden and violent pain in the gall-bladder region. This pain usually radiates toward the right shoulder-blade, and soon becomes general throughout the abdomen. There are tenderness in and great rigidity over the gall-bladder region, thoracic respiration, exhausting vomiting, septic fever, and in some cases jaundice. If an operation is not performed promptly general peritonitis quickly

takes the patient's life. In one case upon which I operated there were intense jaundice, tenderness, violent pain, abdominal rigidity and distention, chills, and septic fever; and when the abdomen was opened it was found that a portion of the gall-bladder was gangrenous and that a calculus projected through the gangrenous opening.

It is this form of cholecystitis that is especially likely to be mistaken for appendicitis. In making a diagnosis the situation of the primary pain is of importance, and likewise the situation of the tenderness; but a displaced gall-bladder or an abnormally situated appendix may lead to error. Acute phlegmonous cholecystitis is usually accompanied by absolute constipation, and the sudden onset and the abdominal distention may lead to the disease being mistaken for intestinal obstruction. It may also be confused with perforating ulcer of the stomach or of the duodenum.

Treatment.—In any case of doubt an exploratory incision should be made. If phlegmonous cholecystitis is found to exist, the gall-bladder should, whenever possible, be extirpated; but if the desperate condition of the patient forbids this operation, the bladder should be incised, surrounded with iodoform gauze, and a drainage-tube should be carried well up toward the cystic duct. Secondary cholecystectomy may be required.

Pericystic abscess may follow infection of the gall-bladder. It is especially common in the condition known as recurrent simple empyema. When a pericystic abscess exists there are great localized abdominal tenderness and rigidity and the temperature is usually indicative of suppuration. The causative micro-organisms may have passed through a diseased gall-bladder wall, rupture not existing; or the abscess may follow ulceration or perforation of the gall-bladder wall.

Treatment.—Operation should invariably be performed, though it is frequently difficult. After a pericystic abscess has been drained it will be found necessary, as a rule, to extirpate the gall-bladder.

Infective Cholangitis (*Inflammation of Bile-ducts*).—Cholangitis is usually inaugurated by the infected bile, but when it arises during a general infection the bacteria may be brought by the blood. It may arise in a case of hepatic cirrhosis. Naunyn ("Deutsche medizinische Wochenschrift," Berlin, Nov. 2, 1911) says that most germs can cause cholangitis; that mixed infection may occur, and that during an acute general infection cholangitis is seldom recognized. The usual cause of infective cholangitis is gall-stones lodged in the common duct. Some maintain that duct-stones are causal, particularly in those cases in which a gall-stone acts as a ball-valve. A. W. Mayo-Robson, though he believes that infective cholangitis does occur when the gall-stones are freely movable in the common duct, sets it forth as his experience that it is much more common in such cases to find gall-stones impacted in the common duct.

In such cases the patient gives a history of attacks of gall-stone colic without jaundice for several years, and then of attacks followed by temporary jaundice (see page 1032). Finally comes an attack that is followed by a chill and fever; and jaundice, varying in intensity, ensues upon this, and now, though it may fade, it seldom completely disappears between the attacks of pain. The interval between the attacks may be short or long, and the rigors may be repeated daily or at uncertain intervals; the gall-bladder is usually, but not always, contracted; and after the condition has persisted for some time the liver becomes distinctly enlarged. There is tenderness over the gall-bladder or in the epigastric region, loss of flesh, and persistent jaundice which may vary in hue.

Infective cholangitis, even after it has lasted for a considerable length of time, may be recovered from; but it may pass on into an acute condition in which poisoning takes place from the biliary elements, suppurative cholangitis may arise, an empyema of the gall-bladder may develop, and there may be an abscess of the liver or some other dangerous or fatal complication. The ague-like attacks of infective cholangitis have been called by Charcot *intermittent hepatic fever* (see page 1033).

Treatment.—After an incision has been made the common duct is opened, the cause removed, and drainage is put down to the duct. Stones are removed from the gall-bladder and the viscus is drained. Later cholecystectomy may be required; but, as Mr. Robson points out, the complication should be anticipated by the prompt removal of stones. When one finds that carefully applied medical treatment has failed to free the patient from gall-stones, the calculi should be removed surgically.

Suppurative cholangitis is usually a development of the ordinary infective cholangitis, which has just been discussed. Among the other causes that Robson sums

up are acute infectious diseases, particularly typhoid fever and influenza, cancer of the bile-ducts, and hydatid disease.

In this condition the liver enlarges notably and becomes tender. In some cases there is empyema of the gall-bladder, but this is rare; in fact, the gall-bladder is usually very much shrunken. When, in a chronic case, there are enlargement of the liver, blocking of the common duct, and enlargement of the gall-bladder the inference is in favor of cancerous obstruction of the common duct. If the obstruction is due to cancer there will usually be little pain; but when it is due to gall-stones there will be violent attacks of pain, accompanied by rigors and fever, with deepening of the jaundice. In this disease there is always jaundice, usually unfading; but in cases of ball-valve gall-stone in the duct it will be mitigated from time to time (see page 1033). The patient suffers from septic fever and there is very rapid loss of flesh.

The condition is generally fatal unless operation is performed early. There is a strong tendency for abscess of the liver to form, and in 1 case upon which I operated a subphrenic abscess had developed.

Treatment as for infective cholangitis. If an abscess of the liver exists, it should also be drained. If gall-stones are gathered in the common duct they should be removed.

Typhoid Cholecystitis.—Typhoid bacilli were first found in the bile by Futterer in 1888, and typhoid cholecystitis was first described by Girode in 1890. As previously stated, typhoid bacilli are usually present in the bile during, and perhaps are present months or years after, an attack of typhoid fever. They are not always present, however, for in a case of cholecystitis following typhoid on which I operated an unidentified bacillus was found ("New York Med. Jour.," April 8, 1905); in a case on which I had made an artificial anus for typhoid perforation and subsequently performed intestinal resection I drained a greatly distended gall-bladder at the second operation and cultures of the bile remained sterile; and in a case of typhoid with distended and apparently inflamed gall-bladder on which I operated the bile was reported to be sterile. Because typhoid bacilli are usually present in the bile during typhoid does not mean that most cases of typhoid have cholecystitis. Cholecystitis is not very common, and arises when bacilli are very numerous or very virulent, when vital resistance is lowered, when there has been an antecedent inflammation of the gall-bladder, when there are gall-stones, and particularly if there is a block of the duct causing stagnation of bile. Bacilli in bile may do no harm at all, but they may cause catarrh, purulent catarrh, suppuration of the gall-bladder walls, suppuration outside of the gall-bladder, or perforation. When bile or inflammatory exudate contains typhoid bacilli, agglutinins are present and may precipitate masses which become nuclei for gall-stones.

The usual period for cholecystitis to arise is during the third week of the fever, but it is not uncommonly met with during convalescence and is perhaps mistaken for a relapse.

The condition may arise months or a year after the attack of typhoid, and yet a pure culture of typhoid bacilli may be obtained from the gall-bladder. Strange to say, cases of cholecystitis have been operated on in persons giving no history of having had typhoid, and typhoid bacilli have been obtained from the gall-bladder. I operated upon such a case. Such a person may have had a very mild attack of typhoid, or he may be immune to typhoid fever and yet the bacillus may be capable of causing inflammation. Many cases of typhoid cholecystitis are probably unrecognized because of the trivial symptoms, or because a high position of the liver renders the real seat of pain obscure, because the general symptoms are uncertain, because toxemia blurs perception of pain, or because the condition is confused with appendicitis. It is rare in children, more common in adults. Most infections result from the bacilli ascending the common duct, some are by way of the lymphatics (Charles H. Mayo), some by an adhesion of the gall-bladder to the bowel, some by way of the portal circulation and the bile-ducts. Mixed infection may occur, and a secondary staphylococcus infection may be followed by disappearance of the typhoid bacilli. The symptoms of typhoid cholecystitis are pain and tenderness in the gall-bladder region, rigidity of the upper half of the right rectus muscle, perhaps a palpable mass, an elevated and remittent temperature, sweats, perhaps jaundice, and sometimes leukocytosis. In some cases perforation occurs. Erdmann reported 1 case and collected from literature 34 cases of perforation ("Annals of Surgery," June, 1903).

Treatment.—In an ordinary case without perforation we may incise and drain the gall-bladder; but, if the ducts are free, we should prefer cholecystectomy. If perforation exists, do cholecystectomy if possible; if not, drain. No attempt should be

made to suture the perforation. If perforation exists and operation is not done, death is practically certain. Of 27 cases not operated upon, all died; of 7 cases operated upon, 4 recovered (Erdmann).

Gall-stones were mentioned in the sixth century A. D. by Alexander Trallianus. They are formed during life in the gall-bladder or bile-ducts by the agglutination of materials which have been precipitated from bile. The nucleus of a gall-stone may be a mass of bacteria, a blood-clot, epithelium, crystals of cholesterin or carbonate of lime, or a cast of a small duct.[1] A condition of the body thought to lead to the formation of gall-stones is designated by the term *cholelithiasis* (Brockbank). But one stone may be present or great numbers may exist. Solitary stones may be nearly round or cylindric. When several stones or many stones exist the mutual pressure often leads to the formation of facets (Naunyn). In color calculi may be pale yellow, green, black, or brown. Some are heavier than bile and some are lighter. Brockbank gives the following varieties of gall-stones: pure cholesterin stones, stratified cholesterin stones, common or gall-bladder calculi, mixed bilirubin-calcium calculi, pure bilirubin-calcium calculi, and certain rare forms.[2] Gall-stones usually take origin in the gall-bladder, but may arise in the common duct, the cystic duct, the hepatic duct, or the smaller ducts of the liver. As a rule, however, calculi in the common or cystic duct were not formed there, but were transported from the gall-bladder or hepatic ducts.

Causes.—Gall-stones are very commonly found postmortem. In Germany it is estimated that they are found in 12 per cent. of all necropses. In 1655 autopsies in the Johns Hopkins Hospital gall-stones were present in 6.94 per cent. of all cases.[3] The usual estimate is 5 per cent. of autopsies. The cause is a catarrhal condition of the bile-ducts, due particularly to the entrance of bacteria from the intestine (colon bacilli, typhoid bacilli, pus organisms, pneumococci). This catarrhal condition causes stagnation of bile. Healthy bile is sterile, but not germicidal, and bacteria will grow in it. Bacteria have been found in bile years after the termination of an attack of typhoid fever. Experimental infection of the gall-bladder producing mild cholecystitis is almost always followed by gall-stone formation.[4] Welch pointed out that a recent gall-stone has bacteria in its center. Cushing tells us that 30 per cent. of gall-stone cases operated upon in the Johns Hopkins Hospital had previously suffered from typhoid fever, but the experience of the Mayos is not in accord with this opinion. In view of the fact that bile containing typhoid bacilli may contain agglutinins we can understand how masses could be precipitated to form nuclei—30 per cent. of Ochsner's cases had had appendicitis.

The chief predisposing causes are advancing years, insufficient exercise, the daily consumption of unnecessarily large quantities of food, gouty tendencies, and conditions which interfere with the emptying of the gall-bladder. Cardiac disease and cancer of the liver predispose. Gall-stones rarely form before the age of thirty-five. The youngest patient from whom I have removed stones was a girl of twenty. The disease is more common in the insane than in the mentally sound, in the white race than in the black, and in women than in men. In 25 per cent. of all females beyond sixty years of age gall-stones are present (Naunyn). The special liability of women may be brought about by tight lacing, pregnancy, inactivity, or movable right kidney. Stout and lazy women are particularly liable to gall-stone formation, and women who have borne children are far more liable than those who have not. Total abstainers seem to possess a greater predisposition than users of alcohol, probably because they are more apt to be large eaters (Herbert F. Waterhouse in "Lancet," May 8, 1909). There are two forms of the condition to be considered: the acute type, due to efforts made by the gall-bladder or duct to expel the concretion; and the chronic condition, in which a calculus is lodged for a long time, or in which, as soon as one calculus is passed into the intestine, "another begins its journey" (Brockbank's treatise on "Gall-stones"). The fact that bacteria may cause the condition must not lead us to infer that pus is of necessity formed. If the bacteria are present in small numbers, or if their virulence is greatly mitigated, they produce catarrhal inflammation only, the bile stagnates, and a stone forms. There may be one stone, two, several, or many stones. I have removed 400 from a patient. Other surgeons have removed 1000 or more. In one case some were lost but 3370 were counted (Stretton in "Brit. Med. Jour.," Jan. 26, 1924). Multiple stones are usually faceted. Solitary stones are not faceted.

[1] Bevan in "Chicago Med. Recorder," April, 1898.
[2] Brockbank's treatise on "Gall-stones."
[3] C. D. Mosher in "Johns Hopkins Hosp. Bull.," Aug., 1901.
[4] Gilbert in "Archives générales de méd.," Aug. and Sept., 1898.

Many observers believe that inflammation of the mucous membrane causes the secretion of quantities of cholesterin, which forms a large part of most gall-stones. Others maintain that cholesterin is a normal constituent of bile and is not obtained from the mucous membrane.

Bachmeister ("Münch. Med. Woch.," Feb. 18, 1908) demonstrates that if pure sterile bile is permitted to stand for a considerable time cholesterin will be precipitated, and that if epithelial cells are added to this the cholesterin will be precipitated much more rapidly. The catarrhal inflammation furnishes quantities of epithelial cells and the cells precipitate cholesterin, and in this way inflammation causes gall-stones. Aschoff ("Progressive Med.," June, 1914) maintains that gall-stone predisposition depends on the amount of cholesterin in the blood and bile.

The blood certainly contains cholesterin (0.16 to 0.18 per cent.). The cholesterin content is increased by a diet of meat, eggs, fat, fish, etc. It is increased by nephritis, diabetes, arteriosclerosis, pregnancy, and lactation. When the blood holds an excess of cholesterin a first attack of colic may be due to sudden precipitation of cholesterin in a normal gall-bladder. Such an attack is afebrile and the solitary stone is round (Aschoff's theory, Ibid.). Pigmented stones and layered stones prove that inflammation has existed. This theory asserts that stones may form originally without inflammation, but that the presence of a stone favors inflammation. It is probable that when gall-stones exist they are all due to a common cause. It is not likely that one begins and then another, and so on. After a stone once begins it may progressively increase in size. In many cases the stone or stones never cause trouble. A gall-stone may begin to descend because of violent muscular exertion, external pressure, or at the onset of a fresh inflammation which leads to loosening of the stone. A very small stone usually passes freely. A larger stone in passing causes colic. A still larger stone remains in the gall-bladder, or becomes fixed in the cystic duct or in the common duct. In most cases gall-stones form in the gall-bladder. In some they form in the common duct if stones have previously existed in the gall-bladder. When the common duct retains a stone and is suffering from some degree of obstruction and from infection, stones not very unusually form in the hepatic ducts (Wm. J. and Chas. H. Mayo in "Amer. Jour. Med. Sciences," March, 1905). Stones are occasionally found at necropsy in the radicles of the hepatic duct.

Symptoms.—It is probable that the formation of a stone requires several months, and during the period of gastro-intestinal catarrh, which precedes and accompanies gall-stone formation, the *prodromal state* of Kraus, certain symptoms may exist, viz., constipation, flatulence, loss of appetite, migraine, uneasy sensations in the epigastrium or right hypochondrium, sallowness of the skin, slight yellowness of the conjunctivæ, scantiness of urine, which is saturated with uric acid, and may after a time contain a little bile. If this condition is not arrested by treatment, it grows worse. The abdomen becomes decidedly distended; pressure over the stomach or liver may cause distinct uneasiness or even pain; acid indigestion is very troublesome; violent attacks of migraine occur; constipation becomes more decided, the feces become clay colored, gastralgia may occur, the skin is apt to be very slightly jaundiced, itching is complained of, the patient is irritable and sleeps poorly. The liver is found to be enlarged and the urine contains distinct amounts of bile. When the patient reaches this stage, gall-stones have formed or are very liable to form. These symptoms may pass away even if a concretion forms. It is quite true that in some cases a stone exists for years without causing trouble. This is particularly true in elderly people. A stone seldom fails to cause symptoms, but often the symptoms are unrecognized. In many cases the symptoms which stones cause are thought to be due to disease of the stomach (indigestion, flatulence, pain after eating, pyloric spasm, etc.). Most of the cases I have seen, long thought they had stomach trouble, and the real condition was recognized only when there was a seizure of colic or an attack of inflammation.

As Waterhouse ("Lancet," May 8, 1909) says, the symptoms do not bear any relation to the size or the number of the stones. In fact, gall-stones give rise to active symptoms only when infection occurs or when the ducts become occluded and cease to drain, or when a stone starts to pass. If infection occurs, it may pass away spontaneously, but seldom does so. When a stone forms, pain is apt to become a marked feature of the case. John B. Murphy ("Med. News," Nov. 2, 1903) points out that in a person with stones in the gall-bladder there may be:

1. The pain of acute inflammation, the result of a severe infection. In this condition there are abdominal rigidity and contracted gall-bladder.

2. The pain of tension. In this there is not persistent abdominal rigidity, but pressure always causes sudden and transient tension of the belly muscles. *Murphy's method of demonstrating tenderness of the gall-bladder* is most valuable, and I always use it. It is as follows: Hook the fingers well up under the liver and tell the patient to take a deep inspiration. On inspiration pain becomes acute and respiration suddenly ceases.

3. Referred pain may exist with either of the above conditions. *Colic* is spasmodic pain, and means that a stone has left or is trying to leave the gall-bladder, and is in or is trying to enter a duct. Many persons with a stone or with stones in the gall-bladder never have colic. A sense of pressure or of soreness in the hepatic region, the result of cholecystitis, has added to it sudden and transient paroxysms of pain, due to the passage of thick bile from the gall-bladder and small ducts, or of gravel from the small ducts, urged on by bile pressure. When any stone but the very smallest begins to pass from the gall-bladder, violent colic is experienced. Such a colic usually comes on very suddenly, and often about three hours after a meal. It may, however, come on gradually, the patient complaining greatly of flatulence. In some cases it is so sudden and violent as to simulate perforation of the stomach or duodenum. The reason colic is particularly apt to come several hours after a heavy meal is that at that time bile is passing down into the intestine. A bladder containing calculi often tolerates the presence of the foreign bodies for an indefinite length of time, and then suddenly resents their presence and ejects them forcibly or tries to eject them. The pains are violent, spasmodic, and paroxysmal, and over the hepatic and epigastric regions, "radiating upward over the right half of the thorax" (Kraus), and passing particularly from the epigastrium to the right shoulder-blade. The pain radiation toward the right shoulder was pointed out by Glisson in the middle of the seventeenth century. The patient is profoundly nauseated and usually vomits. In many cases the vomiting is violent. The abdomen is distended and a condition almost of collapse is soon reached. The temperature is usually normal or subnormal, but is occasionally somewhat elevated. The patient may shiver and sweating may follow, but rigors are rare. The respirations are shallow, the patient groans, cries out, flings himself about in the bed, and often, in seeking relief, assumes some strange or contorted position. He frequently holds one hand over the liver region. His expression is indicative of intense suffering and apprehension and sometimes of abject terror. The pain is one of the most awful a human being can feel, and women who have felt it assert that the pains of parturition are trivial in comparison. The attack lasts a variable time, and terminates when the stone passes into the intestine or drops back into the bladder. The usual duration of an attack is from four to twenty hours. I have seen attacks that lasted three days, four days, or even five days, almost without intermission. It terminates suddenly if the stone passes or falls back in the gall-bladder. It abates very gradually if the stone becomes wedged in a duct. In many cases at the termination of the attack an enormous amount of clear pale urine is passed. During and for a time after the attack the gall-bladder may be very tender. After the cessation of colic, if the feces are examined carefully during several days, the stone may be discovered. The fact that no stone is discovered does not prove that one was not passed, because a cholesterin stone may be broken up in the intestinal canal. If the stone passes the duct, jaundice almost invariably follows the colic in from twenty to thirty-six hours and lasts several days. The jaundice results from the stone being in or having passed through the common duct. If stones do not pass from the cystic duct so as to enter or protrude into the common duct, jaundice does not occur. In 80 per cent. of my cases of gall-stones (excluding common duct cases) there was no history of jaundice. Even when a stone is lodged in the common duct jaundice may be slight or absent. When jaundice arises after a colic it comes on gradually, bile appears in the urine, and often, but not always, the stools become clay colored from absence of bile. Jaundice may be first noticeable in the urine or in the conjunctiva. The skin is apt to itch annoyingly, even atrociously. The patient is constipated and very thirsty. The liver is enlarged and tender and the spleen is enlarged. Some writers state that the pulse is slow in jaundice. My experience is in agreement with the much larger experience of Moynihan, who says: "I have not found any reduction in the pulse-rate in jaundice unless a degree of chronic pancreatitis is present" ("Gall-stones and Their Surgical Treatment"). If the stone becomes impacted, after a time the pains become gradually less violent, and may entirely cease. If it ceases and the stone does not move, pains do not recur; if the stone moves pains recur, and, usually, again and again the patient suffers from severe pain. An individual may get about when a stone is impacted, but again and again fierce attacks of colic

occur, and if the stone is wedged immovably in the common duct, producing absolute obstruction, the patient becomes and remains deeply jaundiced. Continued deep jaundice is seldom seen when stones are lodged in the common duct, because they are not often absolutely fixed and hence rarely produce complete obstruction. Usually the stone moves from time to time or is at least lifted, so that bile gets by it at intervals. This condition constitutes the *ball-valve stone*, and in it jaundice, though present more or less, is at times much more intense than at other times. It is a jaundice in which the hue is yellow, not deep brown, and it is a jaundice that wanes and deepens. It deepens after each colic and later wanes, but seldom entirely disappears while the stone remains in the duct.

In persistent jaundice due to gall-stones the gall-bladder is seldom enlarged. Courvoisier showed that when persistent jaundice is associated with enlargement of the gall-bladder the cause is usually pressure on the duct from without (malignant disease of the pancreas).

Slight jaundice is not always easy of recognition. Recognition is particularly difficult in sallow individuals and by artificial light. Moynihan praises Hamel's test for slight jaundice. It is made by drawing a little blood from a puncture of the lobe of the ear into a capillary tube and permitting the tube to stand for a few hours. If any jaundice is present the serum, which collects in the upper part of the tube, will be yellow (Moynihan).

In certain cases when a stone is lodged in the common duct an attack of colic is followed by or accompanied by a chill or chills, which may be very violent, moderate, or slight, and by a febrile seizure resembling malaria and called *hepatic fever* or *Charcot's fever*. The temperature rises rapidly, and in an hour becomes 104° F. or more, remains high for several hours, and then, with a profuse sweat, drops suddenly to normal. It may remain normal for a few hours, a day, two days, several days, or weeks. In this condition there are jaundice and tenderness of the liver. Charcot's fever is brief in duration. It usually means stone in the common duct. If stones are in the bladder, we are more apt to get a persistent slightly elevated temperature. These intermissions distinguish Charcot's fever from the remittent fever of sepsis, and the absence of the plasmodium in the blood and the history of colic distinguish it from malaria. The fever is due to intoxication with toxins from infected bile retained in the ducts by obstruction. The condition is ominous because it is due to infection, and may lead to inflammation of the large ducts (*cholangitis*).

The chart of Charcot's fever shows sudden elevations, precipitate descents, and complete intermissions. Moynihan calls it the "steeple chart" ("Gall-stones and Their Surgical Treatment"). When infection spreads widely in the smaller intrahepatic ducts the temperature becomes high and does not intermit. Continuous fever of this type has usually been preceded by Charcot's fever.

If a stone lodges in the cystic duct it does not cause jaundice unless an end of the stone projects into the common duct. It grows in size from incrustation, prevents the entrance of bile into the gall-bladder, and the bladder may shrivel and thicken or become distended and filled with mucus, the bile being absorbed (*hydrops* of the gall-bladder). If a bladder so blocked becomes infected, pus forms, and the condition known as *empyema* of the gall-bladder arises. An empyema of the gall-bladder may rupture into the bowel, the peritoneal cavity, or even through the skin.

The common duct is involved in 1 out of 5 or 6 cases of gall-stone disease.[1] Brewer points out that in 67 per cent. of common duct cases the stone is in the duodenal extremity, in 15 per cent. in the hepatic extremity, and in 18 per cent. in the middle. If a stone *blocks* the common duct, jaundice always exists and persists. Blocking may be complete and the stone may ulcerate into the bowel or the peritoneal cavity. Blocking may be incomplete, the stone acting as a ball-valve and producing *intermittent* colic and jaundice, which wanes and deepens (see above). Fenger pointed out that if a stone remains fixed in the common duct the liver becomes tender and enlarged, but if a stone floats about in the common duct the gall-bladder undergoes atrophy. In complete obstruction the stools become clay colored and bilirubin is found in the urine. Fluctuating jaundice, with attacks of pain and sudden high fever, and a shrunken gall-bladder are strongly suggestive of a "ball-valve" stone in the common duct. Persistent deepening, painless jaundice, the color of the skin becoming brown or even of a mahogany hue, associated with a distended gall-bladder, is strongly suggestive of malignant disease compressing the common duct. The above statements constitute *Courvoisier's law*. It is found true in 90 per cent. of cases. We may add that a persist-

[1] Robson in "Lancet," April 12, 1902.

ent jaundice, varying somewhat, and associated with pain or with actual colic, suggests blocking of the duct by an immovable stone.

Gall-stones may lead to suppurative inflammation of the gall-bladder or bile-passages, ulceration, occlusion of the neck of the gall-bladder, dilatation of the stomach from the formation of adhesions which kink the pylorus, pericystic abscess, peritonitis, empyema of the gall-bladder, and cancer of the gall-bladder. In cancer of the gall-bladder there are usually calculi present or there is a history of calculi. In cancer of the ducts gall-stones are seldom found, at least are seldom found in the ducts. Eddes collected 22 cases of cancer of the papilla. In 3 of these cases there were stones in the gall-bladder, in 1 there was a stone in the common duct ("Boston Med. and Surg. Jour.," March 7, 1901). If the patient develops distinct infection of the gall-bladder or bile-ducts, he will suffer from chills, fever, and sweats.

Gall-stones may lead to cirrhosis of the liver. A stone may ulcerate into the bowel and cause intestinal obstruction. It may be difficult to make a diagnosis between gall-stones with icterus and cirrhosis of the liver with icterus. In the former case the urine contains bilirubin and in the latter case urobilin. In less than half the cases gall-stones can be detected by the *x*-rays.

Treatment.—In the prodromal stage and after recovery from an attack of colic insist on the patient taking considerable outdoor exercise. Direct him to take a cold sponge-bath every morning, to move the bowels freely every day, and to employ a simple diet. He should avoid all highly seasoned foods, pastry, rich soups, fatty food, cheese, raw spirits, and sweets. Alkalies internally are of value. Those who believe that excess of cholesterin in the blood is responsible for gall-stone formation treat the condition as follows:

Rothschild's Diet (John C. A. Gerster, "Virginia Med. Semi-Monthly," Aug. 11, 1916).—Fast for three or four days. During the fast give all vegetables except peas, beans, and lentils. Give cereals, sugar, buttermilk free of fat, and skimmed milk. This diet is too rigid to be maintained, so feast for three or four days, adding lean meat, fish (except salmon, shad, and blue fish), and oleomargarine, but not butter. So periods of feast and periods of fast alternate.

During colic give a purgative enema, apply hot turpentine stupes over the hepatic region, and administer hypodermic injections of morphin and atropin. If vomiting does not occur, let the patient drink a large amount of warm water to favor it. After the attack administer a saline purgative.

When the attack has terminated, examine carefully for any evidence of inflammatory trouble in the hepatic region and sieve the feces in a search for stones.

In certain cases operation becomes necessary. Mr. A. W. Mayo-Robson[1] advises operation in the following cases: in frequently recurring biliary colic without jaundice, whether the gall-bladder is enlarged or not; in cases of enlargement of the gall-bladder without jaundice, even if there is no pain; in persistent jaundice which was ushered in by pain, painful seizures occurring, whether or not febrile attacks occur; in empyema of the gall-bladder; in peritonitis beginning in the gall-bladder region; in intrahepatic abscess and in abscess about the liver, gall-bladder, or bile-ducts; in some patients in whom the stones have been passed, but adhesions remain and produce pain; in fistula cases; in some cases of persistent jaundice due to obstruction of the common duct, although there may be a possibility of cancer existing; in phlegmonous cholecystitis and gangrene of the gall-bladder. Besides these conditions, which may be produced by gall-stones, Robson operates for wounds of the gall-bladder, infective and suppurative cholangitis, and for some conditions of chronic catarrh of the bile-ducts and gall-bladder.[2] The tendency to operate early for gall-stones is growing. It is true that stones *may* cause no trouble, but sooner or later they are apt to cause it, there is no tendency whatever to spontaneous cure, and medicine cannot dissolve them in the bladder. Early operations are easy and comparatively safe; late operations are difficult and dangerous, and by early operation dangerous complications (infection, adhesions, obstructive jaundice) are avoided. As Maurice H. Richardson[3] says: An early operation is less dangerous than the passage of a stone; complications are avoided or lessened; even if the diagnosis is wrong, the real condition may be found and removed. If obstructive jaundice exists operation is dangerous because of the possibility of fatal oozing of blood.

[1] On the "Gall-bladder and Bile-ducts."

[2] Robson's treatise, from which the above is taken, is a valuable exposition of the surgery of the gall-bladder and bile-ducts.

[3] "Boston Med. and Surg. Jour.," Sept. 5, 1901.

The common operation is *cholecystostomy*, which consists in opening the gall-bladder, removing the stones, and making a temporary fistula in the gall-bladder. The drainage may cure the diseased mucous membrane. The fistula is permitted to heal after the bile becomes sterile, hence many call the operation cholecystotomy rather than cholecystostomy. Operation should be done promptly and should not be delayed. Delay permits the gall-bladder to thicken and shrink, and allows the stone to enter the duct. After removing stones and draining the gall-bladder, symptoms may recur. Recurrence of symptoms may be due to a stone or stones having been overlooked, to renewed formation of stone, or to cholecystitis and bile-sand. After drainage gall-stones rarely re-form. Kocher has seen stones recur in 3 out of 31 cases of cholelithiasis after ideal cholecystotomy (suturing the gall-bladder after removing stones). I believe if the gall-bladder alone is diseased and the ducts are free cholecystectomy is a better operation than cholecystostomy. If this operation is performed stones cannot re-form in the bladder and infection is removed. If the ducts are involved cholecystostomy is the proper operation. The operation of incision, removal of the stone, and suture of the gall-bladder is known as *ideal cholecystotomy* or *cholecystendysis*. It is not a proper procedure, as it does not cure the diseased mucous membrane and stones are apt to re-form. *Cysticotomy* is incision of the cystic duct. If calculi exist in the common duct, it may be possible, after celiotomy, to manipulate them back into the bladder and extract them from that viscus by a scoop, but this maneuver is impossible unless the cystic duct is dilated. In some cases the gall-bladder is incised, a fistula is made, and the duct and bladder are frequently irrigated. In other cases the stone has been crushed by the fingers manipulating the duct and the concretion within it or by padded forceps (*choledocholithotrity* or *choledocholitho-tripsy*). The operation was advocated by Lawson Tait, but is no longer employed. Hepaticolithotrity or hepaticolithotripsy is still occasionally practised. Robson points out that crushing of the stone is apt to leave fragments which may cause trouble, and it should be done only when the stones are soft. It is wrong to endeavor to force a stone from the common duct into the duodenum. The attempt will fail, and in some cases the patient will be placed in a worse condition by the stone lodging in Vater's diverticulum.[1] The duct may be opened, and after the removal of the stone closed by sutures (*choledochotomy*) or drained for a time (*choledochostomy*), strands of gauze being carried down to the opening and a tube being carried down to or up into a dilated duct toward the liver. Always drain the gall-bladder. If the stone be impacted near the outlet of the duct, it may be necessary to incise the duodenum in order to remove the stone (*duodenocholedochotomy*). A dilated common bile-duct may be anastomosed to the bowel (*choledocho-enterostomy*) or to the surface (*choledochos-tomy*). The obstruction may be side-tracked by anastomosing the gall-bladder to the bowel (*cholecystenterostomy*) (see page 1111). Cholecystenterostomy affords drainage, but does not remove the cause of trouble, and infection is apt to be received from the bowel. In some rare cases of common duct obstruction, in which the gall-bladder is distended and the condition of the patient is desperate, anastomose the gall-bladder to the colon (*cholecystocolostomy*), to the stomach (*cholecystogastrostomy*) or to the duodenum (*cholecystoduodenostomy*). In many cases of diseased gall-bladder in which the ducts are free the viscus is removed (*cholecystec-tomy*). Wm. J. Mayo and others have pointed out that a danger in operations on the common duct is a sudden fall in blood-pressure when the duct is being manipulated. All operators have observed it. Ransohoff maintains that it arises only when the portal vein is compressed. It may be necessary to resect a portion of the common duct and unite the divided ends (Doyen's operation)—to anastomose the common duct to the duodenum or the hepatic duct to the common duct. The surgeon may be driven to construct a new common duct, or to simulate one by the insertion and retention of a rubber tube.

Papilloma and Carcinoma of the Gall-bladder and Ducts.—In 405 operations on the gall-bladder and biliary passages the Mayo brothers found malignant disease 20 times (5 per cent. of cases). (See Wm. J. Mayo in "Med. News," Dec. 13, 1902.) Malignant disease may be primary or secondary. It may arise from carcinomatous changes in papillomata. We know that papillomata may spring up in any diseased gall-bladder. In 107 of the 2538 cases of cholecystectomy in the Mayo Clinic (from Jan. 1, 1907, to June 1, 1915) papillomata were found (Wm. J. Mayo in "Trans. Amer. Surg. Assoc.," 1915). Papillomata are not cured by a drainage operation. Cholecystectomy is necessary. In primary carcinoma of the bladder calculi are practically always present, and

[1] See A. W. Mayo-Robson in "Lancet," April 12, 1902.

are apparently the cause of cancer by maintaining chronic irritation. Stones are seldom present in cancer of the ducts or in secondary malignant disease. Not very infrequently cancer of the common duct is encountered. Now and then a surgeon discovers cancer of the ampulla of Vater.

Carcinoma of the gall-bladder can usually be palpated. It is hard and nodular, and seldom accompanied by much abdominal rigidity. There will be a long history of attacks of biliary colic and of recent or comparatively recent grave loss of flesh. Sooner or later jaundice arises, deepens, and persists. In cancer of the ampulla or ducts jaundice develops, but ulceration opens a way for the bile and jaundice fades, perhaps to recur again. So it may disappear and reappear. In cancer of the duct above the ampulla jaundice arises. There is no bile, but there is pancreatic juice in the intestine. In cancer of the ampulla during jaundice there is neither bile nor pancreatic juice in the intestine.

Cholecystectomy has been employed for cancer of the gall-bladder, but offers little hope. A wedge-shaped piece of liver tissue should be removed with the gall-bladder and hemorrhage should be arrested by sutures or gauze packing. In 2 cases in which I opened the abdomen without suspecting malignant disease of the gall-bladder the liver was hopelessly involved. In 1 case in which I operated for a supposed impacted stone in the common duct an inoperable cancer of the common duct was found. In cancer of the common duct it may be possible to excise the growth and suture the ends of the duct as has been practised by Moynihan, the Mayos and others. If this is impossible, follow the advice of the Mayo brothers: Ligate the distal end of the duct and implant the proximal end in a portion of the duodenum which is covered by peritoneum ("Keen's Surgery," vol. iii). Cancer of the ampulla has been excised successfully.

The Meltzer-Lyon Test.—Meltzer (in 1917) suggested the introduction of sulphate of magnesium into the duodenum in order to cause dilation of the sphincter of the common duct in obstructive jaundice. Lyon, from this suggestion, has developed a plan for the diagnosis and treatment of diseases of the gall-bladder and bile-ducts. Lyon introduces into the duodenum, by means of a duodenal tube, 50 c.c. of a saturated solution of magnesium sulphate. In a few minutes a quantity of highly pigmented and viscid bile can be withdrawn. After a time less viscid bile is obtained. Lyon maintains that the pigmented and viscid bile comes from the gall-bladder. Studies made upon the supposed gall-bladder bile and duct bile may enable us to determine the nature of any bacteria present, and the situation and character of a pathologic process. Protracted duodenal drainage may be used to drain the bladder and ducts and so to cure the case. This is Lyon's ingenious theory, and he has maintained it most ably. These views are still in dispute. Some deny them (see particularly Diamond in "Amer. Jour. Med. Sciences," Dec., 1923) and assert that most of the viscid bile comes from the liver. I am incompetent to decide.

Injuries and Diseases of the Pancreas

Injuries of the Pancreas.—The pancreas is very rarely ruptured alone, although this sometimes occurs as the result of blows or crushes. In the majority of cases in which the pancreas is damaged other organs are involved; for instance, the stomach, the spleen, and the liver. A gunshot wound of the pancreas is almost certain to injure the left kidney, the stomach, or the vertebral column. It will be remembered that in the case of President McKinley the bullet passed through the stomach, damaged the left kidney, and injured the pancreas. Becker reported an isolated gunshot wound of the pancreas, as the only case on record (Stephen H. Watts). Garré ("Beiträge zür Klinische Chirurgie," xlvi, No. 1) collected 30 cases of subcutaneous rupture of the pancreas, and in only 8 of these cases was the pancreas alone damaged.

Symptoms.—When the pancreas is injured alone, hemorrhage is not usually severe; but if adjacent organs are also damaged, it is sure to be profuse. Hence when adjacent organs are damaged immediate symptoms of severe intra-abdominal hemorrhage appear, but profound collapse is not often present when the pancreas alone is injured. In fact, symptoms may not arise for a considerable length of time after injury of the pancreas. A diagnosis at this stage is impossible without exploratory operation. Wohlgemuth and Noguchi claim that within a few hours of a pancreatic injury there is an increase of diastase in the blood and urine ("Berlin. klin. Wochen.," xlix, 1912). If this observation be correct we have a very valuable diagnostic test. Severe injury of the pancreas is usually, but not invariably, fatal. After slight damage of the gland

the patient may completely recover; but, as a rule, he partly recovers, and, after a number of weeks, a smooth enlargement, palpable in the epigastric region, is formed. When operation is performed this mass is found to be back of the stomach. It contains a quantity of fluid blood, clot, and pancreatic fluid. Such a fluid collection is in the lesser peritoneal cavity and is called a cyst, though it is not a true cyst of the pancreas. It is a *pseudocyst*. Robson and Moynihan, in their valuable treatise on "Diseases of the Pancreas," explain the formation of this collection of fluid as follows:

The injury lacerates the posterior layer of the lesser sac of the peritoneum and the pancreas, to which it is adherent. Blood and pancreatic fluid enter the lesser peritoneal sac. Peritonitis follows. The foramen of Winslow becomes blocked by adhesions; and the lesser peritoneal cavity, being now a closed sac, is distended by a serous exudate mixed with blood and pancreatic fluid. Collections of this character form very rapidly, and several pints may gather in a few days. Other results of injury to the pancreas are abscess, pancreatitis, and true cyst formation. A fistula may follow operation for rupture of the pancreas. Such a fistula is very troublesome, often refuses obstinately to heal, and the pancreatic fluid macerates the skin severely.

Treatment of Pancreatic Injuries.—Operation is imperatively demanded, although the prospects are bad. Garré collected 8 cases, 3 were operated upon, and all died. He reported a successful case of his own (loc. cit.). The pancreas was torn in two and the pieces were separated. The splenic vessels were uninjured. The two portions of gland were sutured together. This stopped the bleeding. Gauze packing was introduced. Mikulicz ("Proceedings of Amer. Surg. Soc.") in 1903 collected 21 wounds and 24 crushes of the pancreas. Twelve of the wounds were due to bullets and 9 were stabs. Five of the 12 gunshot wounds were operated upon, with 2 deaths. All unoperated upon died. The 9 patients who had been stabbed were all operated upon and only 1 died. In a gunshot wound of the abdomen, when exploration leads the surgeon to surmise that the pancreas has been injured, this organ is usually approached by dividing either the gastrocolic omentum, the transverse mesocolon, or, preferably, the gastrohepatic omentum. It can be easily exposed by separating the great omentum and its mesentery from the colon (the epiplo-enterocolic method). Accessory injuries must be carefully noted, and if a bullet has penetrated the posterior wall of the stomach, the pancreas is almost certain to be damaged. One should remember that, as Park says, even after opening the abdomen it is difficult to explore the pancreas, especially in a stout person. If there is no evidence of posterior perforation of the stomach by a foreign body, one may assume that the pancreas has escaped. When the pancreas is exposed, if it is found to be bleeding, the bleeding vessels should be ligated and the tear in the gland should be sutured with catgut, care being taken not to puncture the main duct of the gland. If this duct has been cut, it should be carefully sutured. In some cases of gunshot wound it is necessary to resect a portion of the gland. At the termination of an operation upon the pancreas posterior drainage, preferably at the costovertebral angle, should always be obtained. It is necessary to drain away all escaping pancreatic fluid, as it tends to cause necrosis of tissue with which it comes in contact.

In cases of crush with pancreatic injury the associated injury to other structure usually proves rapidly fatal, but in a less severe case the abdomen may be opened for exploration, and if this is done, the surgeon should proceed as previously directed.

The question of excising a lacerated portion of the pancreas is one of great interest. It is known that dogs have lived for some time after complete excision of the pancreas. Four-fifths of the pancreas can be removed from a dog without producing permanent glycosuria, but if more than this is removed the dog develops saccharine diabetes and eventually dies of it. In man quite large-sized pieces of the gland have been removed and recovery has followed. Hence it is justifiable to excise a hopelessly damaged portion, bearing in mind Park's caution that the chief danger in excising a portion of the pancreas is injury to the splenic artery.

Wounds of the Pancreas During Operations on the Stomach and Spleen.—In the performance of gastrectomy, partial or complete, the pancreas will be injured if the growth or ulcer be adherent to it. Such an accident is held by many operators to increase mortality greatly. The Mayos report 448 resections of the stomach for benign and malignant disease. The average mortality was 10 per cent. In 8 per cent. of these cases the pancreas was injured, and the average mortality of such cases was only 11 per cent. (Wm. J. Mayo in "Annals of Surgery," Aug., 1913). The injuries reported by the Mayos were superficial at the point to which the stomach adhered. In no case was the main duct opened. It was noticed in these cases that local peritonitis had caused the formation of a fibrous capsule. Bleeding was controlled by suture

ligatures of catgut. The pancreatic wound was not sutured. As stated on page 1066, if the pancreas is wounded during pylorectomy, the closed end of the duodenum is placed in the pancreatic wound and the anterior peritoneum and adventitious sheath is sutured to the anterior portion of the duodenum. If an ulcer of the posterior wall of the stomach is adherent to the pancreas, transgastric excision removes considerable pancreatic tissue. Such a wound is not sutured, but the gap is filled by a mobilized bit of gastrohepatic or gastrocolic omentum (Wm. J. Mayo, Ibid.). In 2 of my cases of splenectomy I damaged the pancreas, tying off a bit of the tail with the splenic vessels. In 1 case leakage occurred and death followed, anterior drainage having been employed. In the other case there was profuse drainage for several days, which was carried off by a posterior drain. This patient recovered. Both were cases of Banti's disease.

Pancreatic Fistula.—A fistula may follow a wound of the pancreas. It is a very troublesome condition, often refuses most obstinately to heal, and the pancreatic secretion causes maceration and violent irritation of the adjacent skin. The usual treatment is to keep the way open for easy drainage. Wohlgemuth's plan is promising ("Berliner klin. Wochen.," 1908, No. 8). He reported 5 successful cases. I have had 2 cases. Each followed operation upon a pancreatic cyst. The treatment consists in feeding upon strict antidiabetic diet and in giving large doses of bicarbonate of soda before and after meals. By cutting off carbohydrates a powerful stimulus to the flow of pancreatic juice is removed. The bicarbonate of sodium lessens the acidity of the stomach contents. The more acid the contents which enter the duodenum, the greater the flow of pancreatic juice; the less acid, the less the flow.

Displacement of the Pancreas.—In cases of splanchnoptosis the pancreas may become considerably displaced, though this condition cannot be recognized without opening the abdomen. It may be a portion of the pedicle of a movable spleen. So far I know of no case in which fixation has been attempted, though, of course, theoretically it could be done. The pancreas has been found in umbilical herniæ. In 10 per cent. of diaphragmatic herniæ the pancreas constitutes part of the contents. Körte collected 8 cases in which the pancreas prolapsed through an abdominal wound. In several cases in which the pancreas prolapsed into an abdominal wound the protruding part was excised. In other cases it was restored.

Pancreatitis often leads to the production of jaundice; always to very rapid loss of weight; occasionally to the presence of fat and sugar in the urine; sometimes to the presence of fat in the stools, and frequently to the condition known as fat necrosis. Robson and Moynihan[1] point out that when there is no diarrhea and the stools contain undigested muscle-fiber, one may assume that there is a deficiency in pancreatic juice (Garrod in "Internat. Med. Digest.," Feb., 1921). When there is a blockage to the secretion from the pancreas, if salol be given by mouth, salicyluric acid does not appear in the urine. The test is made by putting 15 gr. of salol into 3 gelatin capsules hardened with formalin (Sahli) and giving them with a roll and a cup of water. If pancreatic ferment is in the intestine, salicyluric acid appears in the urine in from three-quarters of an hour to one hour; if the ferment is absent from the intestine, salicyluric acid is not found in the urine because the salol is not split up and absorbed. The test for the acid is ferric chlorid, which, in the presence of the acid, turns the urine violet. The general cause of pancreatitis is infection. Often obstruction of the common duodenal outlet of the pancreatic duct and common bile-duct is followed by infection and suppuration of the pancreatic ducts and pancreatitis. Besides the general cause, which is infection, various exciting causes may be named, among which are gall-stones in the common duct and calculi in the pancreatic ducts, traumatism, cancer of the stomach or duodenum, catarrh of the stomach or duodenum, and many infectious diseases. It thus becomes evident that the infection may be by way of the blood; but, undoubtedly, in the vast majority of cases, the infection comes from the duct or gall-bladder by way of the lymphatics. One manner in which the disease may be produced was suggested by Halsted and Opie, of Baltimore: A stone becomes impacted in the duodenal outlet of the common duct and pancreatic duct, the pancreatic duct, where it emerges above the common duct, not being blocked. The bile and pancreatic juice are thus prevented from entering the duodenum, and the bile flows back into the pancreatic ducts. Swelling of the papillæ could act in the same way. So could a plug of mucus. It is thought that overacid duodenal contents may enter the duct and produce pancreatitis. Deaver and Pfeiffer ("Annals of Surgery," 1913, 58) believe that pancreatitis is lymphangitis. J. E. Sweet ("Internat. Clinics," vol. iv, Series 25)

[1] Robson and Moynihan on "Diseases of the Pancreas."

makes the subject clear. According to that investigator not all acute cases are due to stones in the ampulla, but, whether caused by stones or not, infection is the real cause. Infection kills cells, sets free in the tissues an agent which activates trypsinogen into trypsin, trypsin digests living tissue, erodes blood-vessels, causes hemorrhage and perhaps gangrene. If infection takes place without activating the protein ferment, an abscess forms. Infection of the interlobular connective tissue is chronic pancreatitis and it is lymphangitis. Pancreatitis is predisposed to by obesity and arteriosclerosis (Balch and Smith, "Publications of the Mass. Gen. Hosp.," Oct., 1911).

That strange condition known as *fat necrosis* is often present in pancreatitis. In fat necrosis the fat is decomposed into fatty acids and glycerin. The glycerin is absorbed, but the fatty acids unite with calcium salts and remain in the tissues, forming patches of yellowish-white color and varying size. These patches are found in the fat beneath the peritoneum, in the omentum, and in the mesentery, and even in distant parts (for instance, the pericardium).[1] It is an undoubted fact that fat necrosis may be found after diseases and injuries of the pancreas; and many assume that it is produced by the entrance of the ferment of the pancreas into the fatty tissue. Opie and Coffey maintain that pancreatic juice only causes fat necrosis when it enters the retroperitoneal tissues, never when it enters the unbroken peritoneal cavity. How the ferment gets there is a matter of some doubt. In the case of a wound of the pancreas one can understand the flow of the secretion and its imbibition by adjacent parts; but in other cases one must assume that it has been absorbed by the lymphatics and distributed to more distant parts. When one reflects that in some conditions of the pancreas there is no fat necrosis, while in others this condition arises, it is presumable that the pancreatic conditions associated with it are such as to permit the fat-splitting ferment to diffuse into neighboring tissues.

In pancreatic disease *hemorrhage* into that organ is common. The hemorrhage is not, of necessity, fatal, but frequently is so. Occasionally death takes place as the result of sudden pancreatic hemorrhage in a person apparently in excellent health. It is thought by Robson and Moynihan that during the existence of cancer of the pancreas there is a strong tendency to excessive hemorrhage after any operation. In 1 case of my own the patient bled to death after the performance of cholecystostomy for obstructive jaundice. The oozing of blood in this case was from the margins of the gall-bladder and the adjacent peritoneal surfaces. We, therefore, conclude that in certain conditions of the pancreas there is a tendency to local hemorrhage in that organ; and that there may also be a tendency to the development of a general hemorrhagic diathesis, the general hemorrhagic tendency being much increased if jaundice exists. During acute inflammation of the pancreas hemorrhage is almost certain to occur into that gland; in other varieties of inflammation hemorrhage may occur or may be absent. In degenerative lesions of the pancreas a material like unfermented pentose is frequently present in the urine. When the reaction for this material is obtained we speak of it as the *Cammidge reaction*, after its discoverer. (For Cammidge's improved method see "Brit. Med. Jour.," May 19, 1906.) The Cammidge reaction is not by any means conclusive proof of organic pancreatic disease. It may be found in a great variety of other conditions (gall-stones, cholecystitis, gastric carcinoma, burns, etc.). In most patients who exhibit it there is arteriosclerosis and, of course, this condition might affect pancreatic secretion (Watson, "Brit. Med. Jour.," April 11, 1908). My own views coincide with those of Swan and Gilbride ("New York Med. Jour.," April 23, 1910). They believe a positive reaction indicates disturbed pancreatic function, but not, of necessity, organic disease.

Forms of Pancreatitis.—This disease is divided by Robson and Moynihan into the acute, the subacute, and the chronic forms; and they say that recorded cases demonstrate the fact that three distinct classes of inflammation may arise: (1) Cases that die within forty-eight or seventy-two hours from the beginning of the trouble. In this group hemorrhage is usually found, and if fat necrosis is present, it is limited in area. (2) Those that live for some weeks after the beginning of the trouble. In these cases the pancreas may become necrotic or suppuration may occur. Fat necrosis is usually wide-spread. (3) In the third class of cases long-continued inflammation or repeated attacks produce sclerosis of the pancreas.

Acute Pancreatitis.—Normal pancreatic juice does not digest living pancreatic tissue. In acute pancreatitis the tissue is digested. Bacterial infection reaches the pancreas and kills cells. The dead cells furnish a substance which activates trypsinogen into trypsin and trypsin digests living tissues. If material from the duodenum reaches

[1] Robson and Moynihan on "Diseases of the Pancreas."

the pancreas trypsinogen will be activated. If pancreatic drainage is blocked (as by a stone in the diverticulum) infection may be inaugurated and existing infection intensified. It digests or ruptures the walls of the small ducts and diffuses through the gland, producing necrosis of gland tissue, exudation into gland tissue, necrosis of the blood-vessels, and, in consequence, hemorrhage (Balch and Smith in "Publication of Mass. Gen. Hosp.," Oct., 1911). Hemorrhage usually, but not invariably, occurs. It is apt to be profuse. A part of the gland or the entire gland may be involved. Fat necrosis occurs from the action of the fat-splitting ferment which does not require activation. A part of the pancreas or the entire gland may become gangrenous.

The *symptoms* of this condition come on suddenly and consist of violent, colicky pain in the epigastric region, but seldom marked tenderness, usually vomiting, constipation, weakness of the circulation, slow or moderately rapid pulse, cold extremities, and collapse, with a great fall in blood-pressure. The temperature is normal or moderately elevated. Some maintain that collapse is due to trypsin; others, that it results from the absorption of toxic products from the gland. The pain is extremely violent, is intensified in paroxysms, is perhaps radiated to the right shoulder and back, and there is rigidity of the epigastrium. In some cases there is appreciable epigastric tenderness. The patient vomits the contents of the stomach and then bilious matter. Distention soon becomes distinct in the upper portion of the abdomen. The patient presents the appearance of one suffering from peritonitis. This condition is not unusually mistaken for intestinal obstruction, but in acute pancreatitis the constipation is not absolute; the patient passes gas, and may even have a bowel movement as the result of the administration of an enema. The condition is usually fatal within two days, but may last for several or many days, but in very rare instances recovery takes place without operation. In acute pancreatitis from stone in the common duct there is no leukocytosis (Murphy). In some cases of pancreatitis from other causes there is high leukocytosis. Sugar may appear in the urine. In acute pancreatitis signs of hyperthyroidism may be noted and probably exist in some cases in which they are not observed. Tremor, dermatography, and ocular signs have been reported (Cohn and Peiser, quoted by Garrod in "Lancet," July 2, 1923).

The *diagnosis* cannot be made with certainty and is merely an inference. Reginald Fitz told us that the existence of this disease should be suspected when a person previously in good health, or who has complained only of occasional attacks of digestive disorder, is suddenly seized with severe pain in the epigastric region, followed by vomiting and collapse; and when, within twenty-four hours or more, there appears a circumscribed swelling in the epigastrium which is resistant or tympanitic. Visible oil in the stools, a Cammidge reaction, or sugar in the urine add probability to a diagnosis of pancreatitis. When an exploratory incision is made in the abdomen, if fat-necrosis is detected, the diagnosis becomes certain. The peritoneal cavity may contain thin, bloody fluid.

Treatment.—Operation was suggested by Naunyn in 1903. Some surgeons, just as soon as the patient has been roused from shock, explore by way of the abdomen. I think we should operate at once, even in shock. It is quite true that the patient might possibly, if let alone, pass through the acute stage, and that a local abscess might then form, the treatment of which would be obvious. But the danger of waiting is too great to justify delay, and if suppuration should occur it might not remain local, but might spread widely in the retroperitoneal tissues, and abscess of the pancreas is very dangerous. When observation after exploratory incision into the greater cavity of the peritoneum suggests the existence of acute pancreatitis, the infected area should be exposed, preferably above the stomach, through the gastrohepatic ligament. The pancreas should be incised, necrotic tissue should be removed, hemorrhage should be arrested by ligation or packing, the gauze pack emerging above the lesser curvature, a stab incision should be made at the costovertebral angle, and posterior drainage should be made from the lesser peritoneal cavity. One should follow the rule laid down by Roswell Park, and explore in every case in which the disease is suspected to exist. Of Körte's 16 cases operated on during the first week, 11 recovered ("Annals of Surgery," 1911, vol. lv). Of Balch and Smith's cases ("Publication of Mass. Gen. Hosp.," Oct., 1911), 11 were operated upon within three days, and 3 recovered. The two authors just quoted state that the Massachusetts General Hospital records for twenty-one years show only 1 victim who recovered without operation. Mikulicz ("Annals of Surgery," 1903) recorded 75 operations for acute pancreatitis. In 36 the pancreas was attacked surgically, with 25 recoveries. In 41 the pancreas was not directly attacked and only 4 recovered.

Subacute pancreatitis comes on suddenly, with violent pain, vomiting, and constipation, but there is far less exhaustion and weakness than in the acute form. The vomiting is less marked and the swelling in the epigastric region is not so rapid. The symptoms are similar to those of the acute form, but not so violent nor so rapidly progressive. The temperature frequently rises higher than in the acute form, and it may become irregular or chills may occur. In many cases the patient seems to grow better after a time, the violent pain abating, though distinct pain may remain, but he does not gather strength and continues to lose flesh, and there is usually albumin and there may be sugar in the urine. Signs of hyperthyroidism may arise. In rare instances fat is found in the urine. In subacute pancreatitis abscess is prone to form. The abscess may make a distinct swelling in front, and may lead to the development of a subphrenic or of a perirenal abscess. In rare cases an abscess of the pancreas tracks its way for a long distance in the subperitoneal tissue; occasionally it opens into the stomach or bowel. Cases of subacute pancreatitis usually die, but occasionally recover after a long illness.

Treatment.—Exploratory incision. Expose the pancreas, preferably by dividing the gastrohepatic ligament; determine its condition; remove purulent matter and necrotic areas; arrest hemorrhage with packing, and insert posterior drainage at the costovertebral angle. Leave the anterior wound open for the emergence of the gauze packing.[1] Drainage of the gall-bladder has been recommended, but, as a matter of fact, it gives, as a rule, but temporary relief.

Chronic Pancreatitis.—There are many causes which favor the development of chronic pancreatitis, viz., syphilis, alcohol, bacteremia, block of the common duct (stenosis, stone, etc.), extension of inflammation from the bile-ducts, and ascending infection from the duodenum. It is a lymphangitis of the interlobular tissue and is due to infection. It usually results from disease of the bile-passages and is often associated with gall-stones. In 2200 operations performed by the Mayo brothers on the gall-bladder and bile-ducts, the pancreas was found diseased 141 times (6.4 per cent.).

In 168 cases of pancreatic disease on which they operated 81 per cent. were caused by or, at least, associated with gall-stones. In operations upon the common or hepatic ducts the pancreas was diseased in 18.6 per cent. of cases. It was diseased in 4.45 per cent. of cases of operation upon the gall-bladder. Chronic pancreatitis produces enlargement of the organ, especially the head, and the enlarged area is hard and feels like a malignant growth. This condition is more common than the acute or subacute form. Robson and Moynihan have operated upon 30 cases. This disease is frequently associated with gall-stones or with stones in the pancreatic duct, and occasionally with ulcer of the stomach or of the duodenum. In some cases symptoms of the condition come on acutely. Pain, nausea, and vomiting occur, and jaundice develops rapidly, as it does after the passage of a gall-stone. It is noted, however, that the pain is not in the region of the gall-bladder, but is in the middle of the epigastrium. It usually radiates to the right, but may radiate to the left rather than to the right. The tenderness, too, is near the middle of the epigastrium and not in the gall-bladder region. If a line is drawn from the umbilicus to the apex of the right axilla, a point on the line 2 inches from the umbilicus is the seat of greatest tenderness (*the point of Desjardins*). It corresponds to the opening of the duct of Wirsung. There is either constipation or diarrhea. A series of these attacks may occur, the jaundice growing worse after each attack. In some cases, however, the condition comes on gradually and insidiously, the pain slowly developing, but no violent seizures taking place. There are rigidity of the rectus muscles, rapid loss of flesh, anemia, sometimes bronzed skin, usually vomiting, and considerable flatulence. The gall-bladder is enlarged and commonly palpable.

In some cases it is possible to palpate the inflammatory mass. There may be irregular fever and chills with episodes of subnormal temperature. None of the above indications are conclusive signs of disturbed pancreatic function. Signs of disturbed function of the gland are of great importance in making the diagnosis, and these signs are glycosuria and impaired power of digesting fats and proteins (Walko in "Archiv. f. Verdauungskrankheiten," 1907, xiii). Fatty stools containing unsaponified neutral fat are very significant. Seldom, however, do we find neutral fats, but rather split fat, and that only, when the bile-duct is blocked. Finding unstriated muscle-fibers in the feces is of great significance. Glycosuria is rather unusual, but indoxyluria is common (Coope in "Brit. Med. Jour.," Jan. 26, 1924). Hyperthyroidism may arise.

The jaundice in chronic pancreatitis results from compression of the duct by the hyperplastic mass, or blocking of the duct by a stone. Stenosis of the duodenum may

[1] Roswell Park, "Annals of Surgery," Dec. 15, 1901.

occur. In jaundice from chronic pancreatitis capillary hemorrhage is particularly common. Mayo-Robson attaches importance to the Cammidge reaction. In the Jefferson Hospital we regard it as of some use, but we do not attach as much importance to it as do some clinicians (page 1039). In some cases *Loewi's test* for pancreatic disease may be positive (mydriasis of the pupil after instillation of adrenalin solution between the lids). I believe it to be uncertain. Estimation of diastase in the blood and urine has not proved helpful. Study of fluids removed from the duodenum by Lyon's tubage may be of service.

Treatment.—Drainage of the gall-bladder has been the usual treatment either by cholecystostomy, cholecystgastrostomy or cholecystenterostomy. It may cure a case, but in many cases the benefit is temporary and after a time the symptoms are apt to return.

Wm. J. Mayo ("Amer. Jour. Med. Sciences," 1914) says: "In at least half of the cases operated on in our clinic the following sequence has occurred: Cholecystostomy had been done for chronic cholecystitis without stones, and with a complicating chronic pancreatitis. The patient was relieved for some weeks or months and then the symptoms returned." Drainage was again instituted and there was perfect relief so long as drainage was continued, but when the fistula closed the symptoms returned. Mayo now removes the gall-bladder and finds that a permanent cure is obtained.

Pancreatic Calculi.—When the pancreatic secretion is blocked, stones tend to form; and the blocking may be due to inflammation of the duct of Wirsung, or may result from chronic pancreatitis. The stones may be single or multiple.

Symptoms.—There is pain in the epigastric region, which usually comes on in paroxysms that resemble those due to gall-stones, though they are not so violent. Pain is accompanied by vomiting, exhaustion, and sometimes actual collapse, and may be followed by rigors. Portions of stone are sometimes recovered from the feces, and sugar is occasionally found in the urine. Fat has also been noted in the stools in some cases. Sometimes jaundice develops because the calculus presses upon the common duct. Pancreatic calculi are composed of lime salts and can be skiagraphed.

Treatment.—Pancreatic calculi have, in rare instances, been removed by operation; and this is the proper procedure when the diagnosis can be made. The diagnosis is, however, not always possible without exploratory incision. As a rule, no operation is performed until a cyst results or an abscess forms; and when the cyst or abscess is opened fragments of stone may be found in the fluid, and stones may subsequently come away in the resulting fistula.

Pancreatic cysts are rare. In 5000 consecutive abdominal operations performed at the Mayo Clinic there were 2 for pancreatic cyst. Many forms of cyst may develop in the pancreas; the following are set forth by Robson and Moynihan: (1) Retention cysts; (2) proliferation cysts, including cystic adenoma and cystic epithelioma; (3) hydatid cysts; (4) congenital cysts; (5) hemorrhagic cysts; (6) pseudocysts. What we speak of as pseudocysts have already been considered in discussing effusions into the lesser peritoneal cavity. They result from lacerations of the pancreas and the posterior layer of the lesser peritoneal cavity (see page 1037). Retention cysts are due to blocking of the duct of Wirsung or of smaller ducts. The block may be due to stricture, calculus, or primary chronic inflammation. Undoubtedly chronic pancreatitis plays a great part in the production of retention cysts. Blocking causes dilation, acini fuse, and a cyst forms. Such a cyst is accompanied by diffuse pancreatitis involving a considerable portion of the pancreas and seriously affecting metabolism and secretion. One-third of such cysts follow traumatism. Proliferation cysts are neoplastic and are very rare. In 1907 Kleinschmidt could collect from literature 21 cases only. Fifteen of these cases involved the tail alone. Any chronic pancreatitis is limited and disturbances in secretion and metabolism are slight or absent until late in the case. Proliferation cysts are not caused by traumatism. Congenital cystic disease is extremely rare. Hemorrhagic cysts result from hemorrhage into the substance of the pancreas itself.

Symptoms.—Cysts are somewhat more common in men than in women. A cyst of the pancreas proper is more often met with in the head of the organ than in its body or tail. Cystic disease may be single or multiple. In its growth it either destroys the substance of the pancreas or it grows away from the pancreas and damages it but little. In some cases the cysts grow to a very large size; and Robson and Moynihan refer to a case in which the cyst attained the size of a man's head, and to another in which it was the size of a full-term pregnancy. A pancreatic cyst is smooth, round, elastic,

and rather tense (Robson and Moynihan). The contained fluid varies greatly. As a rule, it is brownish-red in color; in 1 case upon which I operated it was clear yellow; in some cases it is milky, and in others it is nearly black. The fluid is always albuminous. Urea may be present, and in many cases pancreatic ferments are found. In most cases the cyst adheres so closely to the surrounding structures as to render extirpation practically impossible. A pancreatic cyst of considerable size causes epigastric discomfort, pain during digestion, and frequently vomiting. In some cases the pain is trivial, in others it is very violent. As a general rule, the patient is constipated, but sometimes diarrhea occurs, and the movements may even contain blood. If the tumor presses upon the common bile-duct, jaundice will develop. In some cases the patient loses flesh markedly and with considerable rapidity, and he becomes very weak. A large cyst causes marked pressure symptoms. Joseph Ransohoff ("Surgery, Gynecology, and Obstetrics," March, 1916) had charge of a case in which the pressure of a cyst upon the left renal vein caused unilateral hematuria. In rare instances fat is present in the stools, and in other unusual cases sugar is found in the urine. A test should always be made with salol, to see whether pancreatic ferment is present in the intestine (see page 1038). In the beginning the pancreatic cyst is behind the stomach; but it enlarges and, as a rule, pushes the stomach upward and to the right side, and the transverse colon downward. The cyst approaches the surface of the abdomen below the greater curvature of the stomach (Robson and Moynihan). The same authors tell us that in rare cases the cyst appears at the upper border of the stomach, and that in others it inserts itself between the layers of the transverse mesocolon. In a case upon which I operated it had worked its way through the subperitoneal tissue into the right loin, and was looked upon by Professor Montgomery and myself as a hydronephrosis. As a rule a pancreatic cyst is immovable, but in rare instances it is movable. When a hand is placed in the loin and another on the abdomen, ballottement may be appreciated. If the distended stomach or colon overlies the tumor there will be a tympanitic percussion note, but when the tumor reaches the abdominal wall there will be a dull percussion note. On inquiring into the history of these cases it will be found frequently that there has been a severe injury to the upper abdomen.

Treatment.—Exploratory incision makes the condition clear. In the majority of cases the cyst is incised, emptied, and stitched to the wall of the abdomen. This operation may be done in two stages—first, exposing the cyst and fixing it to the abdominal wall; second, when adhesions have formed, opening it. As a rule, however, it is performed in one stage, the abdominal cavity being carefully protected by gauze. Some authors advocate exposing the cyst, opening and evacuating it through the abdominal wound, and draining through the loin. Complete extirpation is usually impossible because of the adherence of the cyst. If the cyst is movable, extirpation may be carried out, but the safest operation consists of incision and drainage.

Tumors and Other Growths of the Pancreas.—The pancreas may be affected by sarcoma, carcinoma, adenoma, tuberculous disease, or syphilis. Primary tumors are very rare. In two-thirds of the cases of pancreatic cancer the growth involves the head. The body and tail seldom suffer. Most pancreatic cancers have an abundance of fibrous tissue. Billroth in 1884 removed an adenocarcinoma. Finney reported 1 case and collected 16 from literature which came to operation ("Annals of Surgery," June, 1910). He says the diagnosis can only be made by exclusion and that in 25 per cent. of cases the mass is not fixed, but is movable. In Finney's series of cases there were 9 recoveries and 8 deaths. Wm. J. Mayo reports the successful removal of a cyst with sclerosed pancreatic tissue (Ibid., Aug., 1913).

After an exploratory incision has determined the condition, the pancreas is exposed at the point at which the tumor projects. This is usually done by opening through the gastrocolic omentum. If the tumor is in the tail of the pancreas, however, the exposure may be effected in the flank. When the tumor has been exposed an attempt may be made to enucleate or resect it. Coffey ("Annals of Surgery," Jan., 1911) shows that ligation of the duct does not occlude it permanently. Tumors of the splenic portion of the pancreas have been removed. The entire gland was removed by Billroth in 1894 and the patient recovered from the operation (A. W. Mayo-Robson in "Oxford Surgery"). It is stated that Franke in 1901 performed the operation successfully. I doubt if total extirpation is justifiable. Even if accomplished the patient would die of diabetes unless insulin could save him.

In a large tumor of the head of the pancreas palliate the condition by cholecystgastrostomy or cholecystduodenostomy. Villar reports 13 cases of partial resection of

the pancreas for tumors, with 5 recoveries from operation (French Surgical Congress of 1905). Finney's paper deals with 17 cases (see page 1043).

Injuries and Diseases of the Spleen

Wounds of the Spleen.—Stab wounds of the spleen alone are rare. Those by way of the pleura are more common than those by way of the abdomen, hence in most stab wounds of the spleen the pleura and diaphragm are injured. A considerable wound of the spleen causes great hemorrhage and, if surgical aid is not soon at hand, will almost inevitably produce death. It is caused by a bullet or a stab and, as a rule, other viscera are also damaged. Immediate operation is indicated. Laparotomy alone is suited to few cases. In most cases the damaged structures can be reached by opening the abdomen through the diaphragm (that is, by enlarging the original wound). If the injury is from the front, and there are evidences of intra-abdominal hemorrhage, open the abdomen, divide the eighth, ninth, and tenth costal cartilages to enter the pleural cavity, and enlarge the wound in the diaphragm. In some cases remove the spleen. In some few cases arrest bleeding by packing, by suture, or by transplantation. If operation be performed promptly the mortality is under 20 per cent.

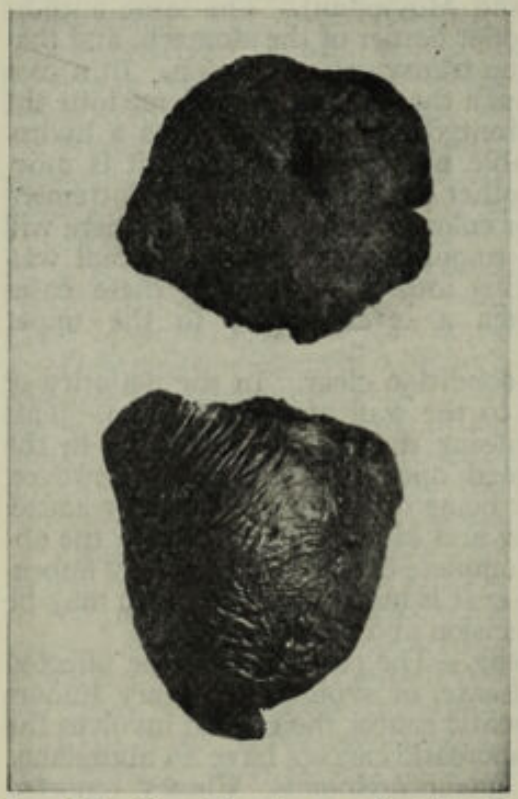


Fig. 777.—Fauntleroy's case of ruptured spleen. External surface.

Rupture of the Spleen (Fig. 777).—Rupture may be spontaneous from distention if the organ is much congested and enlarged. Sometimes bleeding takes place beneath the capsule and at autopsy nothing can be found to account for it. If the capsule ruptures, a subphrenic hematoma forms. In some cases a cyst forms and bleeding takes place into the cyst. Rupture may occur in diabetes. Malarial spleens are prone to rupture. Traumatic rupture is far more common than spontaneous rupture. It is unusual if the organ be healthy, but does occasionally occur from crushes. It is rarely found unassociated with other injuries. The spleen may be dislocated as well as ruptured. An enlarged spleen is particularly liable to rupture not only from a crush, but from a kick, a blow, or a fall. Rupture of the spleen produces pain in the lower part of the left side of the thorax and in the left hypochondriac region, and rigidity in the left hypochondriac region and the signs and symptoms of intra-abdominal hemorrhage. There is tenderness over the spleen, pain over the heart, and great shortness of breath. The bleeding is profuse, but sometimes slow. The splenic blood contains numerous leukocytes and clots rapidly, hence the bleeding may be arrested for a time, and if it should be, the patient will not bleed to death rapidly and reaction will generally occur (Ballance). The blood in some cases clots so rapidly that it gathers in the left loin, and does not diffuse throughout the abdomen, but in most cases it does diffuse. If it does not diffuse a subphrenic hematoma forms. It gives rise to an increasing area of dulness on percussion in the left flank, which, Ballance points out, seldom shifts when the position of the patient is shifted, as it does in bleeding from other intra-abdominal structures. In some cases, however, the blood remains fluid and spreads throughout the belly, and then there is rising dulness in each flank. The cases reported by Le Dentu and Mouchet show that the blood may remain fluid ("Bull. de l'Academie de Med.," June 16, 1903). In some cases the signs of hemorrhage are late and they may even be deferred until the fourth day (Eisendrath, "Annals of Surgery," Dec., 1902). In some cases there is violent pain in the left shoulder (*Kehr's sign*). Exploratory incision will be required to recognize the condition positively. In Elder's table there are 52 uncomplicated cases, not a case was operated upon (operation was not the rule until 1890), and 84.6 per cent. died. Eisen-

drath[1] has collected 50 cases operated upon: 56 per cent. recovered and 44 per cent. died. Février[2] has collected 56 ruptures of the spleen. In 46 cases operation was performed and the mortality was 50 per cent. E. Berger ("Archiv. für klinische Chirurgie," Bd. 28, Heft 3) collected 167 fatal cases of rupture of the spleen: 145 died during the first day and every one of them died from hemorrhage. After the first day 23 died. In 90 per cent. of the entire series hemorrhage caused death; in 10 per cent. infection was responsible for death. Vedova collected 194 cases of splenectomy for traumatic rupture, with 65 deaths, a mortality of 33.5 per cent. ("Practical Medicine Series," vol. ii, 1913). Hemorrhage is the great danger in ruptured spleen—hemorrhage from the parenchyma rather than from the great vessels. The parenchyma is friable and contains multitudes of capillaries and veins, there is no muscular tissue, divided vessels do not tend to contract, and the capsule is thin (the elder Senn in "Jour. Amer. Med. Assoc.," Nov. 21, 1903).

Treatment of Wounds.—The treatment is evident from the previous remarks. It is as follows: Open the abdomen immediately, the patient being surrounded with hot bottles and hot salt solution flowing into a vein. Explore the spleen and other viscera. If the spleen is damaged, we may do splenectomy (total or partial), may use the suture, the cautery, or the tampon, and any other visceral injuries are, of course, attended to.

The usual operation has been total splenectomy. In partial splenectomy only the injured part is excised and the wound margins are sutured.

The arrest of hemorrhage by suture is known as *splenorrhaphy*. Lamarchia, in 1896, was the first to perform this operation. The tear or wound is sutured with catgut and the suture line is covered with omentum. Berger collected 14 cases of suturing, with 2 deaths, but these were injuries of less severity than those requiring splenectomy. In some cases the tampon can be used. Berger collected 10 cases, with 1 death. Another method is to crush the splenic structure slowly with broad forcipressure forceps and suture the crushed margins with catgut. Senn followed this plan. George Ben Johnston (paper read before Johns Hopkins Med. Soc., March 2, 1908) collected 150 cases of splenectomy for wounds or ruptures, with 99 recoveries and 51 deaths, a mortality of 34 per cent.

Abscess of the spleen is a rare condition which is usually metastatic in origin. It may follow appendicitis, pneumonia or typhoid, may develop during pyemia, or may result from injury. Chronic suppuration may be due to tuberculosis or actinomycosis. Some chronic cases are almost free of symptoms. There are pain and tenderness if the serous membrane be involved, otherwise they may be absent. There may be simply a feeling of heaviness. In many cases enlargement is noted in the splenic region, and the symptoms of pyemia exist. In acute cases there will be chills, fevers, and sweats. Leukocytosis exists, but may not be excessive. The abscess may become adherent to the belly wall, may become encapsulated, or may rupture into a viscus or the peritoneal cavity. Fluctuation can seldom be obtained. What is known as a tropical abscess (Fontoynant and Jourdrau in "Archiv. Prov. de Chir.," No. 11, 1902) may develop during a malarial attack as a result of severe exertion. There are severe pain in the left hypochondrium, dyspnea, and dry tongue. There may or may not be fever. The pus may be sterile.

The **treatment** of abscess of the spleen consists in incising the abdomen at the outer edge of the left rectus muscle, suturing the spleen to the abdominal wall, opening the abscess, and providing for drainage (Tédenat[3]). If the abscess is adherent to the abdominal wall, incise it directly. Splenectomy has been performed for abscess. In 9 recorded cases of splenectomy for abscess there was 1 death (George Ben Johnston, paper read before Johns Hopkins Med. Soc., March 2, 1908).

Enlargements and Tumors of the Spleen.—(See Royale H. Fowler in "Long Island Med. Jour.," July, 1911.) The spleen undergoes hypertrophy in the course of infectious disease, from amyloid disease, from malaria, from splenic anemia, from tuberculosis, from leukemia, and from Hodgkin's disease. Secondary cancer is seen after cancer of the stomach. Genuine primary tumors are extremely rare. Fibroma, enchondroma, hemangioma, endothelioma, lymphangioma, angioma, and sarcoma occasionally develop. Goldstein ("Int. Jour. Surg," 1922, xxxv) collected 66 cases of sarcoma of the spleen. Primary cancer is extremely rare. There are only 8 or 9 cases on record. Primary carcinoma can only arise from fetal inclusion. It is usually med-

[1] "Jour. Amer. Med. Assoc.," Oct. 25, 1902.
[2] "Rev. de Chir.," Nov., 1901.
[3] "Rev. de Gynéc. et de Chir. Abd.," July, August, 1901.

ullary and is sometimes melanotic. Secondary carcinoma and secondary sarcoma are more common. Echinococcus cysts, dermoid cysts, lymph cysts, serous cysts, and blood cysts occasionally develop. The spleen alone may suffer from hydatid disease. The liver is apt to be also involved. "There is but a single recorded case of dermoid cyst. It was reported by Andral in 1830" (Royale Hamilton Fowler in "Surg., Gynec., and Obstet.," Aug., 1910).

Non-parasitic cysts may be unilocular or multilocular. In 1912 R. H. Fowler analyzed 86 cases and in 1921 added 4 cases ("N. Y. State Jour. of Surg.," Sept., 1922). Fowler divided them into:

1. Infoliation cysts due to peritoneal inclusion. They may be inflammatory or traumatic, single or multiple.
2. Dilatation. These distended sinuses are multiple.
3. Neoplastic. Lymphangioma and hemangioma. Gosselin ("Jour. Amer. Med. Assoc.," March 15, 1924) makes a group of *pseudocysts*. Some are large and arise from traumatic hematomata. Others result from degenerative changes about infarction. Trauma is the great cause of single, large, unilocular cysts. The cysts are noted as a rule a year or less after the injury, but the interval may be much longer. The usual age is from thirty to fifty. They are more common in women than in men. Syphilis and malaria, especially with splenomegaly, predispose.

A blood cyst is usually preceded by injury or an infectious disease. A serous cyst may result from a hemorrhagic cyst, and a blood cyst may be due to hemorrhage into a serous cyst.

Treatment.—The condition may become clear after exploratory laparotomy only. For malignant tumors splenectomy is indicated. A hydatid cyst is treated as is a hydatid cyst of the liver (see page 1018). A blood cyst may be sutured to the incision in the abdominal wall and may be drained. Splenectomy is the best treatment for pseudocysts.

Splenoptosis, or Wandering Spleen.—The spleen may wander into any part of the general peritoneal cavity. This condition is seldom met with except in women. It is most common in women who have borne children. A wandering spleen may undergo atrophy, engorgement, or axial rotation (Sir J. Bland-Sutton). The spleen may be healthy or enlarged from malaria or leukemia. As a matter of fact, it is usually diseased. The organ when displaced drags upon the stomach, producing dilated stomach; it may interfere with the bile-duct, causing jaundice; it may cause intestinal obstruction by forming adhesions, or may cause uterine retroflexion or prolapse by passing into the pelvis.

Sir J. Bland-Sutton[1] says this condition may endanger life, as it may lead to rupture of the stomach, intestinal obstruction, splenic abscess, or splenic rupture. A wandering spleen can be identified by the fact that it has a notch upon its edge, and can be pushed about the abdomen. When the spleen wanders it may be missed from its normal situation. Always examine the blood in order to determine if leukemia or malaria exists.

Treatment.—Greiffenhagen advocates suturing the organ in place (*splenopexy*). Most surgeons prefer to perform splenectomy. In a case without leukemia the operation is very successful. Splenectomy for wandering spleen is rarely followed by serious blood changes or other trouble. The reason is that a wandering spleen is usually a diseased organ, having undergone hypertrophy or fibroid change, and other structures have taken on splenic function. Splenectomy should not be undertaken if leukemia exists. In such a case surgeons usually apply a support and employ medical treatment for the existing disease, but some endeavor to suture the organ in place. If the wandering spleen were enlarged by malaria, I would perform splenectomy. If the spleen were healthy I would surround it with gauze exactly as is done with the kidney in a case of movable kidney. If the spleen were enlarged by leukemia I would not operate at all.

Operations Upon the Abdomen

Abdominal Section (*Celiotomy; Laparotomy*).—There are many different methods of opening the abdomen. The plan selected depends upon the nature and the situation of the disease, and upon the inclinations and the custom of the operator. The abdomen may be opened to attack a recognized seat of disease or injury or to determine what the disease or injury is and where it is situated. Abdominal section performed for the latter purpose is spoken of as exploratory section or exploratory incision.

[1] "Brit. Med. Jour.," Jan. 16, 1897.

An incision should not be unnecessarily lengthy, but it should be long enough to permit of thorough exploration and rapid and safe work. A very lengthy incision favors visceral prolapse and renders the patient liable to hernia. Again, a lengthy incision requires longer to suture than a short one, and so operation is prolonged. James E. Moore protests against too small incisions, which are often made as a matter of pride ("Jour. Amer. Med. Assoc.," Sept. 16, 1911).

Of recent years exploratory operations have become extremely common, and many abdominal conditions would be unrecognized without such exploration, or would be recognized at so late a period as to be beyond the reach of surgery after diagnosis. This is notably true of the surgical diseases of the stomach. The wise surgeon will not be too radical in employing exploratory operations. The fact that he can explore with such comparative impunity does not release him from the obligation to endeavor by every proper method to make a diagnosis before resorting to operation. I fancy that of recent years the belief that it is almost waste of time to make prolonged efforts to diagnosticate many intra-abdominal troubles because the solution is so much easier by section, has become so common as to have led inexperienced and unskilled surgeons to perform section in cases in which the diagnosis might have been made without this procedure.

Before opening the abdominal cavity for exploratory purposes or to gain access to some area of abdominal or pelvic disease the patient is carefully prepared as for any other operation. In an appendicitis case the patient is moved with the utmost care and is prepared for operation most gently because of the possible danger of rupturing an abscess. In an emergency case no prolonged or complicated method of cleansing can be employed. The abdomen and loins are scrubbed carefully with soap and water, special attention being given to the umbilicus; the pubic region is shaved, the soapsuds are washed away with sterile water, the surface is gently scrubbed with alcohol and then with a hot solution of corrosive sublimate (1 : 1000), and is covered with gauze wet with the sublimate solution. In emergencies the iodin method can be used after dry shaving. We no longer regard it as necessary to "prepare" the abdomen the day before. The patient can be prepared antiseptically the morning of the operation, or can be shaved just before etherization, and be cleaned when under ether. The instruments required depend upon the nature of the case. Have at hand an electric light and appliances for throwing salt solution into a vein. Always have the instruments, sponges, and pads counted twice by two people, write down the number, and have two people count them twice after operation. This rule is adopted so that no instrument, sponge, or pad will be left in the abdomen. Some surgeons do not use abdominal pads and sponges when dry, believing that dry gauze injures the peritoneum and favors the subsequent development of adhesions (Sanger). Believers in this hold that pads and sponges should be wrung out in hot normal salt solution before being used. I find moist pads and sponges satisfactory, but moist packs cannot be satisfactorily adjusted. If dry packs are used, dry pads and sponges may as well be.

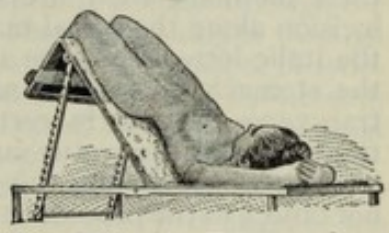


FIG. 778.—The Trendelenburg position.

Operation.—An anesthetic is given. In some cases the patient is placed recumbent. A blanket, made into a roll, is placed in the hollow of the back to prevent sprain of the sacro-iliac joints, a common cause of postoperative backache. In some cases the *position of Trendelenburg* is employed (Fig. 778). In the Trendelenburg position the pelvis is elevated, the intestines fall toward the epigastrium, are removed from the necessity of being handled and from the danger of being bruised, the pelvis is thoroughly exposed, and pelvic work becomes easier and safer. This position should not be used if there is myocardial disease, as the increased pressure in and flow of blood from the inferior cava may cause fatal acute dilatation of the heart (Kraske, of Freiburg, in "Proceedings of German Surg. Congress," 1903). The position is of little use in very fat people (Trendelenburg), and in such subjects may cause intestinal obstruction (Kraske). When this position is employed, the table should be lowered as soon as possible, to avoid gastric hemorrhage (von Eiselsberg). The normal position should not be suddenly assumed, as this may cause intestinal obstruction, the omentum being mixed with coils of intestine, pulling the colon down (Pasteau in "Bulletins and Mém. de la Soc. Anat. de Paris," July, 1905). The position should not be used in a pelvic abscess

(König), as it may lead to a flow of pus from the pelvis into the far more dangerous regions above.

Volvulus or kinking of the ileum and of the large intestine has followed the use of the position. Organic disease of the blood-vessels, heart, lungs, or kidneys adds to the risk of ill effects from the position. The flexion of the legs often causes much pain and stiffness and may predispose to pulmonary embolism. If the Trendelenburg position has been employed, before closing the belly return the omentum to its proper position and spread it out (Lauenstein). In every abdominal operation the patient is to be carefully protected from cold, the extremities and the chest are covered with blankets, and sterilized sheets are placed well around the field of operation. The skin is sterilized anew immediately before operating. The surgeon steadies the skin of the belly with the fingers of his left hand, and, holding the knife free in the right hand, makes an incision. Incision may be in any region, and is made as long as is necessary. Incisions may be straight, curved, angled, vertical, transverse, or oblique. The vertical incision is most commonly used. For purposes of exploration the incision is made about 2 inches in length, and it is lengthened if it is found necessary. The abdomen may be opened in the median line above or below the umbilicus. This incision is advantageous for operations on the pelvis, for general exploration, and for certain procedures upon the stomach, the intestines, and the left lobe of the liver. The closure of such an incision, however, lacks strength, as compared with the closure of an incision where strong muscles will overlie the scar through the peritoneum and the transversalis fascia. Incision through the semilunar line is practised by a number of operators. A favorite incision is through the rectus muscle. The fibers of this muscle are separated, the structures beneath it are divided, and, after the completion of the operation the deeper structures are sutured and the parts of the separated muscle are allowed to fall together. The scar resulting from such an incision is well supported and solid, hence the likelihood of hernia developing is diminished. A favorite method with some is to open the sheath of the rectus muscle, retract the entire muscle aside, incise the posterior portion of the sheath and the structures back of it, and, when the operation has been completed, allow the entire muscle to come back into place, thus strengthening the deep-seated scar. When the abdominal trouble is in a region that admits of it, I almost invariably go through the rectus muscle or retract the entire muscle. Besides these methods, there are special incisions, suitable for particular cases: An oblique incision along the costal margin, for reaching the gall-bladder; an incision shaped like the italic letter *f*, for the same purpose; special incisions for certain operations upon the stomach, for abdominal nephrectomy, etc. Some operators have even used a transverse incision in certain pelvic operations especially. Years ago Billroth at times divided the rectus muscles transversely. Many surgeons object to a transverse incision which divides the rectus muscles (the Mayos and Moynihan). Murphy did not object to the procedure. Moschowitz and Lilienthal warmly advocate it for certain cases. I never hesitate to divide one rectus for a gall-bladder operation. Retraction ceases at the nearest transverse lines. G. G. Davis made a transverse incision outside of the rectus for appendectomy (page 1052). Farr (Ibid.) points out one advantage in the closing of a transverse incision. If there is any tension it can be greatly lessened by raising the shoulders in order to curve the dorsal and lumbar spine. (A full discussion of abdominal incisions will be found in an article by R. E. Farr, "The Journal Lancet," Nov. 1, 1912.)

In an operation through the median line the first cut goes to the aponeurosis of the external oblique muscle. Clamp the vessels. Do not hunt for the linea alba below the umbilicus, but go right through or between the recti muscles. Above the umbilicus the linea alba is very distinct and the surgeon often cuts through it. Divide the transversalis fascia, beneath which is a little fat, and expose the peritoneum. The latter structure is recognized by its glistening appearance, by the ease with which it can be pinched up between the finger and thumb, and by the readiness with which its opposed surfaces may be made to glide over each other. On identifying the peritoneum, catch it at each side of the incision with forceps, raise a fold, nick it with a knife, and open the layer by scissors to the length of the external wound. To prevent stripping of the peritoneum a good plan is to anchor it to the belly wall with a stitch on each side of the incision. Through the wound thus made the abdomen and its contents are explored, the trouble located, and determination made as to whether or not further operation be advisable, and, if it be advisable, what form it shall take. It may be necessary to enlarge the wound. This is done by placing the index and middle fingers of the left hand in the belly, with their pulps against the peritoneum, in the line where the surgeon will

cut, to serve as supports to the scissors and as guards to intraperitoneal structures. The scissors are introduced and the wound is enlarged upward or downward, going around the umbilicus if necessary. As soon as the incision is complete for work in the lower abdomen or pelvis it is a good plan to push a large pad into Douglas's pouch and leave it there until the operation is finished, when it must be removed. Slender adhesions are stripped off with the finger or are pushed off with gauze; firm adhesions are tied in two places and cut between the ligatures.

The *toilet of the peritoneum* is important after the operation is completed. Following a clean laparotomy, when but little blood has flowed into the cavity, flushing is not required; if much blood has flowed or if septic matter has passed into the peritoneal cavity, after removing the pad from Douglas's pouch flush the belly thoroughly with hot normal salt solution. In a clean case empty out most of the fluid, but let a pint or more remain in the abdomen. In flushing the abdomen bear in mind Monks's observations as to the mesentery. It is a sort of shelf. If we follow down the left side of it with the finger the finger must enter the left iliac fossa; if we follow down the right side of it the finger must enter the right iliac fossa. Hence in order to flush the right cavity carry the nozzle down the right side of the mesentery to its root, and in order to flush the left fossa carry it down the left side of the mesentery to the root (Monks, "Annals of Surgery," Oct., 1903). The retention of the saline fluid in the belly minimizes shock. It is absorbed with great rapidity after the operation if the patient is placed with his head lower than his feet, because in this position the saline fluid gravitates to the diaphragmatic region, where absorption is very active; in fact, in one hour the peritoneal cavity can absorb from 3 to 8 per cent. of the body weight. If there be wide-spread infection with stomach contents or feces, eviscerate, wipe out the peritoneum with pads soaked in hot normal salt solution, and wipe the intestines carefully, slowly returning them as they are wiped. Extravasated septic matter is apt to collect in the peritoneal fossæ and between the liver and diaphragm, and these regions must be carefully wiped and irrigated. In cases of septic and purulent peritonitis, flushing, evisceration, and wiping with gauze are not advisable (see page 1009). In some cases it is desirable to drain through a lumbar incision. Rutherford Morison has pointed out that a lumbar opening into the right kidney pouch will drain a fossa which holds over a pint of fluid, and which, when the patient is recumbent, is the most dependent portion of the peritoneal cavity. In some cases a drainage opening is made through the linea alba, through one side or on each side of the belly, or above the pubis or through the vagina. In septic cases it may be advisable to drain with several pieces of iodoform gauze instead of inserting tubes. After most laparotomies drainage is not needed, but it should be used when stomach contents were extravasated, and it must be used if feces or urine have been extravasated, in certain recent septic cases, and when hemorrhage has been severe. We may drain by a rubber tube, strands of gauze, a cigarette drain, or a glass tube. If a glass tube is used, it is introduced at the lower angle of the wound and reaches the bottom of the pouch of Douglas. The tube is repeatedly emptied during the progress of the case by means of a syringe. Before closing the wound arrest hemorrhage and ask for the count of the instruments and pads in order to know that nothing foreign has been left in the belly.

It is highly important that an abdominal incision shall be accurately closed, for any failure of neat approximation will, in all probability, result in the formation of a hernia through the cicatrix. Various methods have been employed. Probably the majority of operators use layer sutures, sewing up the peritoneum with a continuous suture of catgut, and the aponeurotic layers with the same material or with chromicized catgut, and closing the skin with either interrupted sutures of silkworm-gut or a subcuticular stitch of catgut, silkworm-gut, or silver wire. Other operators close the peritoneum with a continuous suture of catgut, then pass silkworm-gut sutures through all the other structures, leaving them for the time untied; put in and tie layer sutures of catgut or of chromicized catgut, and then tie the silkworm-gut sutures. A layer suture makes a beautifully neat approximation, and is frequently quite satisfactory; but I have become persuaded that the dead space, so often left unobliterated when this method of suturing is employed—a space in which blood and inflammatory exudate may gather—is a danger to the future integrity of the wound. The combination of a dead space with catgut, a material that is always somewhat uncertain, is an unfortunate one from the surgical point of view. I have returned in many cases to the use of the through-and-through suture, applied according to the method of the late Dr. Joseph Price. This suture is inserted with the straight needle, is composed of silk or of silkworm-gut, is put in close to the margin of the skin, gathers up a great deal more muscle

than skin, and then passes close to the margin of the cut peritoneum and transversalis fascia. When these sutures are adjusted the peritoneal edges are brought into accurate and firm apposition, the peritoneal surface is overlaid with abundant muscle, the skin edges are brought into neat approximation, and the formation of a dead space is rendered impossible. When passing the sutures have a gauze pad under the wound and be very careful not to include bowel or omentum in the stitches. It is necessary to tighten and tie most carefully to prevent omentum being caught in the loop of the stitch. After closing a laparotomy wound, dress with aseptic gauze and apply a flannel binder. In badly infected cases the wound is often kept open.

If a 2-inch incision has been closed without drainage and primary union has taken place, the patient can usually get out of bed in seven or eight days. A large incision offers greater danger of subsequent hernia, and the patient should be kept in bed for two or three weeks. If the wound has been kept open for drainage, a prolonged retention in bed may be necessary. I allow patients up at an earlier period than used to be my custom, but I do not permit them to get up in one to three days as do Kümmel and others (Kümmel in "Zentralblatt f. Chirurgie," 1908). To get them up reasonably early lessens constipation, favors an early return of appetite and strength, and diminishes the risk of postoperative thrombosis and embolism and of bronchitis. We must bear in mind that, if there be myocardial degeneration, the assumption of the upright posture very soon after abdominal section may prove disastrous or even fatal, and that in septic diseases there is often myocardial degeneration (E. W. Foote in "Progressive Medicine," June, 1909). In a case in which an incision of considerable length has been made, an abdominal binder or a lacing support should be worn for a variable time. It limits the movements of cough, laughter, etc., and *reminds* the patient of the necessity of caution in lifting, hurrying, etc.

The **after-treatment** depends somewhat on the case, but certain general rules can be laid down. The late J. Greig Smith said many wise things, and among them this: "A golden rule in the treatment of cases of celiotomy is to let the patient alone. Everything approaching to meddlesomeness is to be condemned. The patient must not be upset by fussy applications of tentative therapeutics; when an emergency arises, it is to be met, promptly and decisively, by a method which has been approved trustworthy" ("Abdominal Surgery"). In many cases immediately after the operation the patient must be treated for shock by methods previously set forth. The treatment of vomiting resulting from the administration of an anesthetic is discussed on page 1208. If vomiting persists during the third or fourth day it may be due to acidosis, but is probably due to the development of inflammation which has caused intestinal paresis; and if it is so produced, medicine is practically useless. In this condition there is usually marked tympanitic distention, and vomiting is, in a sense, a relief. Nothing should be given by the mouth and the patient should be fed entirely by enemata. The insertion of a rectal tube and its retention for a considerable time may afford relief. Lying on the side is more comfortable than recumbency. Washing out the stomach from time to time gives great comfort and is often of realser vice (see Postoperative Obstruction on page 975).

In the average case of celiotomy, in which persistent vomiting does not occur, the question of feeding is of much importance. Usually, for the first twelve or twenty-four hours, nothing is given by the mouth but small quantities of hot water. The day after the operation, if everything is satisfactory, liquid food is given to the patient. In many cases, however, food is not given by the stomach for forty-eight hours and the patient is fed by the rectum during the wait. He should not be given milk because it will not be easily digested, may lead to nausea, and cause flatulence. Peptonized milk, if the patient will take it, does not possess these hurtful qualities. At first small amounts of albumen-water should be given, and later fresh meat-juice, beef-jelly, broth, etc. Food is given every third or fourth hour, and stimulants are administered if required. After the first twenty-four or forty-eight hours considerable quantities of plain water or Poland water should, if possible, be taken, to favor elimination by the kidneys. Hot coffee is not only a stimulant, but is an excellent diuretic. The urine is always scanty after an abdominal operation, and a normal daily amount is not voided for ten days or more. Solid food is not given for seven or eight days. The patient is apt to suffer greatly from thirst, in spite of the hot water given during the first twelve to twenty-four hours. He seldom takes and should never have any great amount of hot water, and iced water and ice are inadmissible and tend to induce nausea and vomiting. Sucking ice or sipping water draws air into the stomach and causes distention. Thirst can be much mitigated by enemata of salt solution.

J. Greig Smith recommended an enema composed of from 4 to 20 oz. of tepid water and some brandy. Usually, after the first twenty-four hours, a sufficient amount of liquid can be given to keep the patient free from actual distress.

The bladder must be watched to see that retention does not occur. If retention occurs, a clean catheter must be used at regular intervals. If tympanitic distention occurs after forty-eight hours, a saline purgative should be given and it should be followed by an enema of turpentine. The rectal tube is frequently of signal service in such cases. If obstruction develops, it is treated as directed on page 978.

In any ordinary case after operation the bowels should be moved after forty-eight hours as a prophylactic measure against distention, peritonitis, and obstruction. From four to eight 1-dram doses of Epsom salts may be given, in hot water, the solution having been filtered through gauze. The saline is followed by the administration of an enema consisting of soap, water, and ½ oz. of castor oil. Should opium be given? Never as a routine, and not to secure sleep; but if the patient be in pain which not only harasses him, but causes him to turn and shift in torturing restlessness, one or possibly two hypodermic injections each containing ¼ gr. of morphin may be given with confidence that the good will overbalance the harm.

Operation for Appendicitis.—Before operating try to locate the situation of the appendix, and the relation the area of infection bears to the ascending colon. The incision should be over the seat of disease. In the rare left-sided cases and in median cases the incision is median. In some cases in which the appendix is posterior the cut may be in the loin. In 1 case I opened a purulent collection through the rectum. In the vast majority of cases the incision is made in the right iliac region. In acute appendicitis, of a normally situated appendix, when there is not thought to be a distinct abscess, the incision usually made is 2 inches internal to the anterior superior iliac spine and perpendicular to a line drawn from the spine to the umbilicus (Fig. 779). The skin incision is usually 3 inches in length, the upper third of the incision being above the omphalospinous line; the incision in the peritoneum is about 2 inches in length, but if there are many adhesions, it may be necessary to make it much longer. The oblique incision may be carried out as advised by McBurney, the muscles being separated by blunt dissection. By this method very few nerve-fibers are divided, and hence the operation is not followed by marked muscular wasting, a condition which strongly predisposes to hernia. Further, as Van Hook[1] points out, the oblique incision enables the surgeon to reach freely all the ordinary areas of appendix trouble, the wound is parallel with the lines of traction of the abdominal muscles, and does not tend to gape widely. In an acute case I make an oblique incision, but cut the muscles (Fig. 779). In an interval case in a man I separate the muscular fibers. Battle's incision at the outer edge of the rectus muscle is preferred by many surgeons. The anterior layer of the rectus sheath is opened

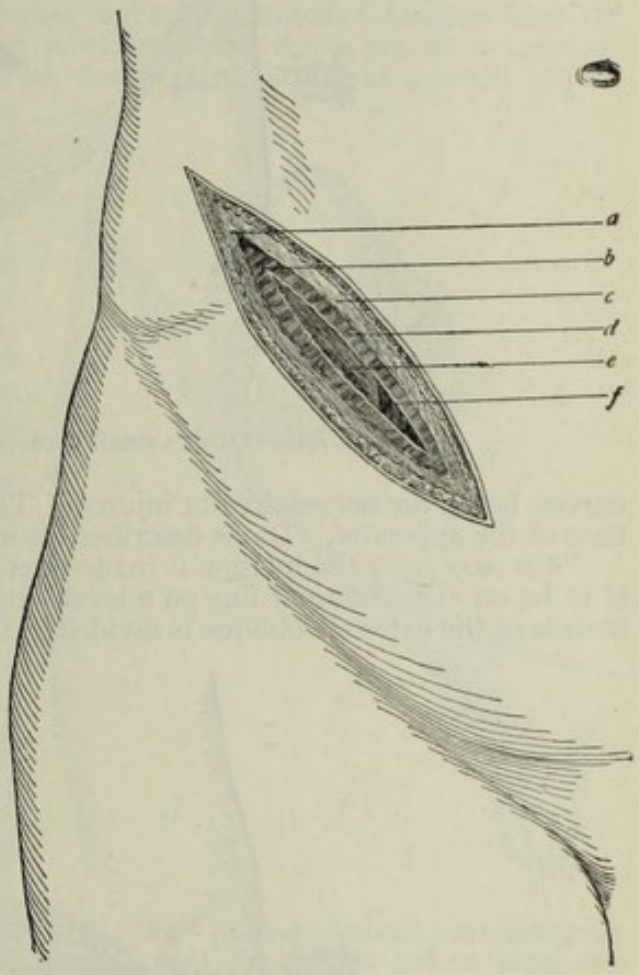


FIG 779.—Resection of the vermiform appendix, incision through the abdominal wall: *a*, External oblique muscle; *b*, internal oblique muscle; *c*, aponeurosis of external oblique; *d*, aponeurosis of internal oblique; *e*, transversalis fascia and peritoneum; *f*, outer border of rectus abdominis muscle (under it the deep epigastric vessels). (Kocher.)

[1] "Jour. Amer. Med. Assoc.," Feb. 20, 1897.

longitudinally, the rectus is drawn inward, and any existing portion of the posterior rectus sheath with the transversalis fascia and peritoneum is incised.

I have used *Davis's transverse incision* (Figs. 780 and 781) in many interval cases with entire satisfaction (Gwilym G. Davis in "Annals of Surgery," Jan., 1906). This incision does not divide arteries, but it divides the deep muscles in the direction of the

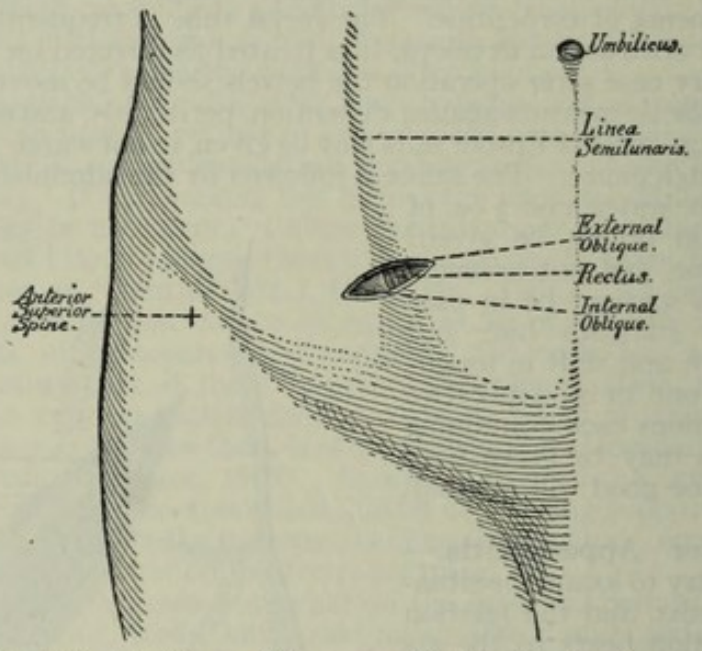


FIG. 780.—Davis's small transverse incision for simple cases.

nerves, hence the nerves are not injured. The center of this incision is almost over the base of the appendix. Davis describes his incision as follows:

"*For easy cases* the incision is made directly transverse, 1½ inches long. Its center is to be on the semilunar line on a level with the anterior superior spine. The aponeurosis of the external oblique is divided in the line of the skin incision, but obliquely

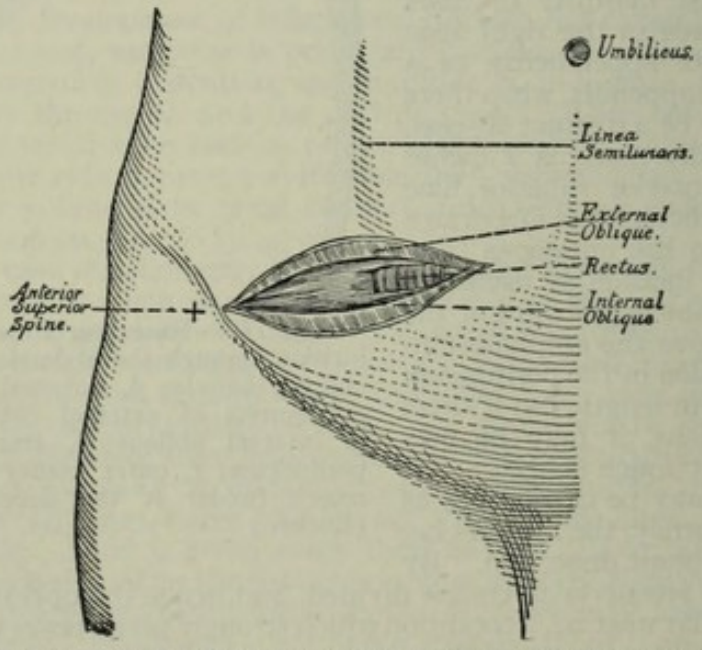


FIG. 781.—Davis's large transverse incision for difficult cases.

to the direction of its fibers. The fibers of the internal oblique and transversalis muscles are parted—not cut—in the same line as the structures above. The peritoneum is then opened and the incision is carried inward, first through the anterior layer of the sheath of the rectus. A blunt retractor ¾ inch wide is then inserted and the muscle drawn toward the median line. This exposes the transversalis fascia and peritoneum posteriorly, which are then also divided. Thus is obtained a triangular

opening with its base of ¾ inch and two sides of about 1 inch long, which is ample for simple cases.

"*For Difficult Cases.*—If the case is a difficult one, the outer end of the incision is prolonged to the anterior spine or even above and inwardly through the sheath of the rectus to within 1 inch of the median line. This will give an opening 4 to 5 inches long, according to the size of the patient, sufficiently large to insert the hand if necessary and through which the appendix can be extracted under almost all circumstances."

After opening the peritoneum examine very gently to detect the situation of the appendix, and if there are or are not adhesions. In a very recent case and in a very acute case there will probably be no adhesions unless there have been previous attacks. If there be infection, surround the region involved with packs of plain gauze, each strip being 2½ inches wide, 15 inches long, and four layers in thickness. The edges of the wound should be lifted up by retractors and the strips inserted around the cut, between the parietal peritoneum and intestines and to a distance of 3 inches from the wound. Strips of gauze are passed, when possible, below the appendix to prevent entrance of infected material into the pelvis, and a piece is pushed upward toward the liver (Van Hook). Over the packing gauze, which it may be necessary to leave in place after the operation, other pads are packed. The appendix is sought for by finding the colon. The colon is found by following the parietal peritoneum with the finger. The course of the finger is first outward, next backward, and finally inward; the first obstruction it encounters is the colon. The fact that it is the colon can be confirmed by finding the longitudinal bands. The anterior longitudinal band leads directly to the appendix. Pass the finger down to the head of the colon, find the appendix, usually posterior and internal, and lift it and the head of the colon into the wound. In many cases it will be advisable to deliver the head of the colon from the belly (Fig. 782); in other cases this will not be necessary, in some it will not be possible. Do not permit the appendix to touch the skin of the abdomen as in Fig. 782. If adhesions exist, they must be gently and carefully separated. Barker's method (Fig. 783) is a very satisfactory mode of removing the appendix. It is done as follows: Turn up a cuff of peritoneum, pull down the other coats, ligate at the base, cut through the tube, let the musculomucous stump retract, and tie or suture the peritoneal cuff over the stump. Another method, which is the one I usually employ, is as follows: Pass a ligature through the meso-appendix, as shown in Fig. 784, *A*, tie the ligature, and cut off the meso-appendix on the appendical side of the threads. Crush the stump of the appendix with strong straight hemostatic forceps. This divides the mucous membrane, submucous tissue and muscular coat, and leaves the peritoneal coat undivided. Remove the forceps. Surround the appendix with a catgut ligature and tie the ligature in the groove produced by the crushing. When the ligature is tied, peritoneum is brought against peritoneum. Cut off the appendix between the ligature and a clamp by the cautery, a knife, or scissors. Disinfect the stump of the appendix by pure carbolic acid, being careful to allow no excess of the acid to run over the adjacent peritoneum. Such excess should be touched quickly with an alcohol sponge. The stump beyond the ligature contains mucous membrane and muscle, which are lifted out with forceps and scissors. Suture the fringe of the meso-appendix, invert the stump into the wall of the colon, and suture a portion of the wall over it by inversion stitches. Figure 784 shows an older method still used by many. The meso-appendix is tied off by one ligature, the appendix is not crushed, but is tied off by another ligature, and both structures are cut off below their respective ligatures.

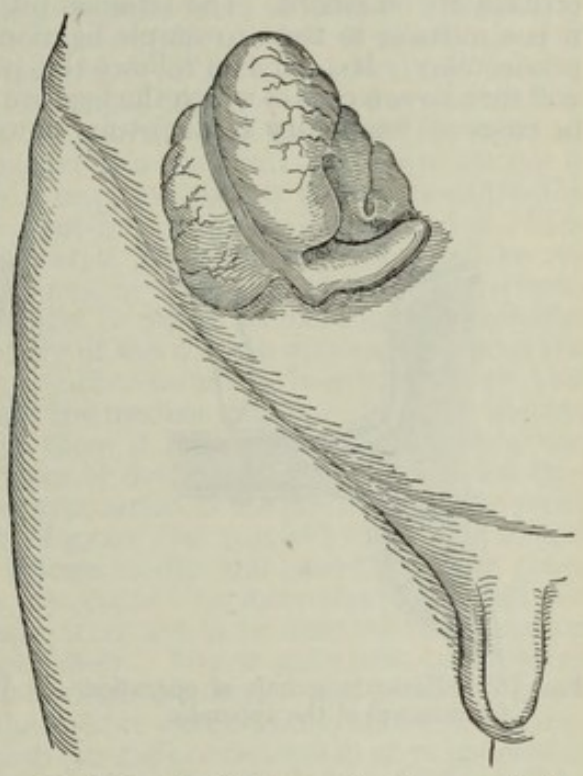


FIG. 782.—Radical operation for appendicitis (appendix and colon should rest on gauze and not on the skin). (Kocher.)

The stump is disinfected with pure carbolic acid or the cautery, inverted, and the fringe of the meso-appendix is sutured. This method does not entirely remove the appendix, but inverts glandular tissue into the wall of the bowel. The stump may not be completely asepticized by the carbolic acid and hence may lead to postoperative abscess, dense adhesions or fecal fistula, or the undestroyed lymphoid structure may cause further trouble, even persistent ill health (Joseph Price). Some remove the appendix by an elliptical incision around its base, and close the colon wound by Lembert sutures. This method, of course, removes the appendix completely. Dawbarn surrounds the appendix with a continuous Lembert purse-string suture of silk. This is inserted in the superficial layers of the cecum, ½ inch from the appendix. The appendix is divided so as to leave a stump never shorter than ½ inch. The lumen of the stump is gently stretched by inserting a pair of mouse-toothed forceps and opening the blades. The stump is then invaginated into the cecum, that is, it is turned "outside in." The sutures are tightened, and while this is being done, the mouse-tooth forceps used in effecting inversion are withdrawn. Finally, the sutures are tied (Robt. H. M. Dawbarn in "Internat. Jour. of Surg.," May, 1895). In this method the stump is not ligated and hemorrhage is liable to take place into the gut. Deaths from such hemorrhage are on record. The retained bit of appendix drains into the colon. I believe it is a mistake to trust to simple ligation and to fail to bury the stump left after appendectomy. If a surgeon follows this plan in any great number of cases he will now and then have a case in which the ligature slips and feces pass into the peritoneal cavity, or cases of temporary fecal fistula, or cases of intestinal obstruction from adhesion

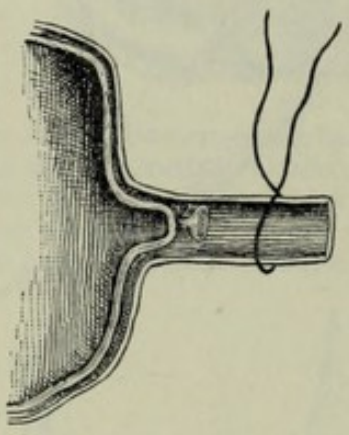


FIG. 783.—Barker's technic of operation for removal of the appendix.

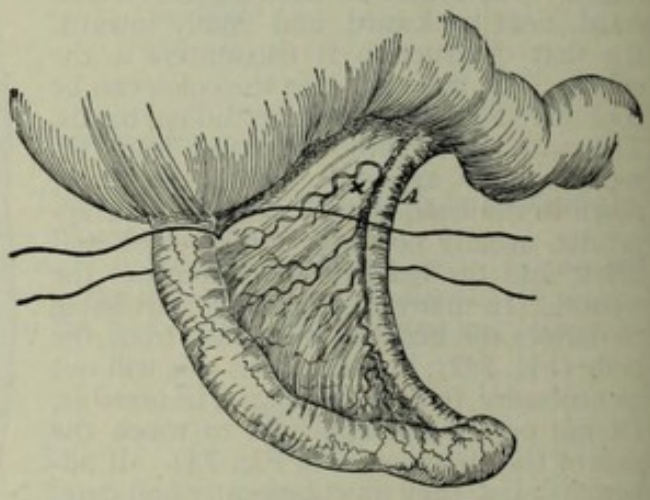


FIG. 784.—Ligation of appendix and meso-appendix.

of some portion of the bowel to the exposed stump (Murat Willis in "Annals of Surgery," July, 1908). I do not believe that a properly prepared stump, when buried, increases postoperative pain.

If drainage is not required, remove the pads which were inserted last, remove the strips of gauze which were inserted first, and close the wound. If drainage is necessary, remove the infected pads, but leave in place the strips which were first inserted in order to limit infection and secure drainage. Pass sutures through the wound edges, tie some of them and leave some untied until gauze is removed at a later period (Van Hook). The rules regarding drainage are on page 1055.

If an operation is performed in a distinct interval, pus is absent and the surgeon can proceed without apprehension. If there is any question of the presence of pus, surround the region with gauze, as suggested above, before breaking down adhesions and liberating the appendix. An interval operation should not be performed until three weeks after an attack. In an interval case McBurney proceeds as follows: He makes the skin incision in the direction of the fibers of the external oblique muscle, separates the fibers of this muscle by blunt dissection, retracts them, separates the fibers of the internal oblique and the transversalis muscles in the same way and retracts them, and opens the transversalis fascia and peritoneum. No muscle-fibers are cut and hernia is not apt to follow. Such a wound is closed as follows: a continuous catgut suture for the peritoneum, sutures of chromic gut for the transversalis fascia, the muscles are restored to place, the aponeurosis of the external oblique is sutured

with chromic gut, and the skin is closed by interrupted sutures of fine silk or silkworm-gut or by a subcuticular stitch.

If an *abscess* is believed to exist, make an incision parallel with Poupart's ligament and over the area of dulness on percussion (Willard Parker's oblique incision). If the abscess is adherent to the anterior abdominal wall such an incision will not enter the free peritoneal cavity. If, after opening the abdomen, an abscess is thought to exist, although it is not adherent to the anterior abdominal wall, surround the abscess with gauze before opening it, as directed under Acute Appendicitis. The gauze is placed under the margins of the incision in the peritoneum all around the appendix area; a piece is carried toward the pelvis and another piece toward the liver. Overlay this gauze with gauze pads (Van Hook). Adhesions are broken through with the finger, and when pus appears it is at once wiped away. Remove the appendix in most cases, but not in all. If the appendix lies hanging in the abscess cavity, if it is sloughed off or but loosely attached to the abscess wall, remove it. If the appendix is firmly fixed in the abscess wall and must be dug out of a mass of inflammatory material do not remove it. To remove it under these circumstances may rupture the wall and disseminate the pus into regions not protected by pads and gauze. Deaver and others tell us always to remove the appendix. I do not believe this to be a safe rule to follow. To insist on removing the appendix may cause death. When the appendix is left, it usually sloughs away. It is true, a fecal fistula may result, but this is in the large bowel and usually heals spontaneously. Even if a fecal fistula forms and does not heal, the surgeon has acted properly in not removing the appendix, because a fecal fistula may be remedied by another operation. It is rarely that secondary abscess forms, and there are not a great many cases recorded in which an appendix has subsequently given serious trouble when left after operation. In fact, in many cases the appendix is destroyed or obliterated by inflammation. In some cases, however, a secondary operation will be required because of a fecal fistula, a persistent sinus, or an acute inflammatory attack. When Deaver decides to remove such an appendix, he makes an incision in the median line of the abdomen, packs around the periphery of the abscess with gauze, opens the abdomen by another incision, removes the appendix, disinfects, inserts drainage, and then removes the surrounding gauze and closes the median incision. In every abscess case search for fecal concretions and remove them if found. Irrigation should not be employed in appendicular abscess. The force of the stream may break down barriers of lymph and spread infection. After the evacuation of the pus take out the pads. If we decide to drain, leave the long strands of gauze first placed to keep the wound open. Introduce iodoform gauze into the abscess cavity and insert a rubber tube, partially suture the wound, and dress with dry gauze. In forty-eight hours all the strands of gauze are to be removed and fresh pieces are to be inserted for drainage. After this period the gauze drain is changed daily. Morris maintains and proves that large pieces of gauze sometimes cause intestinal obstruction and iodoform gauze sometimes causes iodoform-poisoning, but the risk, it seems to me, should be taken. An interval case should be up and about in from ten days to two weeks after operation. An abscess case or a case with purulent peritonitis may require a much longer time for complete recovery. A fecal fistula sometimes results in cases in which the appendix was not removed, and occasionally forms when it was removed.

If on opening the abdomen pus is found, unlimited by adhesions but wide-spread in the peritoneal cavity, remove the appendix, and then bear in mind Murphy's wise counsel as to how to treat general peritonitis (see page 1009). Put a suprapubic drainage-tube into the pelvis and a tube in the appendix region, place the patient in Fowler's position, and administer salt solution by continuous proctoclysis at a low pressure. The after-treatment of an ordinary appendix operation is that advised after celiotomy (see page 1050).

Drainage After Operation for Appendicitis.—At one time drainage was employed not only in abscess cases, but in all cases of gangrene, perforation, and suppurative peritonitis. We have drained much less since Hartmann's important paper ("Bull. and Mem. Soc. de Chir.," 1920, xliv). We now know that we can close in many cases of gangrene and perforation and that because an exudate *looks* like pus is not sufficient reason for draining. Drainage is to be avoided if possible. It retards convalescence, adds to pain and discomfort, causes adhesions, and may be responsible for fecal fistula. The rules laid down by H. St. Leger Brockman ("Brit. Jour. of Surg.," April, 1924) seem to me to rest on the soundest principles. They are as follows: An abscess requires drainage. Drainage is not required simply because an exudate is turbid or looks purulent. In cases of gangrene or perforation, even when the exudate looks purulent,

drainage can be avoided in most cases. The surgeon should drain if the attack began over three days before operation (in such a case the body defences have failed); if the patient is twelve years old or less (is probably a first attack and hence decidedly dangerous—resistance has not developed and without drainage there is but slight tendency to limitation); if toxemia is severe (means much damage to peritoneum and rapid absorption); if there is cyanosis without dyspnea (means toxemia); if there is no fluid or if the exudation is scanty (the larger the amount of fluid, the greater the dilution of the toxins—of course any amount of non-homogeneous fluid calls for drainage); if fluid is bloody (means damage to capillaries and endothelium); if there are flakes or masses of coagulated exudate or false membrane; if the exudate looks like beef-tea; if the appendix was extraperitoneal or bound down by adhesion (a raw surface left after removal); if cecum or ileum is found to be edematous, thick, or rough; if the omentum is thrombosed or covered with lymph; if the appendix cannot be removed.

Mortality After Operations for Appendicitis.—The interval operation is practically without mortality. In over 1000 cases Treves had 2 deaths. In 446 cases of chronic appendicitis the Mayos had 1 death ("Report of St. Mary's Hospital for 1912"). In grave acute cases the mortality is large. In 100 consecutive cases of this character collected by Hearn and operated upon in the Jefferson Hospital by Keen, Hearn, and DaCosta, there were 8 deaths. As previously stated, Maurice H. Richardson reported a death-rate in such cases of 18 per cent. in 750 cases. Deaver reports from the Lankenau Hospital 144 cases, with a mortality of 17.8 per cent. He eliminates 1 death from diabetes, 1 from pneumonia, and 1 from phthisis, and estimates his personal mortality at 15.9 per cent. (Deaver and Ross in "Jour. Amer. Med. Assoc.," Oct. 5, 1901). In 124 cases (including all chronic cases and those acute cases in which the inflammation had not extended beyond the peritoneal coat) there was 1 death. In 347 cases of acute and suppurative appendicitis operated upon in the Mayo clinic in 1912 there were but 2 deaths ("Report of St. Mary's Hospital for 1912"). In the Mayo Clinic from Jan. 1, 1907 to Jan. 1, 1918 there were 12,329 operations for appendicitis, with a mortality of 0.6 per cent. (personal communication to the author). I fancy most of these cases came from a distance and hence the proportion of violent and rapid cases must have been less than is usually the rule in a great city. In Burgess's 500 consecutive operations there were 40 deaths ("Brit. Med. Jour.," Feb. 24, 1912). When infection was limited to the appendix the mortality was 0.74 per cent. (135 cases); when there was circumscribed abscess it was 4.64 per cent. (213 cases); when there was diffuse spreading peritonitis it was 19.07 per cent. (152 cases). The usual causes of death are intestinal obstruction, septic peritonitis, septic endocarditis, pylephlebitis, hepatic suppuration, metastatic abscesses, endocarditis, and gangrene of the bowel. In a further report from September 1, 1902 to September 1, 1903 Deaver reports 566 cases in the Lankenau Hospital, with an aggregate mortality of 5 per cent. In cases with diffuse peritonitis the mortality was 31 per cent. In abscess about a necrotic and perforated appendix it was 12 per cent. In early appendicitis or when disease was confined to the appendix it was 0.8 per cent. In 107 cases of circumscribed abscess in which Burgess removed the appendix the mortality was 1.86 per cent. In 106 cases in which he did not remove the appendix it was 7.54 per cent. ("Brit. Med. Jour.," Feb. 24, 1912).

Appendicostomy (Weir's Operation.).—This operation was devised by Weir, of New York, in 1902 ("Med. Record," Aug. 9, 1902). It consists in opening the abdomen, finding the appendix, separating any adhesions, delivering the diverticulum, and anchoring the base of the appendix to the parietal peritoneum. One catgut suture catches the mesentery of the appendix and the other catches up all the coats but the mucous at a point opposite the first stitch. Pains must be taken to avoid the first arterial branch given off at the base of the appendix. Constriction of this branch will cause gangrene. For fear that the caliber may not be patulous, cut across at the level of the skin and insert a flexible catheter. If the catheter enters the cecum, tie it in. If it does not, remove the appendix and do a cecostomy. Suture the muscles and fascia about the remainder of the appendix, but not so tightly as to cause strangulation, and sew the appendix to the skin with two silk sutures. The operation is done to permit of irrigation. After a few days the permanent catheter should be removed. Afterward the catheter is introduced when needed. The operation is of value in chronic ulcerative colitis, as it enables us to irrigate thoroughly the large bowel. Daily a large tube is passed into the rectum and a small tube into the appendix. The fecal matter is washed out of the bowel through the rectal tube by salt solution, and then a 1 : 5000 solution of silver nitrate or bismuth and starch-water (1 dram to 1 oz.) is used

to irrigate the colon. It is injected by way of the appendix and it runs out of the rectal tube. It is used for the same purpose in some cases of tuberculous rectal or anal fistulæ. A most extraordinary suggestion is that appendicostomy be performed in epileptics, so that the opening may be used to flush the bowel, a suggestion which I will not act upon. The fistula does not leak to any appreciable degree. When we wish to close we insert within the lumen of the tube the Paquelin cautery at a red heat. This destroys the mucous membrane and the fistula closes. Cecostomy is usually preferred to appendicostomy.

Cecostomy (Gibson's Operation).—This operation is usually preferred to appendicostomy. Open the abdomen by splitting the muscles as in McBurney's operation for appendicitis. Suture the cecum to the wall of the abdomen. Open and intro-

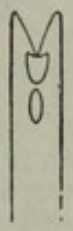


FIG. 785.—Eye of the calix-eyed needle.

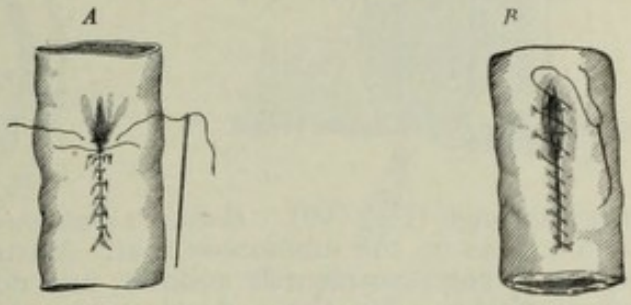


FIG. 786.—Enterorrhaphy: *A*, Lembert suture; *B*, Dupuytren's suture.

duce a tube as in the gastrostomy of Kader or of Witzel. Irrigations are made through the tube.

Enterorrhaphy, or Suture of the Intestine.—Surgical opinion has greatly altered in regard to this operation since the day when John Bell wrote his famous attack on Benjamin Bell. John Bell said: "If in all surgery there is a work of supererogation it is this operation of sewing up a wounded gut." Today we know that if in all surgery there is a proceeding of imperative necessity it is the sewing up of a wound in the intestine. To perform this operation take fine sterile silk and thread a thin, round, straight, calix-eyed needle with it (Fig. 785). The needle is very useful, as it can be threaded rapidly by pushing the calix eye down upon the silk thread while the latter is kept taut. *Lembert's suture* (Figs. 786, A, 787, 788) was devised in 1823. Lem-

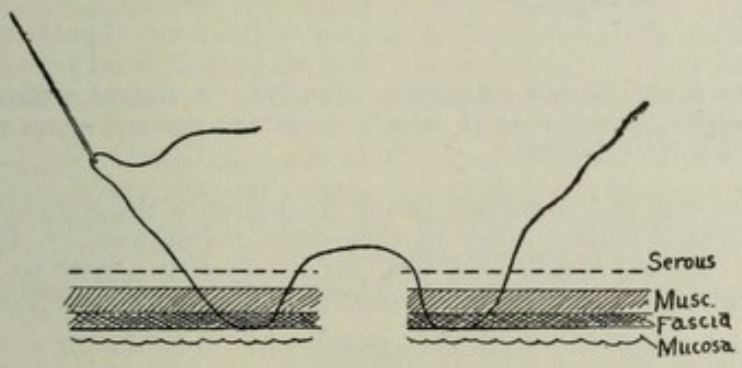


FIG. 787.—Lembert's suture.

bert used it on animals, but never on man. It is inserted at right angles to the wound. It goes down to, but not through, the mucous membrane. It is formed by picking up a fold of the intestine ($\frac{1}{12}$ to $\frac{1}{8}$ inch wide) from the edge on one side of the wound, passing the needle through, picking up a fold on the opposite side of the wound, and passing the needle through. On tying the threads the serous membrane is inverted and peritoneum is brought into contact with peritoneum. For many years it was taught that this suture should include only the serous coat, but Halsted in 1887 showed that it must include the tough submucous coat. The submucous coat is strong and will hold a suture. The other coats are thin, tear easily, and will not hold a suture. So thin are the coats that a surgeon could not suture the serous coat alone were he to try. Sutures which include only the muscular and serous coats tear out easily. *Dupuytren's suture* (Fig. 785, B) is simply a continuous Lembert suture running obliquely

across the wound. *Cushing's right-angled suture* (Fig. 789) is a continuous suture catching up the submucous coat and serving to invert the layers of gut. Ford, of San Francisco, employs a continuous inversion suture, which is tied in a single knot each time

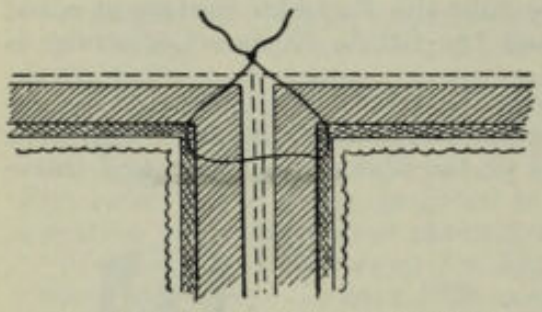


FIG. 788.—Lembert's suture closed.



FIG. 789.—Cushing's right-angled suture (Senn).

it is drawn through (Fig. 790). *Halsted's mattress* or *quilt suture* is shown in Fig. 791. Each stitch picks up the submucous coat. Mattress-sutures do not tear out easily, they appose evenly considerable surfaces, and do not constrict the tissue as much as Lembert stitches. The *Czerny-Lembert suture* is a suture passed through the serous

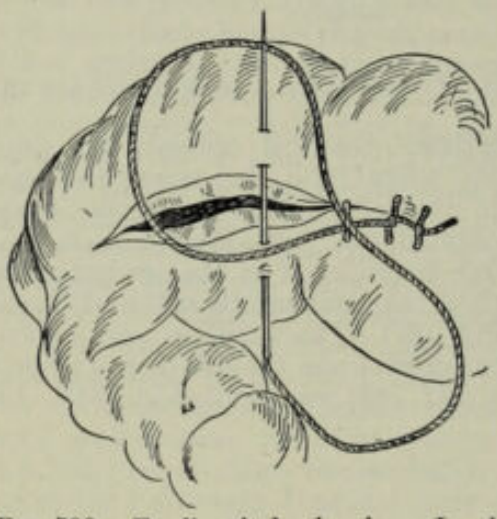


FIG. 790.—Ford's stitch, showing a Lembert insertion and the needle passed so as to tie a single knot by drawing it on through.

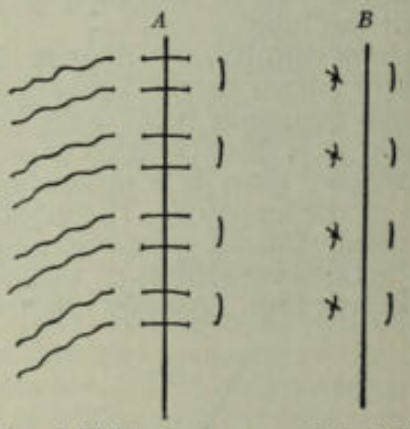


FIG. 791.—*A*, Halsted sutures untied; *B*, Halsted sutures tied and serous surface inverted.

membrane on one side of the wound, made to perforate the mucous membrane, and to emerge at a corresponding point of the serous membrane. A Lembert suture is added (Fig. 792). As at present used, the Czerny suture is carried to, but not through, the mucous membrane (Fig. 793). *Gussenbauer's suture* is similar to the Czerny-

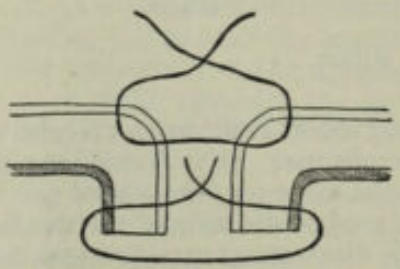


FIG. 792.—Czerny-Lembert suture.

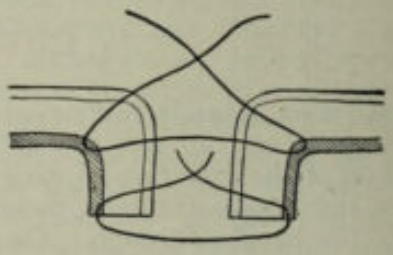


FIG. 793.—Czerny-Lembert suture as at present used.

Lembert suture, except that it applies the Czerny and the Lembert with one suture, and this suture does not pass through the mucous membrane (Fig. 794). In *Connell's suture* (F. Gregory Connell, in "Phila. Med. Jour.," Jan., 1899) the knots are placed within the lumen of the bowel (Fig. 796). Connell's very useful and ingenious stitch

seems to be a modification of a stitch described by Frederick Holme Wiggin ("Med. Record," Nov. 19, 1898). *Wölfler's suture* unites broad layers of the serous coat, the knots being tied internally (Fig. 795). Senn says that after suturing a large wound of the stomach or of the intestine a strip of omentum ought to be laid over the wound and be fastened by catgut sutures (*omental graft*). These grafts adhere and are a safeguard against leakage. (For other methods of enterorrhaphy see Intestinal Resection and Anastomosis.)

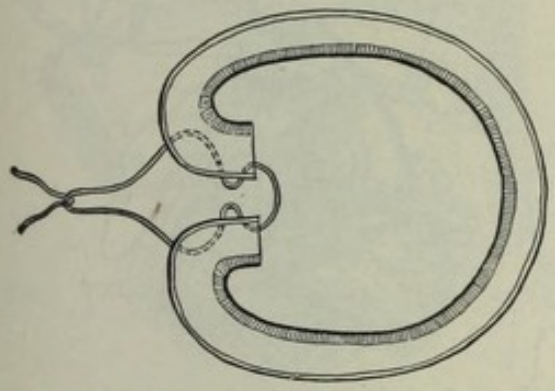


FIG. 794.—Gussenbauer's suture.

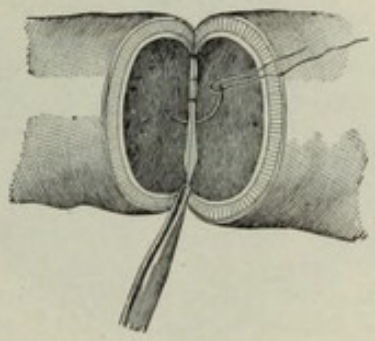


FIG. 795.—Wölfler's suture.

Operations Upon the Stomach.—In some serious operations, for instance, pylorectomy, it may be found desirable to do a two-stage operation—first gastro-enterostomy and two or three weeks later the major operation. The patient is thus nourished and strengthened before the great trial. After gastro-enterostomy the disappearance of fibromatosis makes the outline of a cancer evident. A patient must be carefully prepared for an operation upon the stomach. It is true that normal stomach contents should not contain pyogenic bacteria, but if the acid content is low or if there is no acid such bacteria may be present. When there is normal or increased acidity acid-forming bacteria, yeast, and sarcinæ may be present. The Johns Hopkins method of preparation founded on the researches of Harvey Cushing regarding sterilization of the stomach is to be used. During the two or three days immediately preceding operation clean the mouth and teeth several times during the day with a carbolic solution. Give only sterile water and sterile liquid food by the mouth, and for twelve hours before operation give no food whatever. During the two or three days before operation wash out the stomach with boiled water night and morning. I do not wash immediately before operation, as it sometimes leads to annoying vomiting and thus may interfere with anesthetization. If the tissues of the patient are seriously dehydrated give salt solution by hypodermoclysis for the two or three days preceding operation. After operation give no food whatever for thirty-six hours. Small quantities of hot water are allowed as soon as the patient recovers from ether. During the first twenty-four hours give an enema of hot salt solution and coffee every five hours and then alternate nutritive enemata with salt enemata. After thirty-six or forty-eight hours usually begin to give food by the mouth—at first small doses of albumen-water, and, if this be tolerated, broth and pancreatinized milk. Solid food should not be given for two weeks.

If the patient is advanced in emaciation and much exhausted we should not wait for thirty-six hours to feed him, but should give pancreatinized milk and broth as soon as the patient recovers from ether. The bowels should be moved by enema the day after operation. If the enema fails, calomel is given (3 or 4 gr.).

Digital Dilatation of Pylorus for Cicatricial Stenosis (Loreta's Operation of Pylorodiosis).—Place the patient recumbent and administer ether. Make a vertical incision in the linea alba or through the right rectus muscle. The median incision begins 1 inch below the ensiform cartilage. The cut in either case should be 5 inches in length. When the peritoneum has been opened the stomach is drawn out of the wound, any adherent omentum is separated, and the pylorus is carefully examined. The stomach, after being surrounded with gauze pads, is opened near the center of its anterior surface, "but rather nearer to its pyloric end" (Jacobson).

Insert the index-finger through the stomach wound and into the pylorus, and follow that with the middle finger. The pylorus can be well dilated by separating the fingers. If the stenosis is so tight as to prevent the entry of a finger, introduce a pair of closed hemostatic forceps and open the blades a little when they are within the

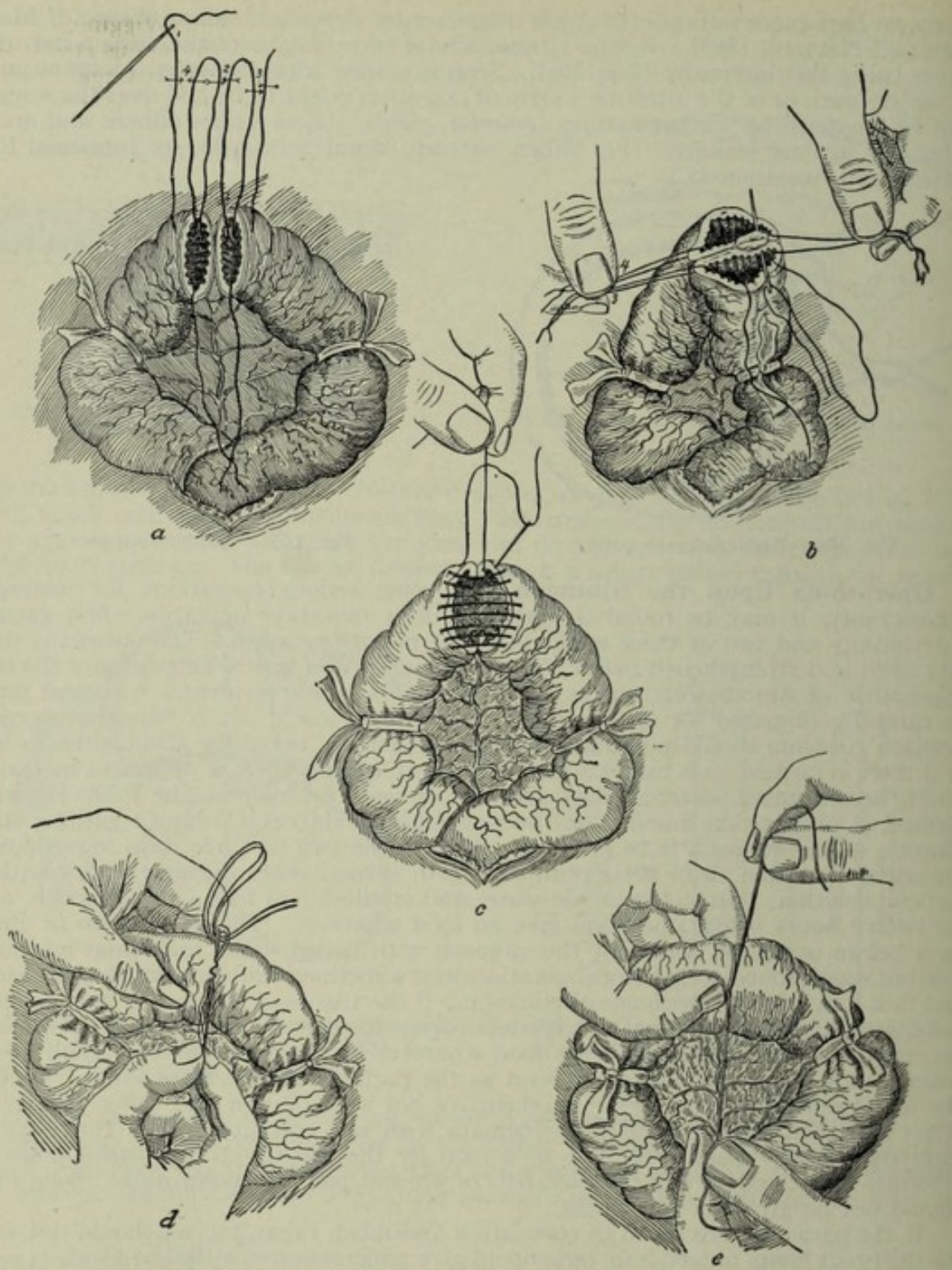


FIG. 796.—Intestinal suture, all knots inside (Connell).

a, Suspending loops 2, 3, and 4 are made with one thread inserted at a point two-thirds of the distance from mesenteric to convex border. The needle with suture is passed through the four walls of the cut ends, and that portion of suture within each lumen is drawn up to a sufficient length, then cut, and the contiguous threads tied at the points indicated by the arrows; thus having as a result four suspending loops dividing the circumference of each cut end into thirds. Instead of employing four suspending loops which divide the circumference of the bowel into thirds, we may use but two loops, and thus divide the circumference into halves; or, if available, the "holder" devised by Dr. E. H. Lee can be recommended highly, and will be found a most efficient aid in maintaining the cut edges in apposition. (The description of the instrument will be found in the "Annals of Surgery," January, 1901.)

b, Loop 2 has been cut away, and loop 1 takes its place in one hand of the assistant, with loops 3 and 4 held in the other hand, thereby bringing into apposition that portion of the walls to be included in the second third of the suture. The operator continues the suture to the points of insertion of loops 3 and 4, where again a back stitch is taken, to fix the suture and prevent a purse-string

lumen of the constricted area. The wound in the stomach is closed by a continuous silk suture of the mucous membrane and two layers of Halsted sutures, to invert and approximate the peritoneal surfaces. After closure of the stomach wound the abdominal wound is sutured.

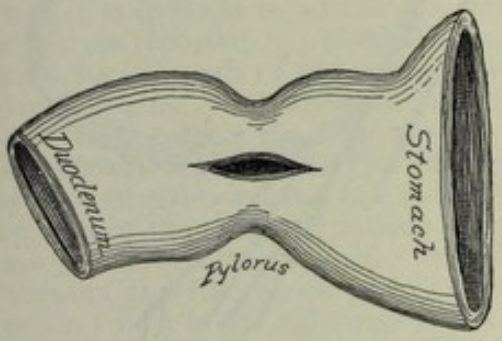


FIG. 797.—Heineke-Mikulicz pyloroplasty: The incision.

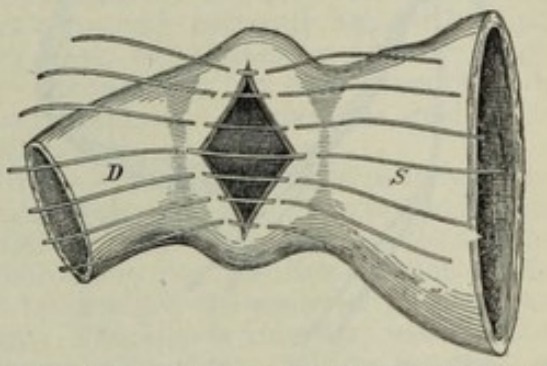


FIG. 798.—Heineke-Mikulicz pyloroplasty: The axis of the incision is changed by traction from horizontal to vertical; sutures in position; only one of the two rows of sutures is shown.

Divulsion by the fingers or by an instrument is no longer practised because experience has shown that the constriction is sure to return.

Pyloroplasty (Heineke-Mikulicz Operation).—The first operation was performed by Heineke in 1886. Early in 1887 Mikulicz, not knowing of Heineke's antecedent operation, did the same thing. Open the abdomen in the middle line or, better, through the right rectus muscle. Draw up as much of the pylorus as possible, and pack warm moist gauze pads around it; make an incision through the stricture and in a direction corresponding to the long axis of the stomach and bowel (Fig. 797). Catch an aneurysm-needle under the upper margin of the incision and draw it up, and an aneurysm-needle under the lower margin and draw it down. The effect of traction is to convert the longitudinal wound into a transverse wound. The sutures are applied so as to maintain the wound in a vertical line (Fig. 798). The mucous membrane is sutured with a continuous suture of silk, and interrupted Lembert or Halsted sutures of silk close the peritoneal and muscular coats (Figs. 798 and 799). Do not drain.

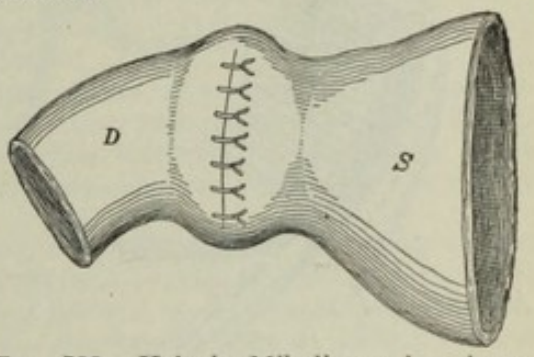


FIG. 799.—Heineke-Mikulicz pyloroplasty: After tying the sutures.

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contraction of the same. The white elevation in the center of illustration, representing mesentery, shows that that portion of the intestinal wall not covered by peritoneum, at the mesenteric border, has been secured in the suture.

c, The needle, after having entered the lumen, is passed out again on the same side $\frac{1}{8}$ inch distant; then over to the opposite cut end, where it is inserted from without in, and again emerges from within out, on the same side. This step—the taking of a bite—is repeated alternately on opposing margins until the necessary number of stitches have been inserted. It will be observed that when the needle enters the lumen the last time, it makes what might be termed a half-stitch, as it does not return again *through* the wall; but having reached the point where the suture was commenced, the free end and the needle end will complete the last stitch, when tied, on the mucosa. The needle at this point is then brought out of the lumen at the angle of wound alongside of the free end of the suture. The cross-over stitches are next carefully drawn up, thus bringing into contact the opposing serous surfaces at every point except where the suture ends still protrude.

d, The eye-end of threaded needle is made to emerge alongside of the suture ends, and is then withdrawn a little, which causes its thread to form a loop, through which the assistant passes the ends of the suture. The operator next withdraws the threaded needle, at the same time bringing with it the suture ends, and they present externally at the point of withdrawal of the needle. The serous coats throughout the entire circumference are now in apposition, and the suture ends can be tied.

e, By slight traction on the suture ends the opposing mucous surfaces are brought in close contact; the suture ends are then tied firmly, and deep between the serous coats, thus tying the knot upon the mucous coat, and the ends then cut off short.

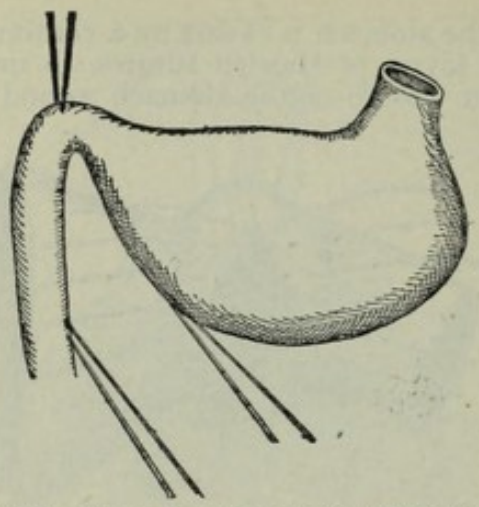


FIG. 800.—Finney's pyloroplasty: The retractor sutures.

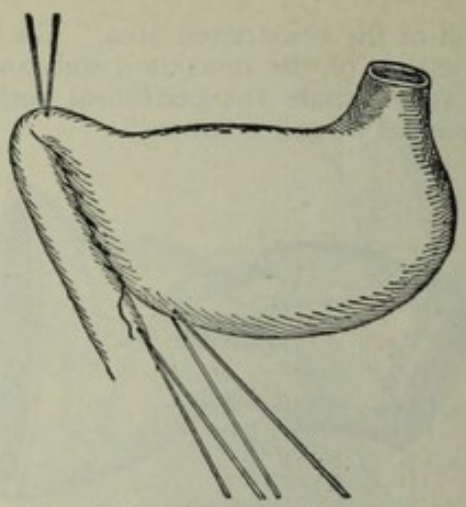


FIG. 801.—Finney's pyloroplasty: Suture of greater curvature of stomach to duodenum.

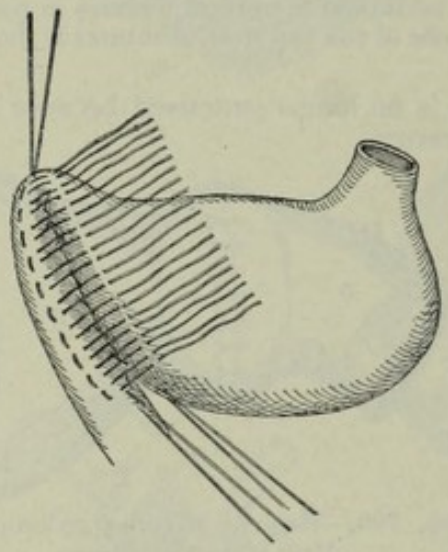


FIG. 802.—Finney's pyloroplasty: Shows the three retractor sutures, the posterior line of sutures tied and the anterior line of sutures untied.

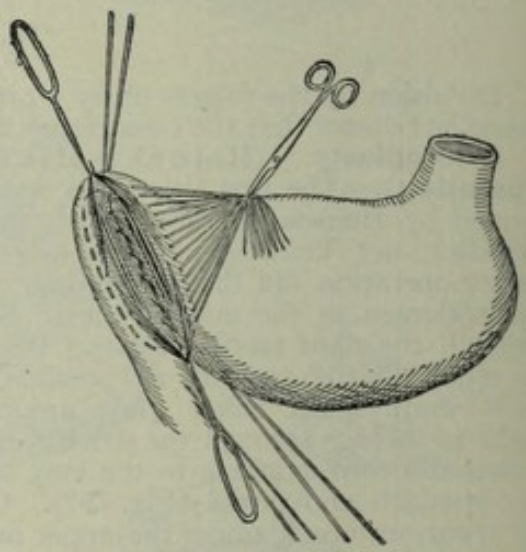


FIG. 803.—Finney's pyloroplasty: The anterior sutures gathered and lifted.

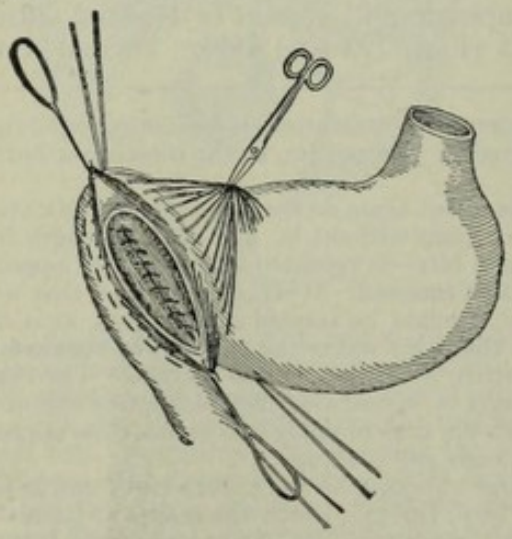


FIG. 804.—Finney's pyloroplasty: The continuous posterior catgut suture.

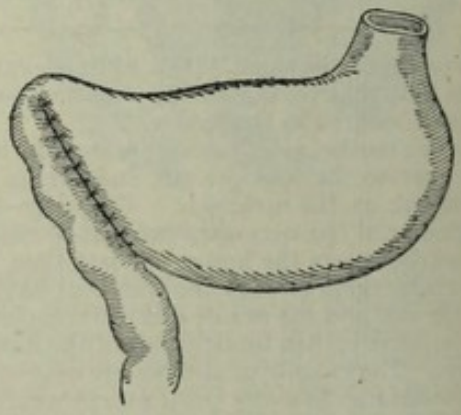


FIG. 805.—Finney's pyloroplasty completed by tying the anterior sutures.

A. W. Mayo-Robson inserts a bone bobbin and then applies the sutures. The operation of pyloroplasty shows a mortality about the same as or slightly less than gastro-

enterostomy. In some cases it is a very satisfactory procedure, but there are objections to it, and in 30 per cent. of cases it fails to give relief (Wm. J. Mayo). The outlet is not at the most dependent part of the stomach, hence the stomach may not empty itself. Further, as Finney points out, it cannot be performed if there are firm adhesions or active ulceration, and the scar may contract and give rise to stenosis. Again, it is difficult to suture the wound so as to provide certainly against leakage. The Mayos reported 21 pyloroplasties without a death, but 7 cases required secondary operations ("Annals of Surgery," Nov., 1905). Pyloroplasty has been abandoned by many surgeons; J. Rutherford Morison still advocates it. Finney has devised an operation to correct the objections to pyloroplasty.

Gastroduodenostomy by Finney's Method.—This operation is usually called a method of pyloroplasty, but it is rather a gastroduodenostomy. The operation was described in the "Johns Hopkins Hospital Bulletin," July, 1902, and was then called pyloroplasty. It is performed as follows: Thoroughly free the first portion of the duodenum and the pyloric end of the stomach by dividing the posterior layer of peritoneum 1 inch to the right side of the duodenum. This step is known as *mobilization*. Insert three retractor sutures (Fig. 800) and draw upon them. Suture together, as far posterior as possible, the peritoneal surface of the duodenum and the peritoneal surface of the stomach along its greater curvature (Fig. 801). Then insert an anterior row of mattress-sutures, but do not tie them as yet (Fig. 802). Make a horseshoe-shaped incision (Fig. 803); arrest bleeding; excise as much scar-tissue as possible on either side of the incision, and trim off the redundant mucous membrane. Insert a continuous catgut suture on the posterior side of the incision and carry it through all the coats (Fig. 804). Straighten out the anterior sutures and tie them (Fig. 805). The Mayos reported 58 Finney operations, with 4 deaths and 2 secondary operations (Wm. J. Mayo in "Annals of Surgery," Nov., 1905).

The mortality is greater than after gastro-enterostomy, due probably to the necessity of separating adhesions and setting the duodenum free. The operation should be restricted to cases in which adhesions are not wide-spread and firm and in which the gastrohepatic omentum is of fair length. In properly selected cases it is a very valuable operation.

Pylorectomy (Excision of the Pylorus).—The removal of a portion of the stomach is a partial gastrectomy, and pylorectomy is a partial gastrectomy in which the pylorus, some of the stomach wall, and also a portion of duodenum are removed.

The experiments of Gussenbauer and von Winiwarter on dogs in 1876 led them to suggest the operation. It was first performed by Péan in 1879. It was next performed by Rydygier in 1880. Billroth did the first successful pylorectomy in 1881. The operation is seldom performed for anything but cancer, but sometimes is done for pyloric ulcer and its results. In many cases of pyloric cancer the abdomen is opened only after a palpable tumor is detected, and when a palpable tumor is detectable it is usually too late to perform pylorectomy.[1] The lesson is to explore suspected cases earlier than has been our custom.

I agree with Hemmeter that stenotic symptoms, even when no tumor is palpable, call for exploratory laparotomy. If the stomach is dilated, if there is cachexia, if there is no free hydrochloric acid in the gastric juice, if there is an excess of lactic acid in the gastric juice, if the patient is forty or beyond, when there is vomiting of blood, when the Oppler bacillus is present, when blood examination shows a diminution in red corpuscles and hemoglobin, and also shows that there is no increase in white corpuscles after a full meal—explore. After the abdomen has been opened the stomach is examined, and if a tumor exists, the surgeon must decide between the performance of pylorectomy and gastro-enterostomy. If the tumor is not very extensive, if there is no glandular involvement or only involvement which can be removed, and if adhesions are not extensive, pylorectomy is chosen; otherwise gastro-enterostomy is selected.

Until comparatively lately the mortality from pylorectomy was usually estimated to be at least 25 per cent., even in favorable cases. During recent years the mortality has been much reduced. The operative mortality in the Mayo Clinic has been from 13.2 to 14.4 per cent. In a personal communication (July 14, 1923) Dr. Charles H. Mayo states that the mortality in the Mayo Clinic for pylorectomy or partial gastrectomy for cancer is 10.49 per cent. These cases include those in which the remaining stomach could be united to the duodenum and those in which a posterior gastro-enterostomy was made and the duodenum closed. In 38 recent cases operated upon

[1] Keen's "Cartwright Lectures for 1898."

by Balfour's method of partial gastrectomy followed by anticolic gastrojejunostomy the mortality was 5.2 per cent. (D. C. Balfour in "Surgery, Gynecology, and Obsertrics," 1917, xxv). During twenty years there were in the Mayo Clinic 651 resections of the stomach for cancer. Of 427 patients operated upon more than three years ago who recovered from the operation, 311 have been traced, and of these, 120 (38.6 per cent.) were alive three years or more after operation. Of 313 patients who were operated upon more than five years ago, 239 who recovered were traced, and 62 (26 per cent.) were alive five years or more after operation. Such results compare favorably with operations for cancer in other regions ("Collected Papers of the Mayo Clinic," 1917). Prepare the patient for pylorectomy as for any stomach operation. The best incision through the abdominal wall is a vertical one near the median line on the left side. A small incision is first made to permit of exploration, and if the growth is found to be removable, the incision is enlarged. In some cases it will also be found necessary to divide the rectus muscle by a transverse cut.

Billroth Method.—This method, which was long employed, did not remove enough of the stomach if there was malignant disease; the opening left in the stomach is much

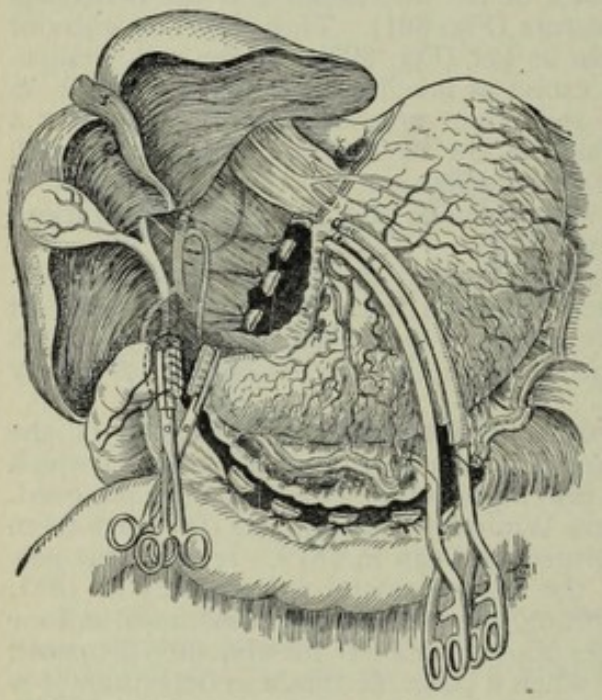


FIG. 806.—Pylorectomy by the Mayo method: Clamps applied, duodenum divided, and continuous catgut stitch introduced (Mayo).

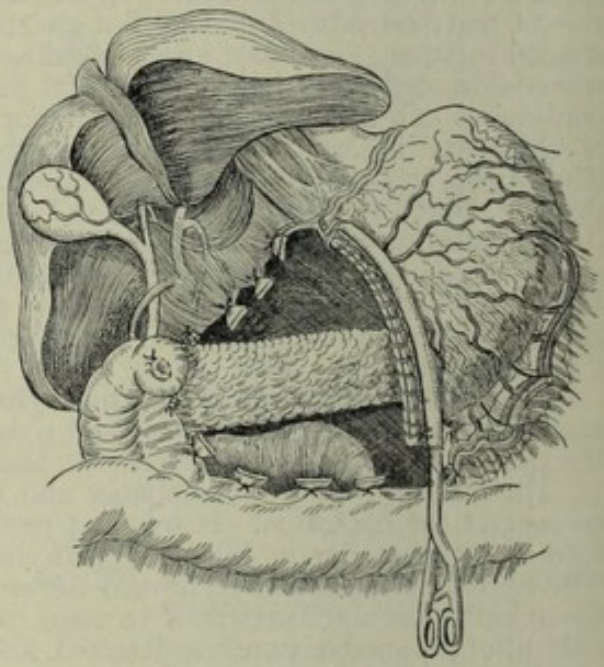


FIG. 807.—Pylorectomy by the Mayo method: End of divided duodenum buried by a purse-string suture. Row of lock stitches inserted in stomach stump (Mayo).

larger than the duodenal opening, and in suturing so as to make the two openings of equal size an angle is left which may leak (the *fatal angle*). Billroth's first operation is shown in Fig. 808. The operation has been improved and may be used for ulcer or limited cancer. In this operation as done at present, and which we now call a Billroth I, the parts are mobilized, and if we are dealing with cancer the glands along the lesser curvature are removed. The diseased area is removed. The stomach portion of the wound is partly closed from the lesser curvature in the direction of the greater, so that the stomach wound will correspond to the duodenal wound in size. The ends are sutured together. Modifications of the Billroth I are shown in Figs. 809–811.

A Mayo Method.—Study of the lymphatic area led to advocacy of removal of the lesser curvature along with the glands in all cases of pyloric cancer. We now know that in many cases it is not necessary to remove so much of the stomach, and that we can extirpate glands without such abbreviation of the stomach. This operation is the best for extensive pyloric growths. In the Mayo method, after the stomach has been exposed the gastric artery is ligated close to the stomach, the lesser omentum is tied in several segments close to the liver, and then divided, and the pyloric artery is tied. Two clamps are applied to the duodenum 1 inch apart, and the duodenum is divided by means of the cautery (Fig. 806).

The right end of the duodenum is closed by means of a continuous catgut suture, the clamp is removed, and the closed end of the duodenum is inverted by a purse-string suture (Fig. 807). A hand is passed from above back of the stomach and lifts the great omentum forward. The right gastro-epiploic artery is tied close to the stomach. The left gastro-epiploic artery is tied distinctly to the left of any enlarged glands in the great omentum. The great omentum is tied in several segments. The great omentum is divided, leaving any enlarged glands attached to the portion of the stomach it is the intention to remove. The stomach is to be divided to the left of all lymphatic glands into which the cancerous region drains. The clamps are applied as shown in Fig. 806. The stomach is divided between the clamps by a cautery, and as the division is being carried out the stump is caught here and there by hemostatic forceps to prevent it slipping through the clamps. Slipping is disastrous and will cause leaking and entrance of air into the stomach, and entrance of air is apt to

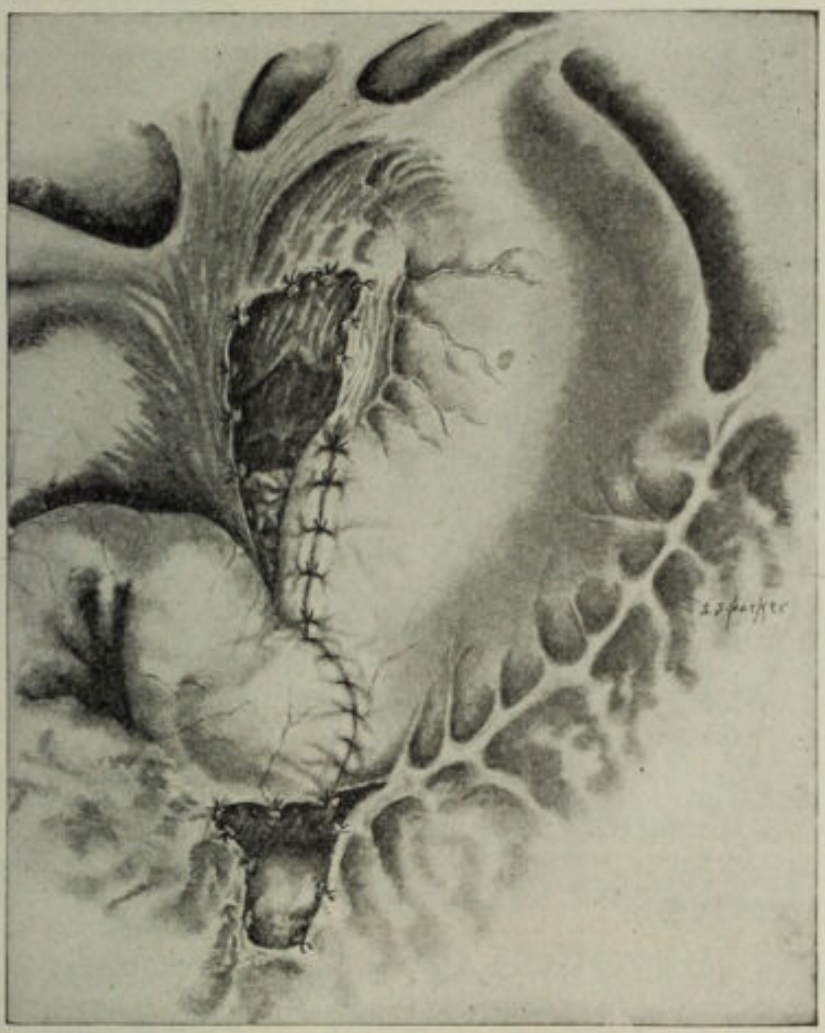


FIG. 808.—Billroth's pylorectomy (Billroth I). The completed operation, except that the omental openings remain to be closed by suture (Bickham's "Operative Surgery").

be followed by pulmonary difficulty. A row of locking stitches is passed through all the coats of the stump. The stitches are tied and a second row is passed and tied (Fig. 807). The clamp is removed and the stump is buried by Cushing's right-angled suture or Dupuytren's suture. A gastrojejunostomy is then performed to the posterior wall of the portion of stomach which remains. (Original Billroth is shown in Fig. 808.)

Modification of Billroth's Original Pylorectomy.—This is known as Billroth II. After pylorectomy both ends are closed. A posterior lateral gastrojejunostomy is performed if it can be done without tension, otherwise the anterior method is preferred. The posterior method may be associated with jejunojejunostomy. Anterior gastro-enterostomy should be associated with jejunojejunostomy. The Kocher plan is to make a posterior end-to-side gastroduodenostomy (anastomosis of the divided end of the duodenum to the posterior gastric wall). Another modification is to

anastomose the side of the jejunum to the wound of the stomach made by excision (Figs. 809, 810).

Mayo's Recent Method.—Pylorectomy. Posterior gastro-enterostomy by side of jejunal loop to end of stomach, the stomach wound being drawn through the transverse mesocolon (*Polya plan*). (See Fig. 847.)

A patient with pyloric cancer is usually much dehydrated, and if he is, salt solution should be given by rectum before and intravenously during the operation, and an enema of warm salt solution should be administered every six hours for several days after the operation. Active stimulation is usually necessary and 8 ounces of coffee should be given by rectum at the completion of the operation. The patient must be placed erect or semi-erect in bed as soon as the effects of the ether pass away. Twelve hours after operation begin to give small amounts of hot water by the mouth. Nourish by the rectum from four to six days, when fluid food may be given by the mouth, starting with small doses of albumen-water, and, if this is tolerated, giving dessertspoonful doses of peptonized milk every hour.

Statistics.—From Jan. 1, 1906 until Jan. 1, 1918 there were 589 resections in the Mayo Clinic, with a mortality of 12.9 per cent. Their mortality after resection for

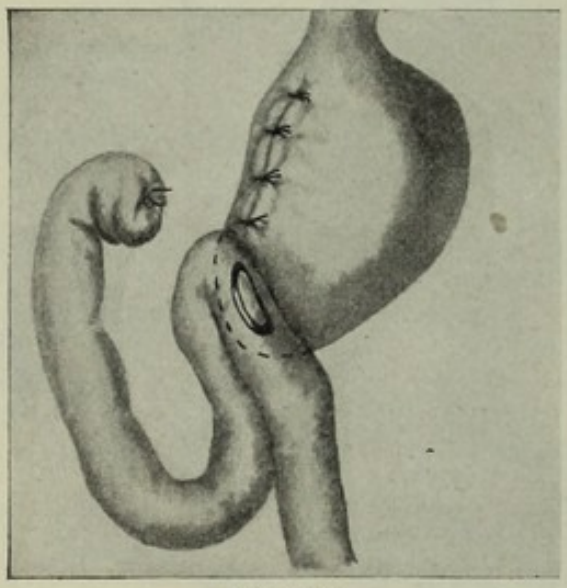


FIG. 809.

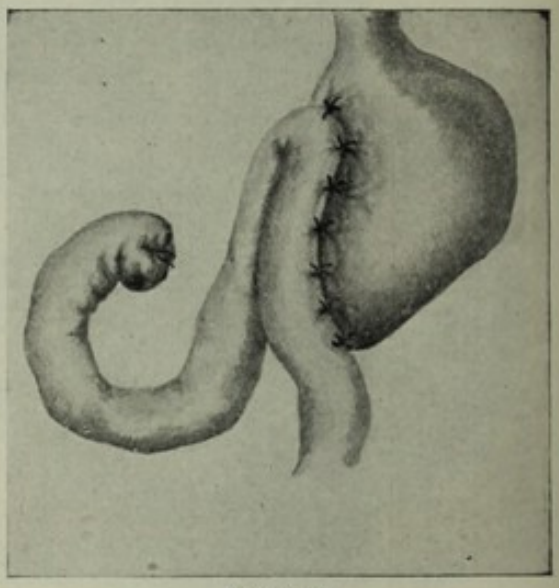


FIG. 810.

FIGS. 809, 810.—Pylorectomy for gastric carcinoma, followed by terminal anastomosis of the jejunal loop to the end of the sutured stomach, over a greater or less part of its extent—alternate technic of Billroth's Method II: *a*, Anastomosing the jejunal loop with the lower end of the sutured walls of the stomach; *b*, anastomosing the jejunal loop with the entire divided end of the stomach. Any intermediate degree of the stomach end, between these extremes, may be utilized (Bickham's "Operative Surgery").

ulcers and benign tumors is very small. If during the operation the pancreas be wounded the closed end of the duodenum is applied directly to the pancreatic wound, as Willy Meyer suggested ("Trans. of Amer. Surg. Assoc.," 1910). "The anterior peritoneum and adventitious sheath of the pancreas are then sutured to the anterior surface of the duodenum." This plan prevents leakage from the duodenum and pancreas (Wm. J. Mayo in "Annals of Surgery," Aug., 1913). Addison's disease has arisen occasionally after pylorectomy.

Total Gastrectomy.—The entire stomach was first removed by Conner, of Cincinnati, in 1883. The first successful operation was performed by Schlatter, of Zürich, in 1897. Total gastrectomy will rarely be required, but in certain unusual cases it will be proper to perform it. In some cases the duodenal end can be sutured to the divided esophagus; in others it will be necessary to close the end of the divided first portion of the duodenum, and anastomose the esophagus to the jejunum.

The cases suitable for total gastrectomy are those in which the entire viscus, or almost the entire viscus, is cancerous, the stomach being still freely movable, and the glands not so much implicated as to forbid attempts at removal. It is a remarkable fact, first demonstrated in Schlatter's case, that an individual can digest food very well without a stomach. This statement is true only if the stomach function has been

gradually abolished by disease. During this period the functions of the stomach have been assumed to a greater or less degree by other parts. In a recent injury of the stomach complete removal would almost certainly be followed by death, as in such a case other parts would have had no chance to learn how to assume gastric duties. Reported cases of total gastrectomy showed 10 deaths out of 27 cases, but, as Robson truly says, if all cases were reported, the mortality would probably be found to be 50 per cent. Trinkler ("Archiv. für. klin. Chir.," Berlin, xcvi, No. 2) reports 1 case (which died on the eighth day) and gathers 25 from literature; 13 recovered. When the duodenum was stitched to the esophagus the mortality was 57.1 per cent. When the jejunum was stitched to the esophagus the mortality was 28.5 per cent.

I have done the operation once. The patient died on the third day. Addison's disease has been found to occasionally follow total or subtotal gastrectomy.

Gastrotomy.—This term is used to designate the operation of opening the stomach for the accomplishments of some purpose, and immediately closing the incision in the gastric wall when that purpose has been accomplished. Gastrotomy may be performed to permit of the removal of foreign bodies, of exploration of the stomach and its extremities, of divulsion of the pyloric orifice, of the treatment of bleeding, of an esophageal stricture or a stricture of the cardiac orifice of the stomach, or of the removal of a foreign body lodged in the esophagus. The first case on record was in 1602, when Florian Mathias, of Brandenburg, removed from the stomach of a juggler a knife which had been accidentally swallowed. When Evelyn was in Leyden in 1641 he saw a knife which had been removed by gastrotomy. He says (Evelyn's Diary): "I was showed the knife newly taken out of a drunken Dutchman's guts by an incision in his side, after it had slipped from his fingers into his stomach. The picture of the surgeon and his patient, both living, were there." In 1635 Schwabe removed a table knife thirty-five days after it had been swallowed, but that was a German case, and was not the one of which Evelyn speaks.



FIG 811.—The completed operation, alternate technic of Billroth's Method II (Bickham's "Operative Surgery").

The patient is prepared as for pylorectomy. The incision may be vertical in the middle line or identical with the incision for pylorectomy. If a large foreign body can be felt, the incision is made directly over it. When the peritoneal cavity is opened, the surgeon decides as to the point where the stomach is to be incised, draws this portion out through the wound, packing gauze pads under and around it. The stomach is opened by means of scissors, the cut being at a right angle to the long axis of the viscus (Jacobson). Bleeding vessels are ligated with catgut. The purpose for which the stomach has been opened is now carried out, the interior of the stomach and the surface of the extruded portion are irrigated with hot salt solution, the mucous membrane is sutured with a continuous suture of silk, and two rows of Halsted sutures are inserted. The abdominal wound is closed, drainage being employed for twenty-four hours.

Gastrostomy is the making of a gastric fistula through which the patient can be fed. In many cases the opening is used as a doorway which permits of the introduction of an esophagoscope and the dilatation of an esophageal stricture. In my clinic in the Jefferson Hospital my chief assistant, Dr. Thomas A. Shallow, performed gastrostomy 80 times. Eight died within two weeks of operation, but one of those

who died was a newborn infant with esophagotracheal fistula, one was moribund from septic mediastinitis, and one was dying of lymphosarcoma of the neck and thorax. Eliminating these 3 cases we get 77 operations, with 5 deaths. Such patients when operated upon are usually weak, wasted, dehydrated, and not uncommonly they are the victims of acidosis. The earlier the operation, the less the risk, but, as Chevalier Jackson says, "we all teach early operation, but seldom do it." Gastrostomy was first proposed by Egebert in 1837 and was first performed by Sédillot in 1849. In 1875 Sydney Jones operated upon the twenty-ninth case and obtained the first recovery (Keen). Up to 1884 the estimated mortality was 80 per cent. Later the mortality in malignant cases was estimated as from 20 to 25 per cent., and in non-malignant cases as from 8 to 10 per cent. Gastrostomy is employed in cases of esophageal obstruction or obstruction of the cardiac end of the stomach. In many cases of malignant disease the operation is performed too late, and if performed when the patient is greatly emaciated and exhausted the operation has, of course, a high mortality. An early operation is far safer and confers the maximum of relief. The operation should be performed, as Mikulicz advises, when the patient is steadily losing

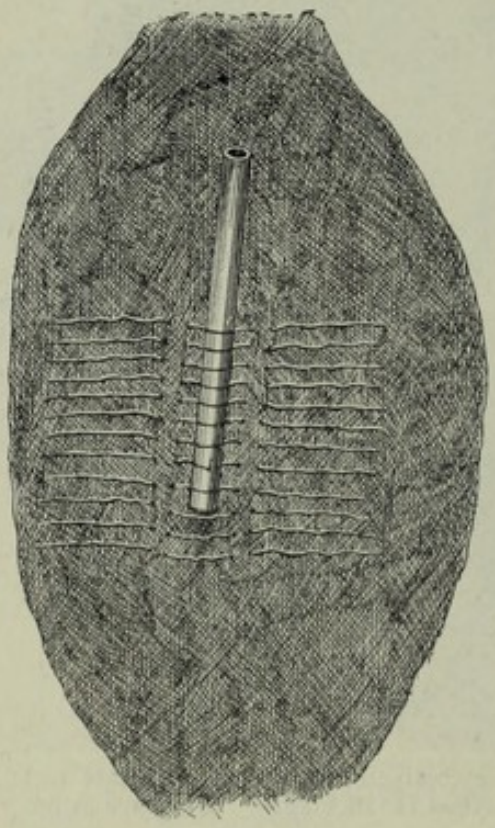


FIG. 812.—Witzel's method of gastrostomy, showing application of sutures in wall of stomach, embedding tube obliquely therein.

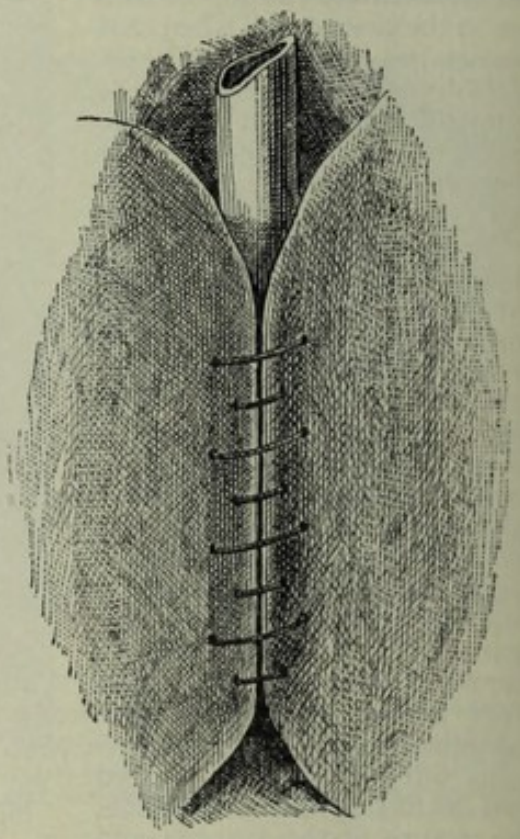


FIG. 813.—Sutures tied, completely embedding tube obliquely therein.

weight and there is beginning to be difficulty in swallowing semisolids or liquids. The surgeon must endeavor to perform an operation which will not permit of leakage. Prepare the patient as for any stomach operation. It will usually be impossible to wash out the stomach.

Witzel's Method.—This operation was first practised in 1891. Make an incision 4 inches in length, to the left of the middle line, just below the border of the ribs. After opening the peritoneal cavity seize the stomach, bring it out of the wound, and pack gauze around it. Introduce a rubber tube into the stomach and enfold it by a double row of Lembert sutures (Figs. 812, 813). This tube should be 5 inches long and of the same diameter as a No. 25 French bougie. The opening is made in the stomach toward the cardiac extremity, the tube is placed parallel with the belly wound, and the outer end of the tube emerges in the median line. The tube is retained in place by a catgut stitch carried through the tube and the stomach wall. The stomach is returned and is stitched by three sutures to the abdominal wall. The abdominal incision is sutured and a clamp is placed on the tube. When the patient is fed, a funnel is slipped into the tube, the clamp is removed, and liquid food is poured into the funnel. After

the wound heals it is not necessary to retain the tube permanently. It is passed when the patient desires food. This operation lessens the capacity of the stomach considerably and also deforms it. If the tube is placed at a right angle to the long axis it may lead to the development of hour-glass stomach. The fistula formed by this operation does not permit of the use of the esophagoscope and dilators.

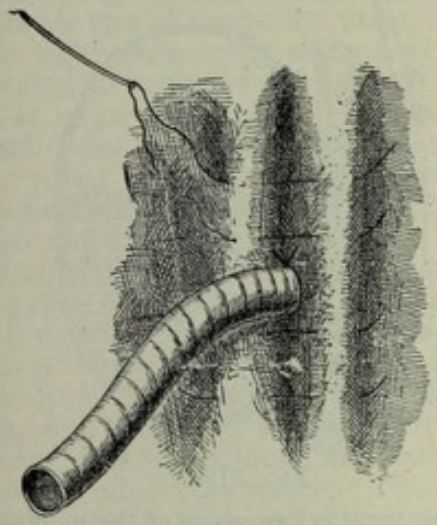


FIG. 814.—Kader's method of gastrostomy: Tube in place and first row of sutures inserted.

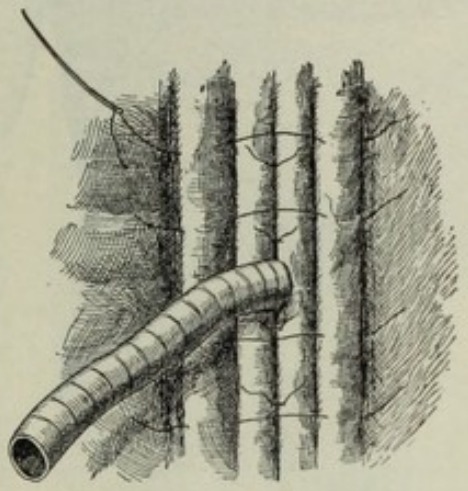


FIG. 815.—Kader's method of gastrostomy: First row of sutures tied and second row inserted.

Kader's Method.—This operation was devised in 1896. It is a modification of Witzel's method and forms a serous channel vertical to the abdominal wall. A small incision is made in the stomach and a tube is introduced and fastened to the stomach by one catgut stitch. Four Lembert sutures are passed so as to form a fold on each side of the tube and turn the stomach wall inward around the tube (Fig. 814). Lembert sutures are inserted in the furrow on each side of the tube. Two more folds are formed over the first two (Figs. 815, 816). The stomach wall is stitched to the parietal peritoneum and sheath of the rectus muscle (Willy Meyer). It can be performed easily and rapidly, even upon a shrunken stomach and the wound does not leak. The fistula can be kept open by the regular passing of a tube and closes rapidly if the passing of a tube be abandoned. I used Kader's operation with satisfaction for a number of years, but now prefer Shallow's modification of it. In case of cicatricial stricture of the gullet the Kader fistula can be used for retrograde dilatation.

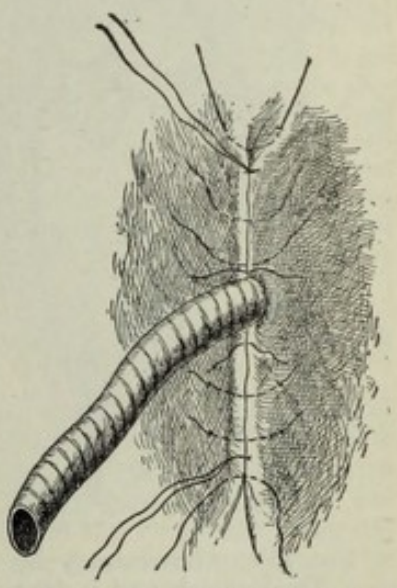


FIG. 816.—Kader's method of gastrostomy: Second row of sutures tied.

The Ssabanajew-Frank Method.—This operation is preferred by some surgeons. I used to employ it, but only if the stomach was not so shrunken as to render the pulling out of a sufficient cone difficult. It was first performed by Ssabanajew in 1890 and was performed independently by Frank in 1893. Fenger's incision is made (a curved incision at the margin of the costal cartilages of the left side). A cone of the stomach is pulled out of the wound and is passed under a bridge of skin which has been prepared for it. The stomach is fixed above the margin of the ribs and opened (Figs. 817, 818). Von Hacker makes the gastric fistula through the left rectus muscles, and Hahn between two of the rib cartilages (Willy Meyer). This operation should not be attempted if the stomach is so shrunken that the cone will be under tension. The fistula cannot be used for retrograde dilatation.

The Younger Senn's Method.—Emanuel Senn devised the following method: A cone of the stomach is pulled out of the abdominal wound, and this cone is puckered by the insertion of two drawing-string sutures of chromicized catgut. A cuff of gastrocolic omentum is sutured by silk around the neck of the puckered cone. The

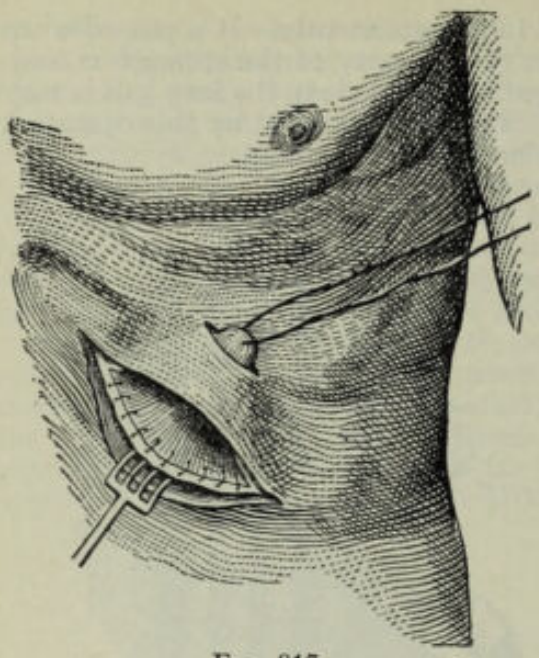


FIG. 817.

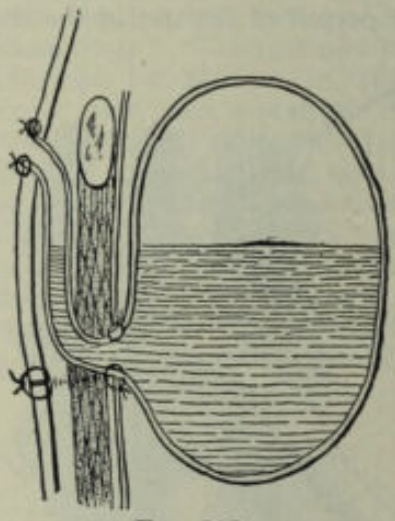


FIG. 818.

FIGS. 817, 818.—The Ssabanajew-Frank method of gastrostomy in carcinoma of the esophagus.

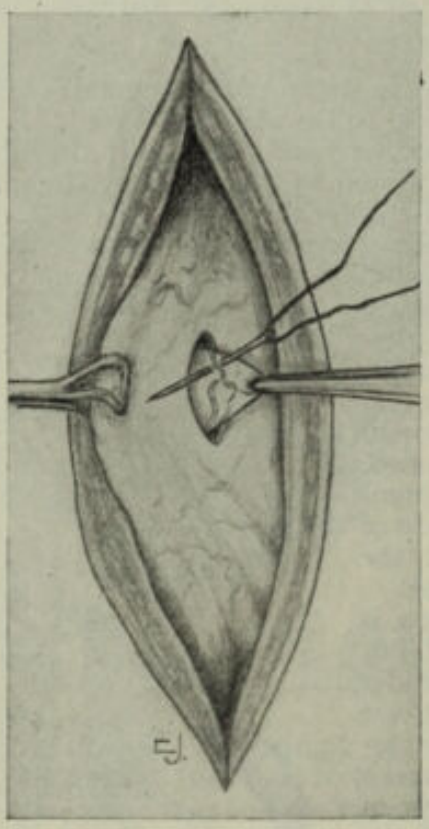


FIG. 819.—Gastrostomy by Shallow's technic. The stomach wall is drawn out and held securely with Babcock forceps. A small nick, no larger than will fit the catheter, is cut with the scissors in the muscular coats, being careful not to cut the submucous coat. The rat-tooth forceps are inserted and a little cone of the mucosal layer is drawn out through the opening in the muscular coats. The vessels in the submucous coat are ligatured by passing a needle under them on each side of the intended cut to be made in the mucous and submucous coats (Shallow in "Surgical Clinics of North America," Feb., 1924).

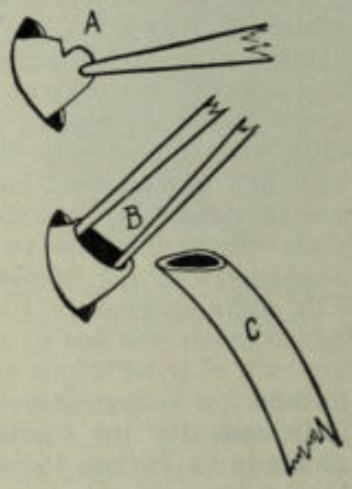


FIG. 820.—The cone of the mucous and submucous coats drawn out after the vessels are ligatured, as shown in Fig. 819, are nicked with the scissors as shown at *A*. A rat-tooth forceps is then inserted in the nick and allowed to expand (*B*), but *only enough to enlarge the opening sufficiently to permit of insertion of the rubber tube, C*, which is cut off with a slant to permit easier insertion at a close fit (Shallow in "Surgical Clinics of North America," Feb., 1924).

stomach is sutured to the belly wall with silk, the sutures including the omental cuff, the serous and muscular coats of the stomach, and the structures of the belly wall, except the skin. The skin is partly sutured. The stomach may be opened at any time. This is a useful operation. The fistula can be used to effect retrograde dilatation of the gullet.

Shallow's method of gastrostomy ("Surgical Clinics of North America," Feb., 1924) distorts the stomach wall and lessens the stomach cavity to the smallest possible degree, hence can be used even when the stomach is much shrunken. The fistulous tract is at a right angle to the abdominal wall, hence is well suited to permit of the catching of the end of piece of string which has been floated into the stomach from the mouth, and of pulling the end of the string guide out through the wound. The fistula permits of the use of the esophagoscope and of instruments being threaded on the string for retrograde dilatation of a cicatricial stricture of the esophagus. An advantage of Shallow's operation is that it constricts the blood-vessels of the stomach wall over the smallest possible area. Cutting off the blood-supply to any marked extent by sutures may lead to sloughing, secondary hemorrhage, and leaking. The 3-inch abdominal incision is at the outer edge of the left rectus muscle. The opening in the stomach is to be made as high in the cardiac portion as possible and midway between the greater and lesser curvatures, a point being chosen which is relatively free from vessels. Figures 819 and 820 show the method of opening the stomach and inserting the tube. The diameter of the catheter is No. 24 French. Figures 821–823 show further steps of the operation. Finally the stomach is fixed to the peritoneum by two sutures (Fig. 823, 1, 2). At the termination of the operation the patient is given through the tube 3 ounces of salt solution; 1 to 2 ounces of salt solution are to be so given every hour. During the second twenty-four hours from 1 to 3 ounces of salt solution are given every other hour, and at the same intervals peptonized milk is given. At the end of ten days the patient is taking thin cereals, mashed potatoes and sieved vegetables, fruit juices, butter, and olive oil. The food is introduced into the tube by means of a syringe. After the operation use a Murphy drip of 2 per cent. glucose and 5 per cent. sodium bicarbonate and continue until acidosis has been abolished. About one month after operation the esophagoscope and bougies can be used through the fistula without causing bleeding.

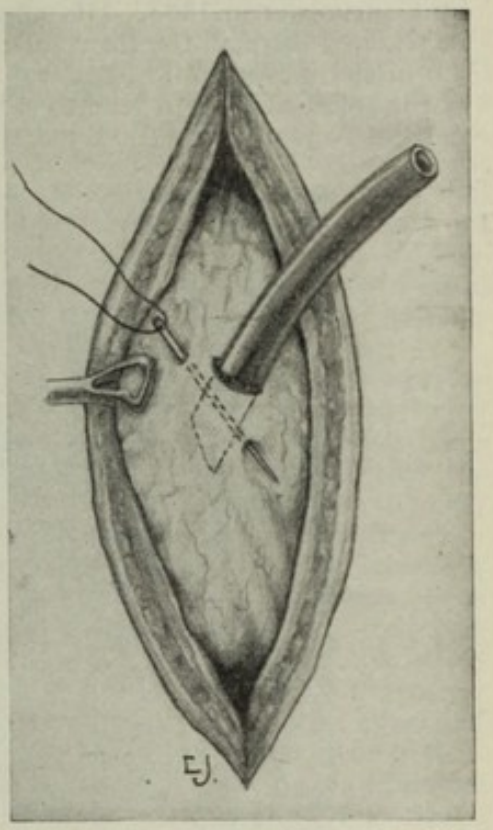


FIG. 821.—The rubber tube is inserted into the stomach for the distance of about 1 cm., and is fixed there by a stitch carried through wall, tube, and wall beyond, as shown by the needle. This stitch is tied and cut off short (Shallow in "Surgical Clinics of North America," Feb., 1924).

Gastro-enterostomy or **gastrojejunostomy** is the establishment of a permanent opening between the stomach and the jejunum, in order to side-track the pylorus. The operation is performed for cancer of the pylorus, for non-cancerous stenosis of the pylorus, for some cases of ulcer of the stomach, and for tetany. When the operation first became popular it was done almost indiscriminately. Then came the view that it should only be done when the pylorus is narrowed mechanically, as otherwise food passes by the old rather than by the new route. To this was added the thought that if the pylorus is found open it should be closed by operation to make gastro-enterostomy efficient. Now some claim that the operation is proper even for ulceration of the body of the stomach and even when the pylorus is not closed by operation. The idea is that pyloric spasm is common in ulcer cases, and that the moment spasm occurs the new opening drains the stomach and at once relieves spasm. After every gastro-enterostomy bile enters the stomach and the constant alkalinity prevents the tendency to recurrence of ulceration. The presence of bile does not impair gastric digestion. Gastro-enterostomy is most useful when the pylorus is blocked or greatly narrowed. It may serve a good purpose even when the ulcer is at the cardia, on the lesser curvature, or on the body of the stomach, because the new opening allows the stomach to empty the mo-

ment pyloric spasm begins. Anterior gastro-enterostomy was proposed in 1881 by Wölfler's assistant, Nicoladoni, and was first performed by Wölfler the same year. In Wölfler's early operations the jejunum was so placed that the proximal end was to the right of the anastomosis opening. Hence peristalsis in the stomach was from left to right and in the jejunum from right to left, and this was supposed to be responsible for the common occurrence of regurgitant vomiting. It was sought to prevent this by altering the direction of the loop (Lücke), then by entero-anastomosis (Braun), and finally by posterior anastomosis. Posterior gastro-enterostomy was first proposed by Courvoisier in 1883. His suggestion was that the posterior surface of the stomach be reached through the transverse mesocolon. His plan necessitated a transverse division of the mesocolon, but it was found that this impaired the blood-supply of a part of the colon and might lead to gangrene. Von Hacker in 1885 devised an improved, the posterior operation. As a matter of fact, the transverse mesocolon has a marginal

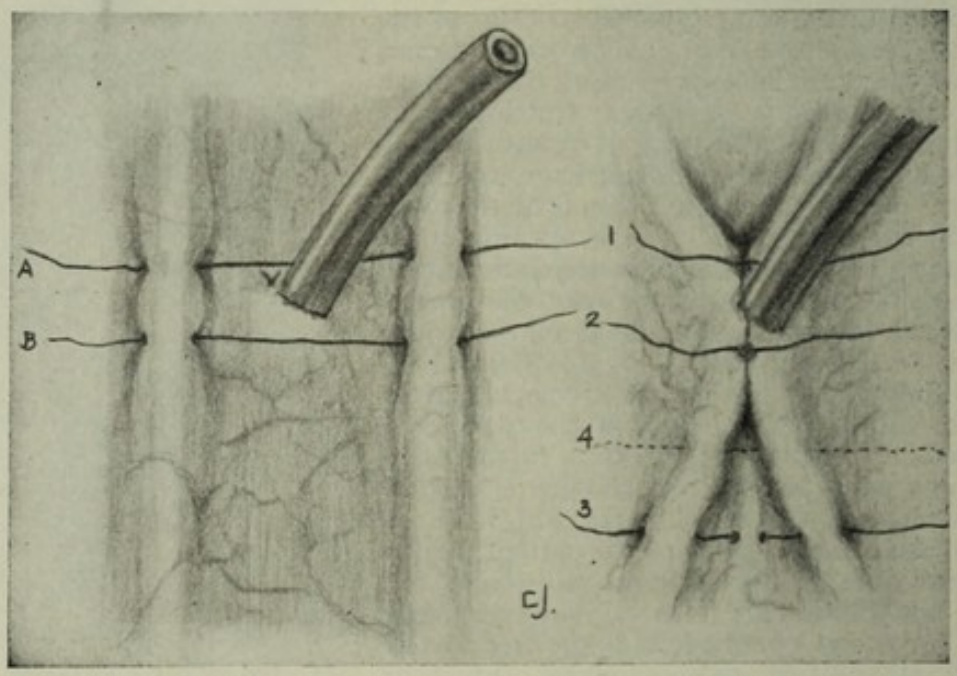


FIG. 822. FIG. 823.

FIG. 822.—The tube being fixed as shown in Fig. 821, one purse-string suture is placed, tied, and cut off short. Only one purse-string suture is used. This dispensing with the strangulation of the tissues by the three tightly drawn purse-string sutures of the Senn operation obviates leakage from the necrotic and sloughing processes, with consequent hemorrhage. Two Lembert sutures (*A*, *B*) are placed one above and one below the tube. These are tied and temporarily left long for anchorage later.

FIG. 823.—The two Lembert sutures, placed as shown at *A*, *B*, in Fig. 822, are tied as shown at 1 and 2, and temporarily left long. The next suture is the very important dam suture shown at 3. This suture passes through the folds like the Lembert sutures, but, in addition, it takes up a fold in the channel between the two ridges raised by the Lembert sutures. The purpose of this is to place a dam in the channel left by a Kader operation, which channel is so often a cause of leakage. This dam suture is one of the great advantages of the improved technic. One of these dam sutures is placed above, as shown below the tube in this illustration. All these sutures are in the same plane. The two layers of Kader are avoided (Shallow in "Surgical Clinics of North America," Feb., 1924).

artery, unlike other parts of the colon, and the danger of gangrene from a transverse incision is probably not very great. In the earlier operations by the posterior method a long loop was used and results were not notably better than after the anterior operation. In 1890 Czerny and his assistant, Peterson, advised the making of the jejunal opening close to the duodenojejunal flexure. The results from this operation are vastly better than from the anterior operation. Posterior gastro-enterostomy has been signally improved in technic by the Mayos, Moynihan, and others. In the earlier operations of anterior gastro-enterostomy the mortality was 40 per cent. In non-malignant conditions the mortality after gastro-enterostomy is now very low (under 2 per cent.), the hyperacidity of the gastric juice disappears, and the functions of the stomach are restored. In malignant cases the mortality is about 8 per cent., but even in such cases, if operation be done early, life may be prolonged and made comfortable for months. Wm. J. Mayo makes the following report upon 421 cases of gastrojejunos-

tomy: "Benign, 307 cases, 19 deaths (6.18 per cent.). In the last 140 there were 4 deaths, a mortality of 2.85 per cent.; the last 80 gave but 1 death. Malignant, 114 cases, with 21 deaths (18.5 per cent.). Of these 114 cases, 63 were in connection with pylorectomy and partial gastrectomy, with 8 deaths (12.6 per cent.). The very unfavorable cases of cancer obstruction were subjected to gastro-enterostomy, so that this operation gives a higher mortality than radical excision. In the last 40 gastro-jejunostomies for malignant disease the mortality was 8 per cent. In the 421 gastro-jejunostomies there were 21 reoperated cases (5 per cent.)" ("Annals of Surgery," Nov., 1905). In the Mayo Clinic from Jan. 1, 1907 to Jan. 1, 1918 there were 302 gastro-enterostomies for ulcer of the stomach, with a mortality of 1.6 per cent.—2593 for duodenal ulcer, with a mortality of 1.3 per cent.—351 for pyloric cancer, with a mortality of 8 per cent. (personal communication to the author). In about 5 per cent. of cases of gastro-enterostomy for benign disease secondary operation has been required. Dr. Charles H. Mayo, in a personal communication, sets the mortality of gastro-enterostomy in all classes of ulcers (perforating, chronic, and acute) at 2.85 per cent. In Krönlein's clinic 51 cases of malignant disease subjected to gastro-enterostomy showed an average duration of life of 192 days; 470 days after operation 17 cases were living. The causes of death, according to Wm. J. Mayo, are: exhaustion, exhaustion with vomiting, pneumonia, and detachment of the anastomosed intestine.

Treatment after Gastro-enterostomy.—On returning the patient to bed at once establish continuous proctoclysis with decinormal salt solution, the reservoir being only 6 inches above the level of the bed. As soon as the patient is out of ether place him semi-erect. Mayo begins in from sixteen to twenty hours to administer by the mouth 1 ounce of hot water every hour, and if it be well tolerated the amount is quickly increased, and in thirty-six hours liquid food is given, and if tolerated, is continued.

Complications Following Gastro-enterostomy.—Among them are *lung complications*. These are not due to the anesthetic, for they tend to occur even when local anesthesia has been employed. They are not due to the epigastric incision interfering with cough and expectoration, for they are not nearly so common after operations upon the gall-bladder (Wm. J. Mayo). Mayo says that the latest theory is that some of the venous blood returning from the stomach does not pass through the liver, and infected emboli are deposited in the lungs. The *suture line* may *leak* after gastro-enterostomy because of imperfect suturing, or the anastomosed intestine may become *detached;* 20 per cent. of the deaths among Mayo's cases resulted from this cause. *Contraction* of the *anastomosis opening* may gradually take place. This has been held by some to be particularly common in cases of dilated stomach, shrinking of the stomach being the efficient cause, but evidence upon this point is not conclusive. In cases in which the pylorus is not obstructed shrinking often occurs, but it rarely takes place when the pylorus is obstructed. In some cases after operation a *spur* forms in the jejunum because of angulation; in other cases kinks or bands produce obstruction; and in some instances ulceration takes place in the jejunum. Cases have been recorded of the small intestine passing as a hernia through the opening in the mesocolon and intussusception of the efferent loop has been observed. Lewisohn has reported a case of intussusception of the stomach ("Annals of Surgery," Oct., 1922). The most common complication after gastro-enterostomy is *persistent vomiting*, which may or may not be expressive of the formation of a vicious circle.

Addison's anemia has followed gastro-enterostomy, due perhaps to achlorhydria (Arthur F. Hurst in "Brit. Med. Jour.," Jan. 19, 1924).

Peptic Ulcer of the Jejunum.—The first case was reported by Braun in 1899. The first English case was reported by Mayo-Robson in 1903. Herbert J. Paterson reported a case and collected reports of 61 other cases (A. W. Mayo-Robson, "Brit. Med. Jour.," Jan. 6, 1912). F. Gregory Connell has collected 38 cases and reported 1 of his own, 39 in all ("Surg., Gynec., and Obstet.," Jan., 1908). He points out that in many of the reported cases acute perforation occurred. Most of the reported cases suffered from non-malignant trouble and had hyperacid gastric juice. It very seldom occurs after operations for cancer. Most of the reported cases happened after the anterior operation and when the anastomosis was very near the pylorus. It has happened, however, in cases after the posterior operation, and cases have been reported following both the anterior and posterior methods associated with entero-anastomosis. It is probable that more cases seem to follow the anterior method because until late years it has been the operation commonly performed. In most of the reported cases the ulcer was single; in 3 out of 24 cases it was multiple. It is usually in the distal loop, but may be in the proximal loop. It may be situated at the anas-

tomosis level, a little way below it, or even 5 or 6 inches below it. The ulcer may appear a few days after the operation, weeks after, months after, or even years after. The condition results from hyperacid gastric juice passing directly into the jejunum before it has been neutralized by admixture with bile and pancreatic juice. It is possible that the condition is predisposed to by a twist in the jejunum and by an anastomosis opening too small to correct hyperacidity. Wm. J. Mayo blames for the development of an ulcer at the suture line silk or linen sutures which cut and hang in the lumen. He says they may hang for months. In one of his cases they hung for twenty-two months ("Brit. Med. and Surg. Jour.," Jan. 29, 1914).

There may be no symptoms at all until there is a severe hemorrhage or perforation, or symptoms similar to those which called for the gastro-enterostomy may return. Connell's table shows that acute perforation took place in 14 of the 39 reported cases. Pain is to the left of the umbilicus, comes on two or three hours after eating, and is relieved by food. There may be tenderness under and there may be rigidity of the left rectus muscle (Robson, Loc. cit.). In some cases an ulcer at the suture line penetrates the transverse colon. In such a condition colonic matter enters the stomach and may be recognized in washings from the stomach. In chronic cases treatment is first medical; if this fails, operation is indicated. If on opening the abdomen it is found that the original pyloric or duodenal ulcer has healed, but there is an ulcer in the jejunum, separate the bowel from the stomach, close the stomach opening, excise the jejunal ulcer, and close the wound in the bowel. If there is stenosis of the pylorus or duodenum we must have a gastro-enterostomy, so we make another after closing the original opening (Robson). Very extensive ulceration may call for resection. If the patient is greatly weakened or if the ulceration is extensive, jejunostomy (see page 1087) may be done (Robson). In perforation, operation must be immediate.

The Vicious Circle and Regurgitation.—Vomiting may occur after the performance of gastro-enterostomy. It may soon cease, may be productive of disastrous consequences, and may be expressive of an existing complication of great gravity. In some cases of gastro-enterostomy vomiting arises because the anastomosis has been made high up on the anterior gastric wall and the stomach is not drained. In other cases ether induces vomiting, and the mechanical efforts force the contents of the duodenum and even of the jejunum into the stomach. The true "vicious circle" is a condition in which the contents of the stomach pass through the anastomosis opening into the duodenal side of the loop of intestine, mix with the duodenal secretions, and return to the stomach (Fowler in "Annals of Surgery," Nov., 1902). The following conditions are often classified under the same head, but each is called by Fowler a regurgitation or reflux: (1) When the duodenal secretions pass back into the stomach through a permeable pylorus (as in cases of gastroptosis, non-cancerous pyloric stenosis, and gastric dilatation); (2) when the duodenal secretions enter the stomach through the anastomosis opening; (3) when the contents of the jejunum pass into the stomach, because of efforts at vomiting or as a result of reversed peristalsis. In some cases the contents of the jejunum may pass into the afferent loop of intestine and distend it. It was long thought that the vicious circle was due purely to bile passing into the stomach from the proximal (afferent) loop of the jejunum. After every gastro-enterostomy some bile enters the stomach. It does no harm and its alkalinity antagonizes any tendency to recurrence of ulceration. Dastre's experiments on dogs show that bile in the stomach does not impair either digestive power or the general health, and Moynihan has confirmed these experiments by clinical observation. It has been held that the cause of a vicious circle is the making of an anastomosis with a long loop between the duodenojejunal flexure and the anastomotic opening into the jejunum, the loop being unable to propel its contents downward and tending by its weight to produce a bend or kink at the seat of anastomosis. This is a very doubtful theory.

Persistent vomiting may be due to spur formation, which deviates stomach contents into the duodenal side of the loop. It is in some cases due to kinking or twisting of the distal loop; in others, to failure of peristalsis in the proximal loop; in still others, to contraction of the opening in the stomach wall (Chlumsky on "Gastro-enterostomy" in the Breslau Clinic; article by Charles L. Gibson in "Annals of Surgery," Aug., 1908). I cordially agree with the statement of Herbert J. Paterson, viz.: "Most, if not all, fatal cases of regurgitant vomiting are due to mechanical obstruction at the afferent opening" ("The Hunterian Lectures," delivered before the Royal College of Surgeons of England, Feb. 19, 21, 23, 1906). In order to lessen the danger of vomiting after gastro-enterostomy, do the operation under a local anesthetic whenever possible;

and in order to prevent regurgitant vomiting take every care in the operation to prevent the formation of a spur on the mesenteric border of the jejunum (Herbert J. Paterson, Ibid.).

After Billroth's operation (Fig. 824) and after all the earlier methods the contents of the duodenum will certainly pass into the stomach, mix with the stomach contents, and usually, but not always, pass into the efferent loop. In all these operations there is great danger of the development of a vicious circle.

Lücke devised an operation with the idea of preventing such a complication. In the Lücke operation the direction of peristalsis in the efferent loop is the same as in the stomach (Figs. 825, 826). McGraw points out that the crossing of the loop which is effected is dangerous. The Wölfler-Lücke operation is shown in Fig. 826. Wölfler also devised the operation pictured in Fig. 827. Von Hacker's posterior operation is thought by most to be less apt than the anterior method to be followed by the vicious circle (Fig. 828). Kocher devised an operation in which a valve is formed, but, as Fowler points out, this valve does not prevent filling of the duodenum and imbibition of the material by the stomach; and, further, that the valve does not work when the parts become cicatricial (see Fig. 832).

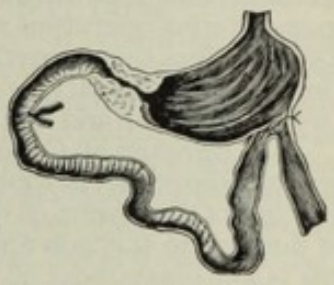


FIG. 824.—Billroth's method of gastro-enterostomy.

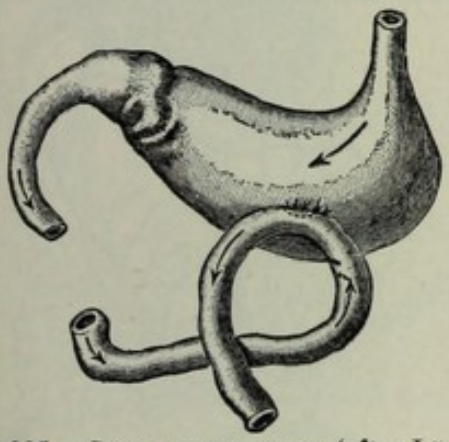


FIG. 825.—Gastro-enterostomy (after Lücke).

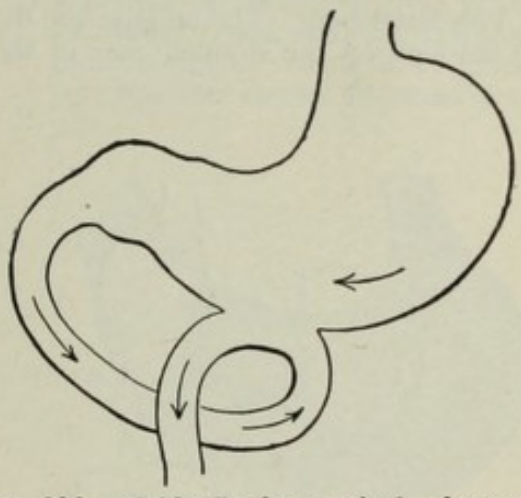


FIG. 826.—Wölfler-Lücke method of gastro-enterostomy.

The combination of gastro-enterostomy with entero-anastomosis was devised to prevent the vicious circle. This operation is shown in Figs. 829, 830. I do not believe

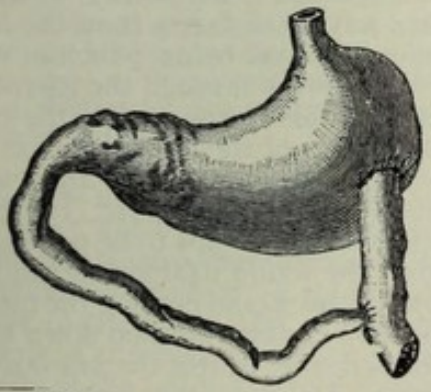


FIG. 827.—Implantation of duodenum into jejunum and jejunum into stomach (after Wölfler).

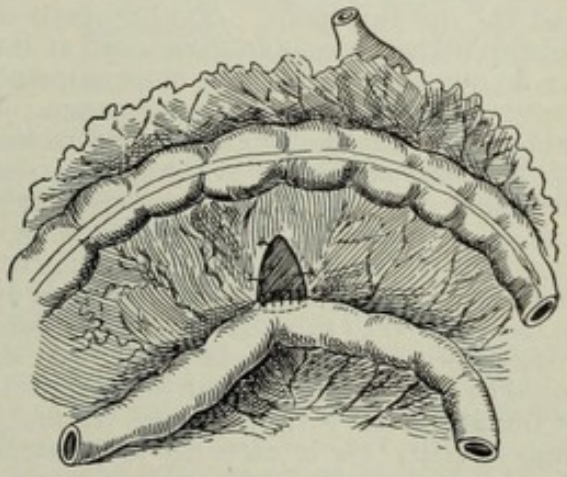


FIG. 828.—Von Hacker's posterior gastro-enterostomy.

it should ever be a primary operation. It permits acid gastric juice to flow directly into the jejunum and keeps away the bile which would normally protect mucous mem-

brane. Hence such an operation exposes the patient to the danger of jejunal ulceration. Another defect in such an operation is that there is still a communication between the stomach and the efferent loop. Fowler's operation (see Fig. 836) closes the jejunum and corrects the defect inherent in Braun's and in Jaboulay's operation. Other operators also close the pylorus. McGraw's operation (see Figs. 833, 834, which show entero-anastomosis) tends to prevent the formation of a vicious circle. It seems certain that the danger of the formation of a vicious circle is greatest after a long-loop anterior operation and least after a no-loop posterior operation. The shorter the loop, the less the danger, hence the latter is the operation of choice. The safest operations and the operations of choice are the short-loop operation of Moynihan or Scudder (see page 1081) and the "no-loop" operation of the Mayos (see page 1083).

The Question of Closing the Pylorus When Gastro-enterostomy Has Been Done.—This was suggested by Doyen in 1893 and in 1895 by von Eiselsberg. The indications are absence of narrowing of the pylorus in chronic ulcers and active ulceration of the pylorus or duodenum (Gibson and Beekman in "Annals of Surgery," April, 1915). If the pylorus is left open, most of the food continues to leave the stomach by that route, except when the pylorus is closed by spasm. If the pylorus is closed, all gastric material passes through the artificial opening. It has always seemed to me that cases did as well without pyloric closure. It is valued by some as a preventive of a vicious circle because it forces the food through the artificial opening and because it prevents access of food to an ulcer. The only permanent method is the disconnection advocated by Von Eiselsberg. The omenta are divided to a sufficient extent and the stomach is cut through on the stomach side of the ulcer. Each end is closed. This is a serious

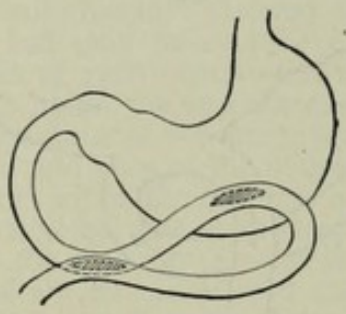


FIG. 829.—Jaboulay's method of gastro-enterostomy, with entero-anastomosis.

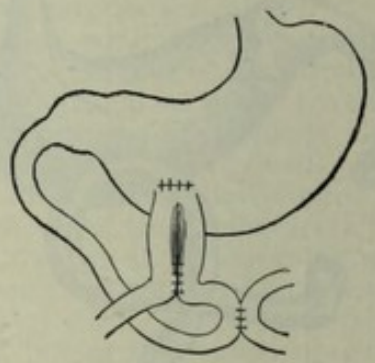


FIG. 830.—Braun's method of gastro-enterostomy, with entero-anastomosis.

operation and adds to the risk of gastro-enterostomy. Blockage has been attempted by the application all around of infolding sutures. Eventually the sutures cut through and the pylorus opens. Another method is to ligate with Pagenstecher thread. The suture catches the submucous coat at intervals. It is tied firmly but not tightly, as we do not desire to cut the mucous membrane. This method is temporary, as the ligature cuts its way into the duodenum. Wilms takes a band of fascia from the fascia lata or the anterior sheath of the rectus abdominis, the band being ½ inch in width and 4 inches in length. A clamp is carried back of the pylorus through the gastrocolic omentum and out through the gastrohepatic omentum, this clamp grasps the fascia and draws it around back of the pylorus, the muscle surface of the fascia being in contact with the serous coat of the stomach. The fascia is pulled sufficiently tight to occlude the pylorus and the fascial ends are sutured with chromic catgut. The fascia is also sutured to the stomach. The closure by this method is not apt to be permanent. Instead of a band of fascia it has been suggested that the round ligament of the liver could be used. If the surgeon decides to close the pylorus, he should employ the method of Biondi. That surgeon divides the omenta and makes a circular incision down to the mucous coat. He retracts the seromuscular coat on each side, ligates the mucous coat doubly, and divides that coat between the ligatures. He closes by approximation and suture of the seromuscular coats.

Hoffman divides the serous and muscular coats, sutures a fascial strip around the mucous membrane, and closes the muscular and serous coats. This is very difficult of accomplishment without opening through the mucous membrane.

Other surgeons have divided the pylorus, closed the duodenal end, and anastomosed

the stomach end to the side of a loop of jejunum, or to the duodenum distal to the area of ulceration.

Bartlett makes a partial exclusion by dividing the prepyloric portion of the stomach from the greater curvature to within an inch of the lesser curvature and suturing the cut edges.

Brewer suggests obtaining occlusion by the use of an aluminum band (see Charles L. Gibson and Fenwicke Beekman in "Annals of Surgery," April, 1915).

Treatment of Persistent Vomiting after Gastro-enterostomy.—If vomiting persists in spite of gastric lavage and rectal feeding following the operation of gastro-enterostomy with a long loop without entero-anastomosis, open the abdomen again and perform anastomosis between the afferent and efferent loops of intestine. This was suggested by Braun in 1892, and both he and Jaboulay performed it in the same year. The operation has saved lives. In a short-loop operation we should assume that the jejunum has been twisted, should open the abdomen, and endeavor to correct the condition. Herbert L. Paterson ("Hunterian Lectures," before the Royal College of Surgeons of England, Feb. 19, 21, 22, 1906) points out that slight cases of regurgitant vomiting not immediately following an operation may be due purely to constipation, and may be recovered from if care be taken to secure daily a free bowel movement. In Paterson's opinion constipation causes reversed peristalsis, and as both the duodenal "siphon and the pyloric sphincter are put out of service," regurgitation takes place from the efferent loop into the stomach.

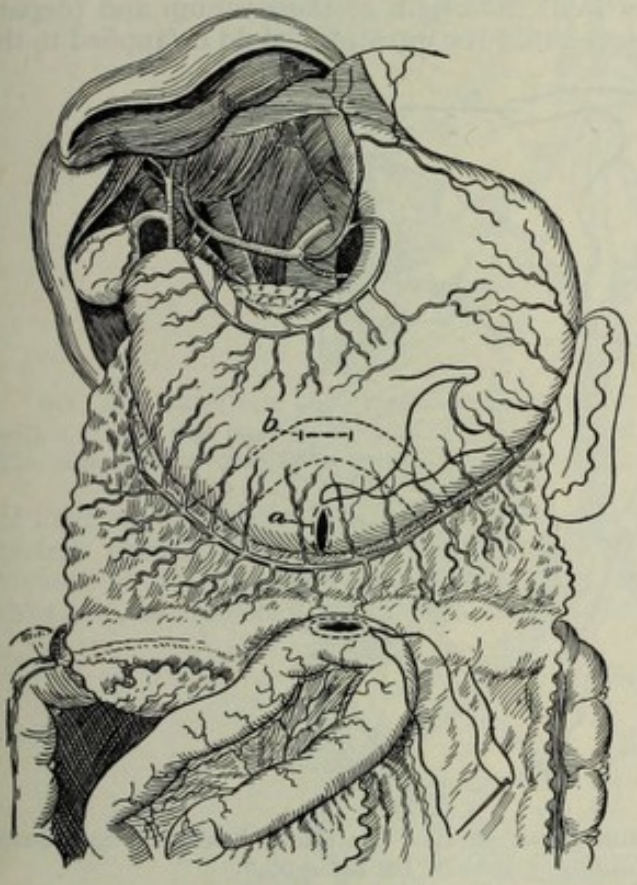


FIG. 831.—Mayo's method of anterior gastro-enterostomy showing proper and improper locations of openings: *a*, Proper position, leaving no pouch; *b*, usual position forming intragastric pouch ("Annals of Surgery").

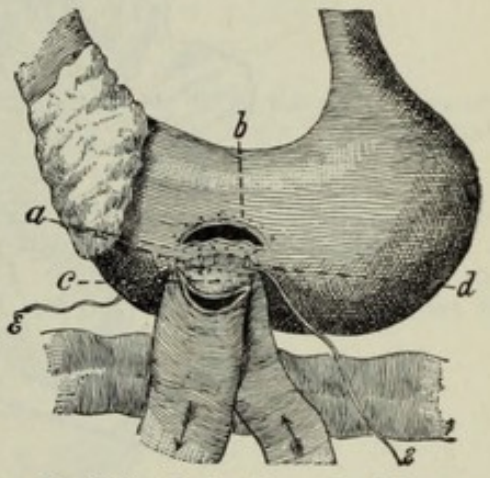


FIG. 832.—Kocher's method of gastro-enterostomy: *a*, Places of posterior annular suture through entire wall of stomach and intestine; *b*, places of anterior annular suture through the entire wall; *c*, valve at the jejunum by arch-formed incision; *d*, posterior annular suture of the serosa; *e*, thread ends for continuing anterior suture of the serosa.

Anterior Gastro-enterostomy.—*Senn's Method.*—A median incision is made through the abdominal wall, from below the xiphoid cartilage to the umbilicus. An opening is made in the lower part of the anterior wall of the stomach in the direction of the long axis of the viscus, and its edges are stitched by a continuous catgut suture. The contents of the jejunum are forced along to below the point where an incision is to be made. The loop of jejunum should be from 12 to 14 inches in length. A rubber tube is fastened around the bowel above this point, and another below it; an incision is made in the long axis of the bowel, and the margins of the wound are sutured in the same manner as the stomach wound. Bone plates are introduced into the stomach and intestine, and the ligatures are tied as in intestinal anastomosis. Catgut rings or rubber rings may be used.

Mayo's Anterior Method (Fig. 831).—Open the abdomen, and pick up the small intestine and find a point of jejunum about 14 inches from the point at which it emerges from under the mesocolon. Effect the union to the inferior border of the stomach close to the greater curvature and at the lowest portion of the stomach pouch. When the anastomosis is completed the stomach pouch is funnel shaped. The usual custom has been to place the opening higher on the anterior wall. It sometimes led to the formation of a pouch on the anterior wall, did not drain the stomach, and caused vomiting. After the performance of gastro-enterostomy the edges of the omentum are caught upon each side of the anastomosis and are sutured to each other and to the stomach wall 1 inch above the opening. The edges are then united to each other in a downward direction for about 3 inches so as to form an apron over the anastomosis, yet not connected with it. Catgut is used for suturing. If leakage occurs, the omentum is adjacent and "available." If it does not occur, the omentum soon returns to its normal position (Wm. J. Mayo, "Annals of Surg.," Aug., 1902).

Kocher's Method (Fig. 832).—After opening the abdomen lift up the omentum, pull up a loop of intestine, and find the point where the jejunum appears from under the mesocolon. Select a loop 16 inches from the origin of the jejunum and prepare to attach it to the stomach. Wölfler believed that the intestine should be applied to the

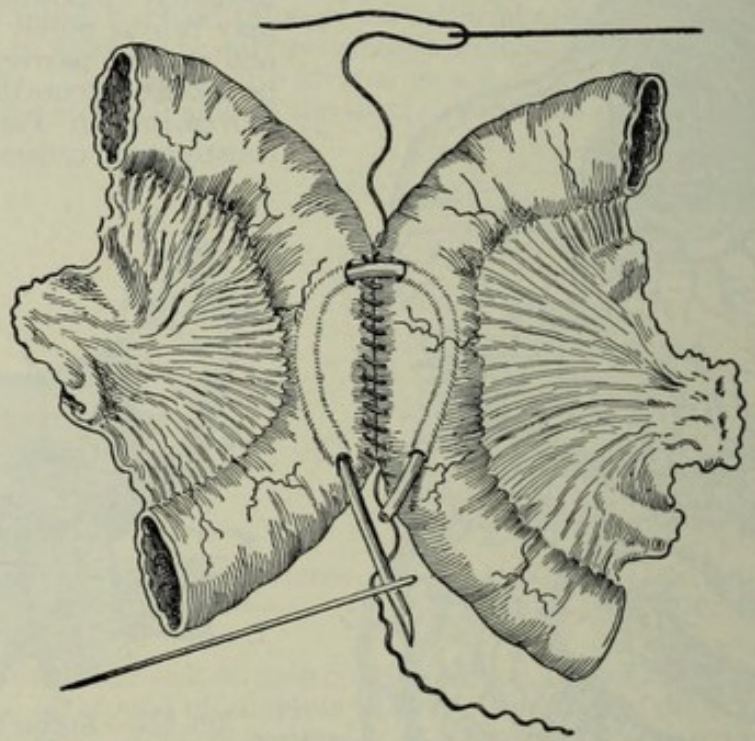


FIG. 833.—McGraw's method of lateral intestinal anastomosis: The elastic ligature is introduced (Walker). Gastro-enterostomy is done by the same plan.

stomach in such a manner that the direction of peristalsis in the bowel would correspond to the direction of the stomach-tide. This can be accomplished by having the proximal portion of gut to the left, and the distal portion to the right (Fig. 825). Kocher's operation is to be so performed that after its completion the stomach contents will pass into the distal portion of the gut, and intestinal contents will not tend to enter the stomach (see Fig. 832). In order to accomplish this Kocher hangs the intestine to the stomach wall in such a manner that the proximal portion of the loop is posterior and ascending, and the distal portion is anterior and descending. The bowel is hung to the stomach by a continuous serous suture of silk, the ends of which are left long. The intestine is opened by a curved incision, the convexity of which is downward. The stomach is opened so that the convexity of the cut is upward. The valve-like portion of the bowel wall is sutured to the stomach below the incision in that viscus. The two openings are well approximated by sutures. This operation fails in its purpose (see page 1075).

Operation by McGraw's Elastic Ligature (Figs. 833–835).—The elastic ligature was introduced by Silvestri in 1862, and was first used in intestinal anastomosis by the same surgeon. McGraw perfected the operation in 1891. (See Dudley Tait in "Annals of Surgery," Feb., 1906.) The operation may be anterior or posterior. The intestine and stomach are sutured together by Lembert stitches. The elastic cord, which

is 3 to 5 mm. in diameter, is passed through the stomach and then the bowel, in the long axis of each, and is tightly tied, and the knot is fastened with a silk thread. Another row of Lembert sutures buries the elastic cord from sight. The cord cuts through in from forty-eight to seventy-two hours and makes the anastomosis. Thus the danger

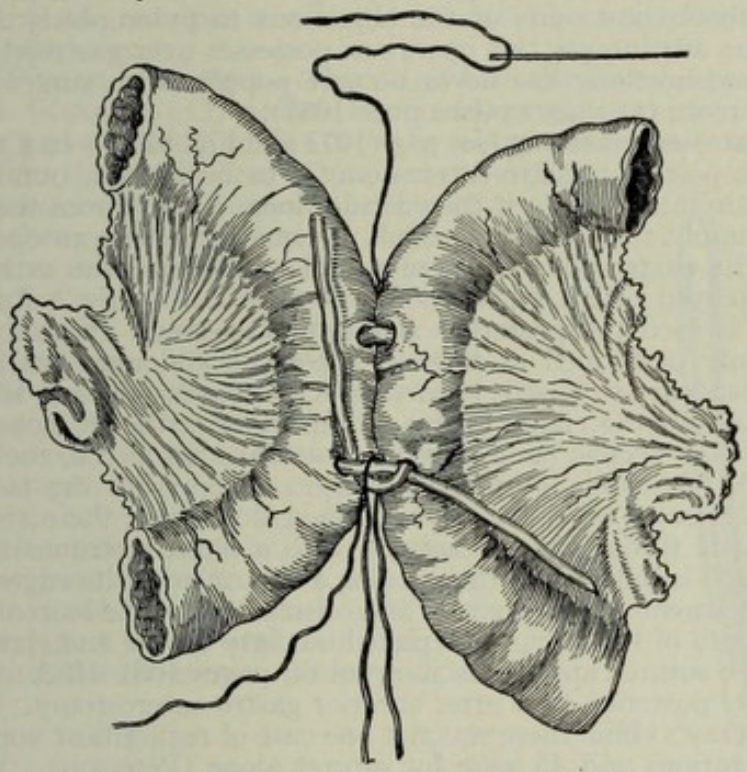


FIG. 834.—McGraw's method of lateral intestinal anastomosis: One tie of the elastic ligature with a strong silk ligature underneath ready to fasten the elastic ligature where it is drawn taut. The same plan is followed in gastro-enterostomy (Walker).

of infection is greatly lessened, for when the anastomosis opening is formed it is completely encompassed by firm adhesions. Further, the danger of the formation of a vicious circle is greatly lessened because there is no communication between the stomach and bowel for between forty-eight and seventy-two hours, the period in

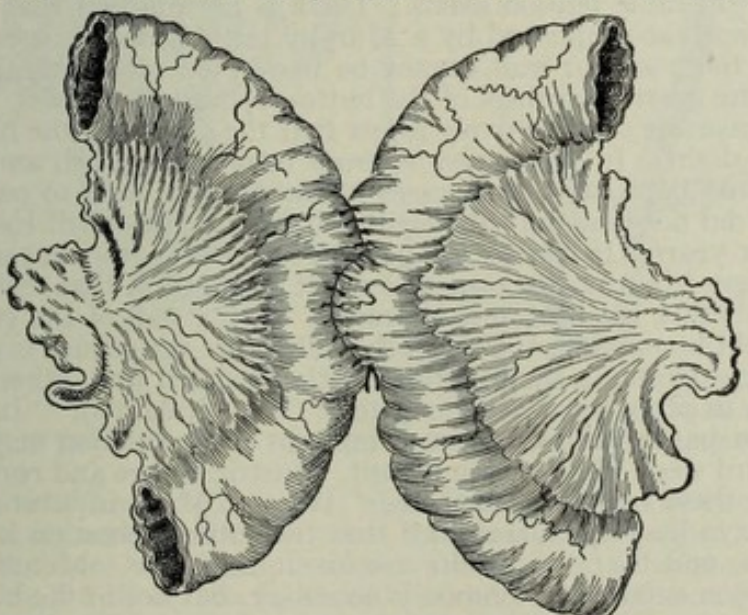


FIG. 835.—McGraw's method of lateral intestinal anastomosis: The operation completed. The same plan is followed in gastro-enterostomy (Walker).

which vomiting of the type previously described is most apt to occur. The method is not suitable if there is absolute pyloric occlusion. In this condition it is imperative to give nourishment early, and, again, an ordinary gastro-enterostomy allays auto-intoxication, and this operation cannot until the ligature cuts through. It is particularly val-

uable in the performance of lateral intestinal anastomosis. Figures 833–835 show the operation of lateral anastomosis of intestine, but gastro-enterostomy is performed in the same manner.

Jaboulay's Gastroduodenostomy.—This operation was devised by Jaboulay in 1892. It aims to obviate some of the objections to pyloroplasty and at the same time to retain the advantages this operation possesses over gastrojejunostomy. Jaboulay's gastroduodenostomy has never become popular with surgeons, and Finney's method is much more satisfactory (see page 1087).

Posterior Gastro-enterostomy (see page 1072 and Fig. 828).—In a thin subject with a long mesocolon posterior gastro-enterostomy is to be chosen, but if the mesentery be short or contain much fat, or if the vascular loop, coming from the superior mesenteric artery to supply the transverse colon, be small—so that an opening in the posterior layer of the gastrocolic omentum would be close to the artery—the anterior operation is employed (Wm. J. Mayo in "Annals of Surgery," Aug., 1902). If a Murphy button is used the posterior operation is selected. Posterior gastro-enterostomy is commonly performed as follows: After the abdomen has been opened the stomach and omentum are raised; a portion of the upper jejunum is seized, emptied, and a site selected for the clamp. This site must be within 5 inches of the flexure. If there be a broad mesocolic band preventing a near approach to the flexure the band must be divided. A clamp is applied on the side opposite the mesenteric attachment. A spot is selected on the transverse mesocolon where there are no vessels, and an opening is made through the mesocolon with a blunt instrument. The posterior wall of the stomach is pulled into the opening and sutured to its edges. This prevents downward displacement of the stomach and obstruction of the loop of gut. A portion of the posterior wall of the stomach is pulled out into a cone and clamped. Openings are made and the sutures applied as directed on pages 1081–1083. Regurgitation is less common after posterior than after anterior gastro-enterostomy. In 250 posterior operations in Czerny's clinic there was not one case of regurgitant vomiting; 170 cases were button operations and 45 were by sutures alone (Peterson). Von Hacker had one instance of regurgitation in 60 posterior operations.

Operation by the Murphy Button.—Gastro-enterostomy may be quickly performed by the use of a large-sized Murphy button. Murphy said that in some reported cases the button has slipped back into the stomach, but this accident can be prevented by the use of an oblong button and by making the anastomosis on the posterior stomach wall. The same surgeon advised us to scarify the peritoneum in order to hasten union, and said supporting sutures about the button are not required except when considerable tension exists. There is no question that an anastomosis on the anterior wall, accomplished by a Murphy button, can be speedily performed. Anastomosis on the posterior wall cannot be performed so rapidly, and it sacrifices to some extent the great advantage of the button operation—that is, speed. In spite of the reported cases we can positively assert that the danger of the button producing grave trouble is slight. In some cases it drops into the stomach and remains there, but seems to do no harm. In other cases it takes a long time to pass. In 1 of the author's cases it did not pass until the eighty-sixth day. In one of Keen's cases it has been retained for years. If it does not pass in four weeks, the rectum should be explored by the finger from time to time to see if it is lodged in that region. The *x*-rays will determine whether the button is in transit. If the wall of the stomach is thick, the incision should be made in the stomach wall before the suture is passed, and this suture should pick up only a small portion of the stomach wall, otherwise the button may be retained in place for a very long time (Wm. J. Mayo). "In many cases in which the button passes vomiting with symptoms of obstruction may appear during the second or third week while it is in transit. Gastric lavage and rectal feeding for a day or two cause these symptoms to subside" (Wm. J. Mayo in "Annals of Surgery," Aug., 1902). Mayo long ago maintained that the suture operation is as good as the button operation, and that the results are about the same. Mikulicz says that in the suture operation entero-anastomosis is necessary, but not in the button operation, because the button, while in place, prevents angulation. The last-named surgeon used the button in malignant cases and the suture in benign cases. Czerny was an advocate of the button. Every button should be tested before it is used. Mayo finds nearly 20 per cent. of buttons as they come from the shop imperfect and dangerous.

Fowler's Posterior Method (Fig. 836).—Anastomose the posterior wall of the stomach to the jejunum and do an entero-anastomosis between the afferent and efferent loops of the jejunum. Pass a No. 20 silver wire two or three times around the afferent

loop of the jejunum and draw it sufficiently tight to occlude the lumen without strangulating the wall of the gut. The ends are twisted, cut short, rolled into a flat coil, the cut ends being in the coil. (See Geo. Ryerson Fowler on the "Circulus Vitiosus" following gastro-enterostomy, "Annals of Surgery," Nov., 1902). This operation positively prevents the entrance of material from the duodenal loop into the stomach and also drains that loop.

Moynihan's Posterior Method.—This plan I have employed repeatedly. It is easy, rapid, and clean: Make a 4-inch incision 1 inch to the right of the middle line and above the umbilicus. Open the anterior sheath of the rectus and separate it from the front of the muscle as far as the middle line. Draw the entire muscle outward, open the posterior portion of the sheath, and then open the abdomen. Inspect and feel the entire stomach. Lift the omentum and transverse colon out of the abdomen and make the mesocolon taut by raising the stomach and colon with the left hand. Find a "bloodless spot in the arch of the middle colic artery," pick up a bit of the under surface of the mesocolon by a pair of hemostatic forceps, lift it from the posterior stomach wall, and open the lesser sac of peritoneum by the scissors. Enlarge the opening by dilatation or tearing until it admits three fingers. Inspect and feel the posterior stomach wall. Place the stomach in its natural position, mark with the thumb the lowest part of the posterior stomach wall, and again turn the viscus over. From the spot

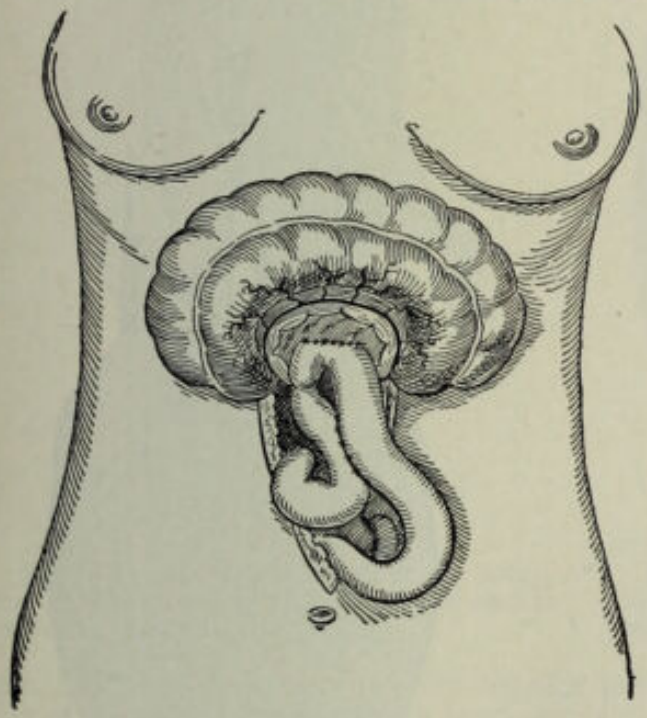


FIG. 836.—Fowler's method of gastro-enterostomy.

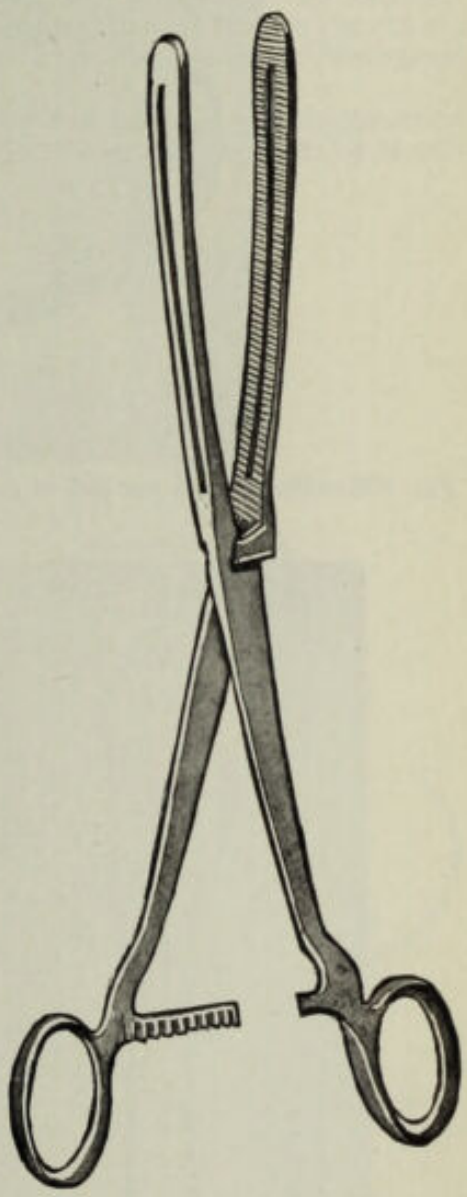


FIG. 837.—Moynihan's clamp for gastric and intestinal operations (made by Down Brothers, London).

marked by the thumb a fold is raised. The fold is oblique and its upper end is to approach the cardia and lesser curvature. A stomach clamp (Fig. 837) having a rubber tube stretched over each blade is applied obliquely so as to grasp the base of this fold. In applying the clamp the tip should point to the right shoulder and the handle to the outer side of the left hip, and the lowest portion of the stomach is grasped in the tip of the blade of the clamp (Fig. 838). The clamp is now put in a horizontal position. The duodenojejunal flexure is found by the finger, the jejunum is identified, and its natural position is noted. The jejunum is packed up and "drawn tight" and a spot is noted which reaches the greater curvature of the stomach when the jejunum is in its natural position. The point noted is 5 inches from the flexure and the anastomosis is made to the jejunum above the spot. The clamp is applied in the side

of the gut opposite the mesentery. The surgeon must be sure that the jejunum is not twisted around its longitudinal axis. If it is, the clamps are not rightly applied, and

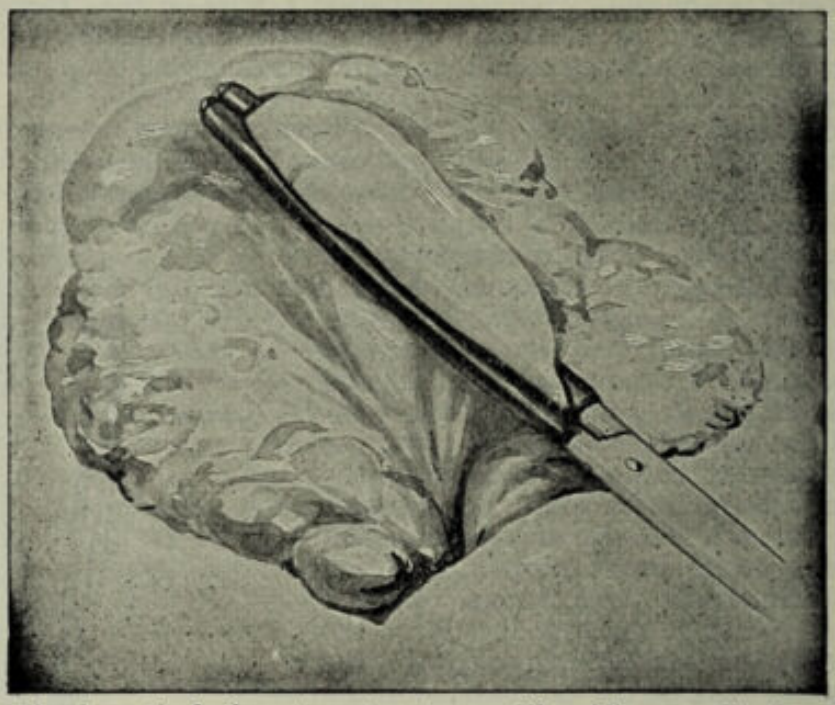


FIG. 838.—Moynihan's method of gastro-enterostomy: The oblique application of the clamp to the stomach (Moynihan).

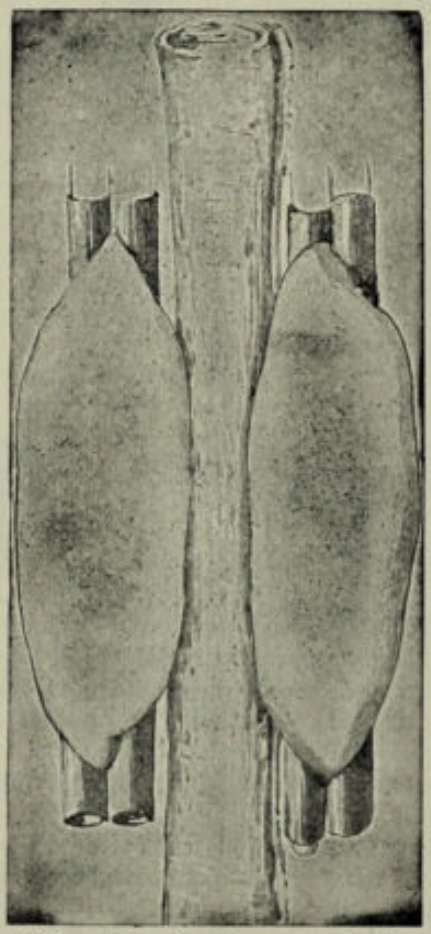


FIG. 839.—Moynihan's method of gastro-enterostomy: The strip of gauze between the clamps (Moynihan).

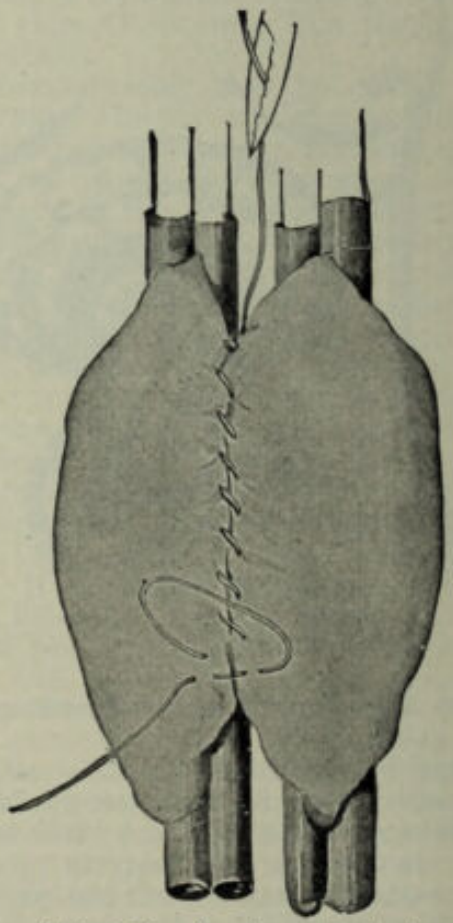


FIG. 840.—Moynihan's method of gastro-enterostomy: The first layer of serous suture (Moynihan).

they must be placed so that after the anastomosis the jejunum lies in its natural position without a twist. The clamped gut is placed by the side of the clamped stomach,

a bit of gauze being put between them (Fig. 839). The stomach (except the clamped portion), the omentum, and transverse colon are returned to the abdomen and the clamps are surrounded by gauze. Each clamp holds a fold 3½ to 4 inches in length. Pagenstecher's celluloid thread is used for suturing. The first line of sutures is passed as shown in Fig. 840. In front of these sutures an incision is made into the stomach and another into the jejunum, the serous and muscular coats being first divided, and an ellipse of mucous membrane being removed (Fig. 841). The next row of sutures is inserted as shown in Fig. 842. When this row is completed the clamps are removed and the long suture of the first row is picked up again and the operation is completed (Fig. 843). Finally the edges of the mesocolic opening are sutured to the jejunum. The parts are cleansed with salt solution, the suture line is inspected, the viscera are returned to the belly, and the abdomen is closed. (See Moynihan's "Abdominal Operations.")

The No-loop Posterior Operation of the Mayos (Figs. 844–846).—It is this operation I usually perform. By it the gastric opening, which is placed in the line advised by Moyn-

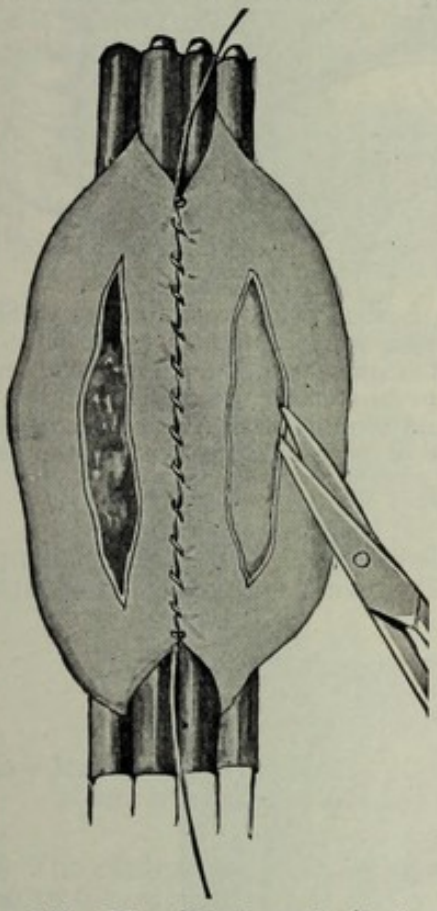


FIG. 841.—Moynihan's method of gastro-enterostomy: Removal of the ellipse of mucous membrane (Moynihan).

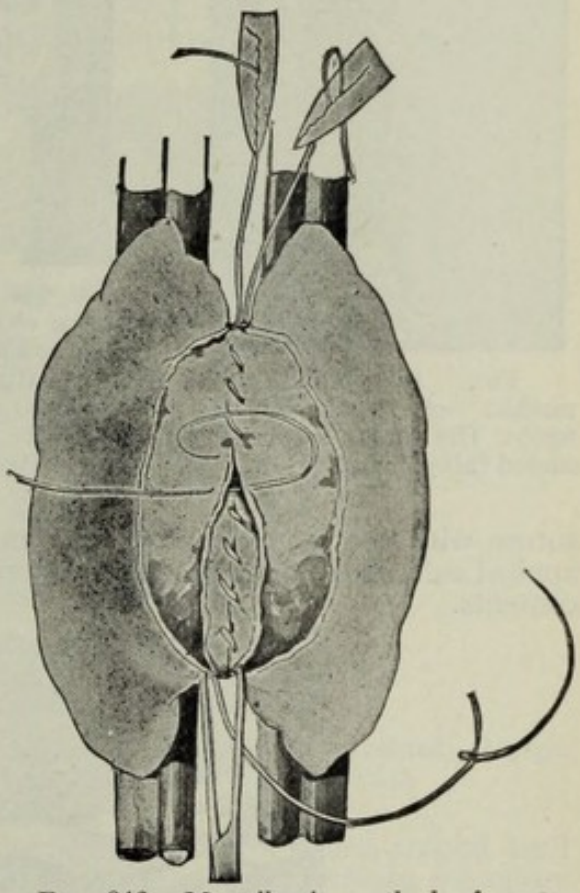


FIG. 842.—Moynihan's method of gastro-enterostomy: The inner suture continued (Moynihan).

ihan, extends ¼ or ½ inch into the anterior wall of the stomach, and thus the lowest part of the opening will be the lowest part of the stomach (Fig. 844). The incision in the intestine begins from 1 to 3 inches from the origin of the jejunum, the measure being made on the anterior surface (Fig. 844).

The object is to get as short a piece of jejunum as can be attached without tension. The operation is described as follows (Wm. J. Mayo in "Annals of Surgery," Nov., 1905):

"(*a*) The abdominal incision is made 4 inches in length, ¾ inch to the right of the middle line, the fibers of the rectus muscle being separated. The lower end of the external wound lies opposite the umbilicus. This opening also enables inspection of the duodenum and gall-bladder and is reliable against hernia when closed.

"(*b*) The transverse colon is pulled out and the mesocolon made taut by traction upward and to the right, in this manner bringing the jejunum into view at its origin.

"(*c*) About 3 to 4 inches of the jejunum opposite the mesentery are drawn into a slightly curved clamp. The handles of the clamps should be to the right to enable

a short grasp on the intestine. Three-fourths of the circumference of the bowel is pulled through; the posterior border is not included, to prevent entanglement of the

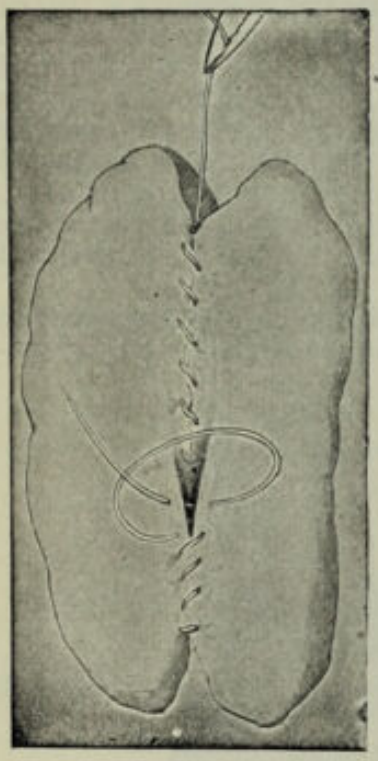


FIG. 843.—Moynihan's method of gastro-enterostomy: The serous suture resumed (Moynihan).

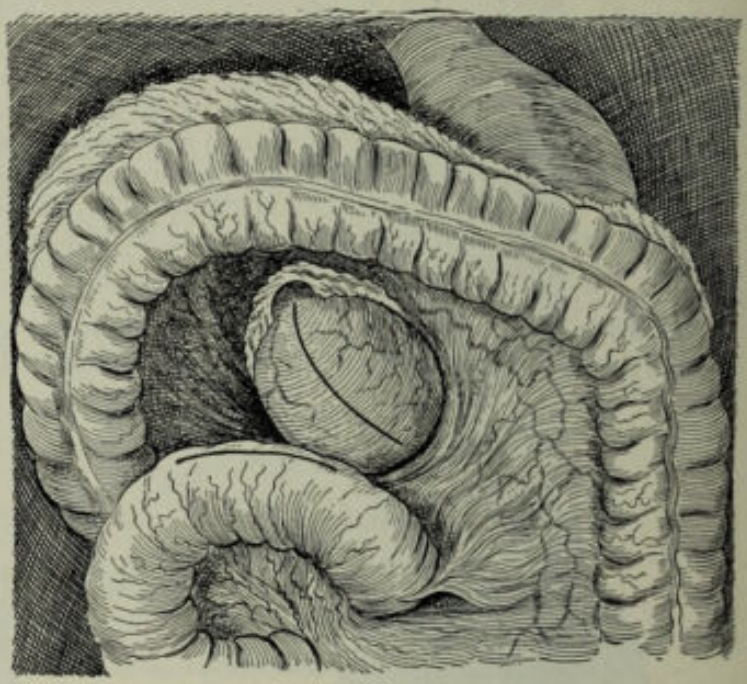


FIG. 844.—Mayo's method of gastro-enterostomy: Showing posterior wall of the stomach drawn through a rent in the transverse mesocolon. Note slight separation of gastrocolic omentum from its attachment to the stomach, permitting anterior wall of stomach to appear, and insuring drainage at lowermost level. Black lines mark site of proposed anastomosis; the jejunum shows at its origin.

suture with the redundant posterior mucous membrane. The holding clamps are applied sufficiently tight to check hemorrhage and prevent extravasation of intestinal contents.

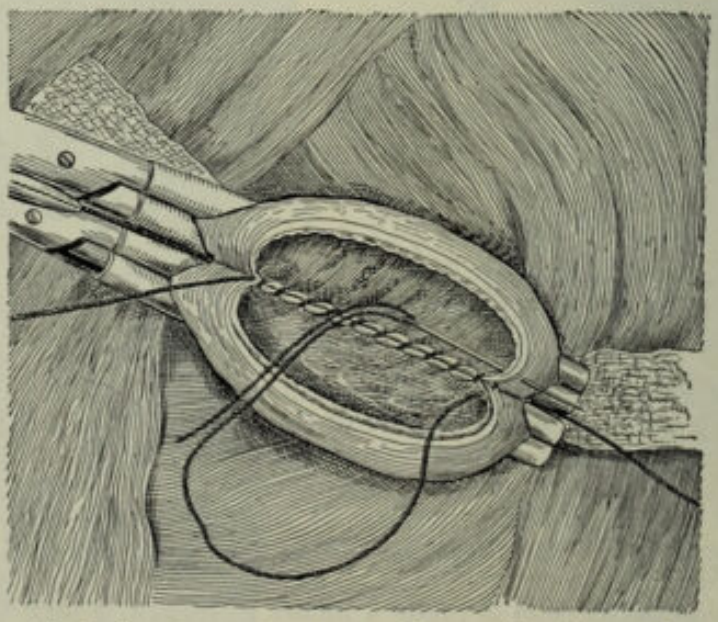


FIG. 845.—Mayo's method of gastro-enterostomy: Forceps in place and anastomosis half completed by suture.

"(*d*) The ligament of Treitz is a short muscular mesentery covered by a variable peritoneal fold (too variable for a reliable landmark) extending upward from the origin of the jejunum on to the mesocolon. This peritoneal fold lies at the base of the arterial loop of the middle colic artery which supplies the transverse colon. The meso-

colon is opened within the vascular loop and the posterior inferior border of the stomach pushed through. A small separation of the greater omental attachment to the stomach enables the anterior gastric wall to be drawn out posteriorly. The posterior gastric wall is drawn into a clamp, with the handles to the right, in such a manner as just to expose the anterior wall at the base.

"(*e*) The two clamps are laid side by side and the field carefully protected by moist gauze pads. With fine celluloidal linen thread on a straight needle the intestine is sutured to the stomach from left to right by a Cushing suture at least 2½ inches.

"(*f*) The stomach and intestine are incised ⅛ inch in front of the suture line and the redundant mucous membrane excised flush with the retracted peritoneal and muscular coats. With a No. 1 chromic catgut on a straight needle the posterior cut margins of the entire thickness of the gastric and jejunal walls are united by a buttonhole suture from right to left; at the extreme left the suture changes to one which passes through all the coats, of each side alternately, from the peritoneal to the mucous, then directly back on the same side from the mucous to the peritoneal. This acts as a hemostatic suture, and also turns the peritoneal coats into apposition. It passes around the anterior surface and is tied to the original end, which has been left long for the purpose. If silk or linen is used for this suture it may hang *in situ*, suppurating for months (Fig. 845).

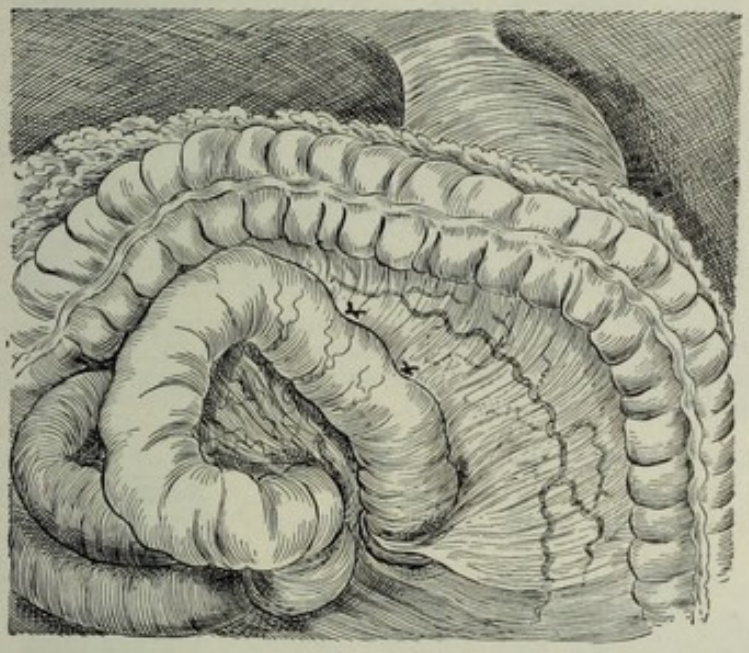


FIG. 846.—Mayo's method of gastro-enterostomy: Completed operation from behind. Margin of torn mesocolon attached by several interrupted sutures to line of union.

"(*g*) The clamps are now removed and the linen thread continued around until it is tied to the original end, firmly catching the blood-vessels in sight along the suture line. The parts are carefully cleansed and inspected. If necessary, a suture or two are applied to coapt accurately or to check the oozing.

"(*h*) The margins of the incised mesocolon are now united to the suture line by three or four interrupted sutures, and the parts returned into the abdomen." In this operation the greatest care must be taken to avoid twisting the gut around its longitudinal axis (Fig. 846).

Gastro-anastomosis or **gastrogastrostomy** is an operation performed for hour-glass contraction of the stomach, a condition which occasionally ensues on the healing of an ulcer. In this operation an anastomosis is effected between the pyloric and cardiac pouches. It was devised and practised by Wölfler in 1894. I have performed it twice with success. Watson folds the two stomachs over each other, using the narrow isthmus as a hinge, sutures the pouches together, and leaves the ends of the sutures long. He incises the anterior wall of the anterior stomach in order to obtain access to the double septum between the two pouches. He makes an anastomosis opening through the double septum, sutures the edges, and closes the wound in the anterior wall of the anterior stomach. Wölfler made a vertical cut in each pouch and united these openings to make an anastomosis. The best plan, short of sleeve resection, is to apply clamps on each side of the isthmus and operate as we would for gastro-enterostomy (Fig. 848).

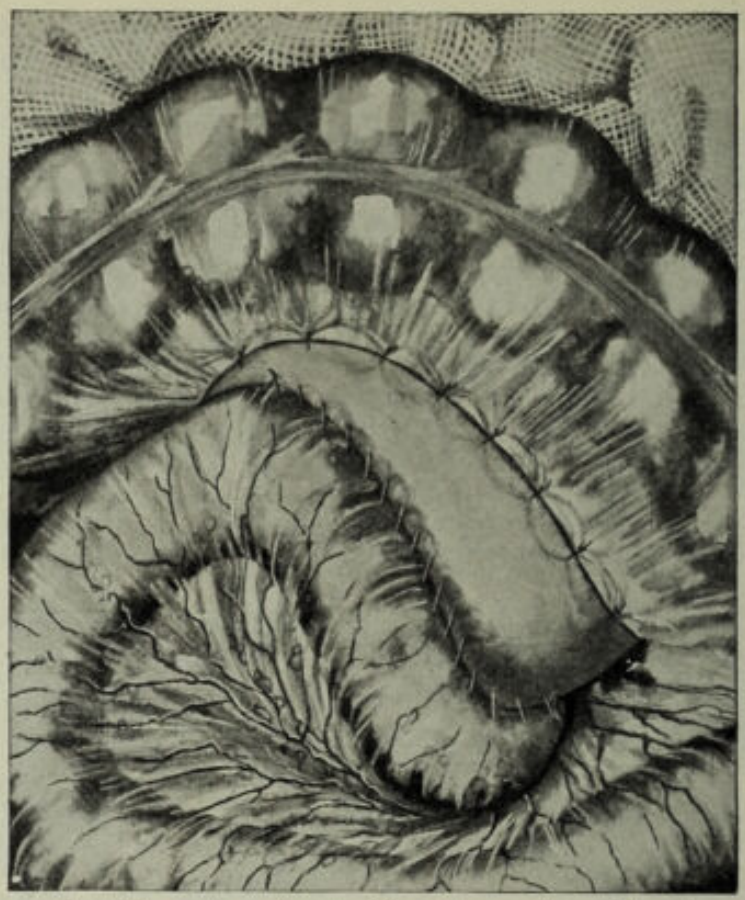


FIG. 847.—The completed loop-to-end gastrojejunostomy after pylorectomy. The anastomosed portion of the stomach has been drawn down below the incision in the transverse mesocolon—the margins of which have been sutured to the wall of the stomach. This operation is done after pylorectomy (Bickham's "Operative Surgery").

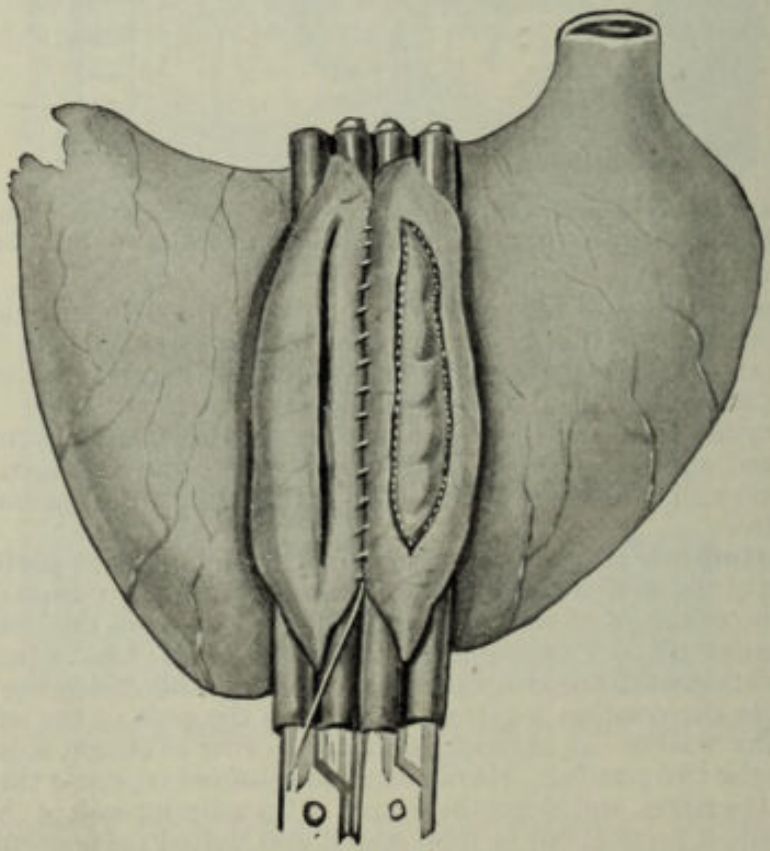


FIG. 848.—Hour-glass stomach. The application of clamps and the method of suture in gastrogastrostomy. The details are the same as in the operation of gastro-enterostomy (Moynihan).

Gastroplication (Brandt's Operation of Stomach-reefing for Dilated Stomach).—Apply sutures in the anterior wall so as to form reefs, then tear through the great omentum, and apply sutures in the posterior wall. The sutures pass through the serous and muscular coats. A continuous suture may be used on the anterior wall and another on the posterior wall, or numerous interrupted sutures may be inserted. This operation is of questionable value, and must never be used if stenosis of the pylorus exists, and stenosis of the pylorus is the most common cause of gastric dilatation.

Bircher's method of gastroplication is shown in Fig. 849.

Gastropexy (Duret's Operation for Gastroptosis).—It has been shown by Duret that dyspepsia of a peculiarly severe type may be produced by prolapse or downward displacement of the stomach. In this condition he advised the following operation: Perform a median laparotomy, but do not incise the peritoneum in the upper portion of the wound. Expose the stomach and fix it by means of a silk suture to the undivided but exposed peritoneum. The suture should be parallel to the lesser curvature and near the pylorus should be horizontal.[1] Rovsing, too, fixes the stomach to the abdominal wall. So do Hartmann and Eve. The operations of Duret, Rovsing, Hartmann, and Eve, of London, fix and distort the stomach. This seems to me an objectional procedure and liable to be followed by pain. To fix an organ which undergoes active peristalsis must surely be productive of difficulty. Byron Davis advises the suturing of the gastrohepatic omentum near its attachment to the lesser curvature to the stomach wall as high as possible. Beyea has devised an operation which is free from the objections which may be urged against Duret's operation. Sometimes gastro-enterostomy is also performed.

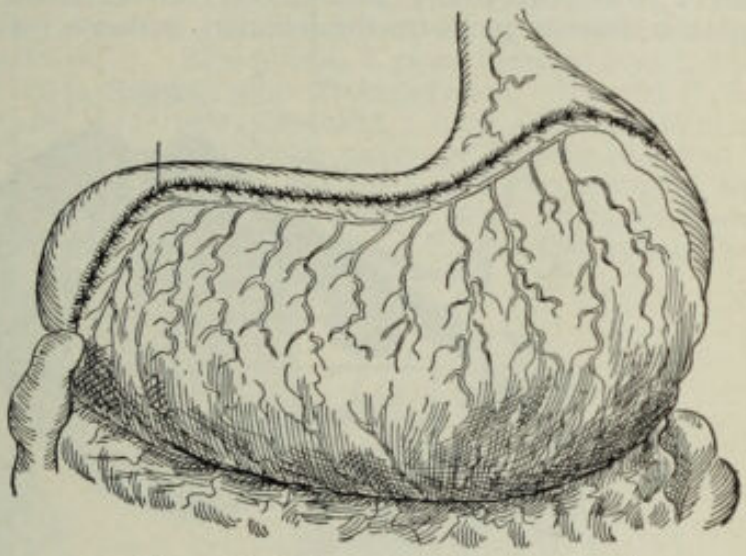


FIG. 849.—Bircher's method of gastroplication.

Beyea's Operation for Gastroptosis.—Insert three rows of interrupted silk sutures through the gastrohepatic omentum and the gastrophrenic ligament. Each suture is passed from above downward, and the rows begin at the right and pass to the left (Fig. 850). When the sutures are tied, a fold or plication is formed in the ligaments, the supports of the stomach are shortened, and the viscus is elevated to a normal position without any disturbance of its physiologic mobility ("Univ. of Penna. Med. Bull.," Feb., 1903).

Ransohoff's Omentopexy for Gastroptosis.—Ransohoff ("Medical Communications of the Mass. Med. Soc.," 1912, vol. xxiii) points out that Beyea's operation is insufficient because only the right and left borders of the gastrohepatic omentum act as supports. He uses the omentum to raise and fix the stomach, and at the same time raises and fixes the transverse colon. He makes spaces between the fascia and peritoneum as advised by Coffey and sutures the omentum into these spaces. If necessary he also does gastroplication or coloplication, or reefs the mesocolon, or separates bands and adhesions, or shortens the round ligament of the liver.

Duodenostomy and Jejunostomy.—It has been suggested that one of the above operations should be performed in a case of pyloric obstruction in which neither pylorectomy nor gastro-enterostomy is feasible. Duodenostomy is said by some to be an easy operation because of the mobility of the pylorus and first part of the duodenum, and to be not only easier, but safer, than jejunostomy because it makes the fistula above the opening of the common bile-duct ("Bull. et Mém. de la Soc. de Chir. de Paris," No. 39, 1901). Cachove advocates the operation in some cases of gastric ulcer with repeated hemorrhages and in some cases of gastric cancer. In the latter cases he asserts that the mortality is about the same as from gastro-enterostomy and the prolongation of life is greater ("Arch. f. klin. Chir.," Bd. lxv, Heft 2). Hartmann's

[1] "Rev. de Chir.," June, 1896.

case of duodenostomy lived two months. The operation was performed for extreme cicatricial stenosis of the pylorus due to swallowing hydrochloric acid.

Jacobson disapproves of both procedures, and objects particularly to duodenostomy because it involves a portion of the intestine which is difficult to deal with, and because important fluids escape constantly from the fistula.[1]

If duodenostomy be performed, it should be done in the same manner as gastrostomy by Witzel's method. I regard jejunostomy as an operation which is occasionally justifiable and as preferable to duodenostomy. As performed today there is little danger of leakage, even if the tube slips out. This operation puts the stomach at absolute rest. It is employed in very extensive ulceration, in multiple ulcers, and in some cases of cancer in which gastro-enterostomy is impossible or is contraindicated, because the opening would be in or too near the malignant growth. William J. Mayo ("Amer. Jour. Med. Sciences," April, 1912) regards the operation "as an active competitor of gastrostomy in cases of esophageal and cardiac obstruction." Mayo-Robson ("Brit. Med. Jour.," Jan. 6, 1912) advocates the operation. Mayo makes an epigastric incision, picks up the jejunum, makes a little opening at a point from 12 to

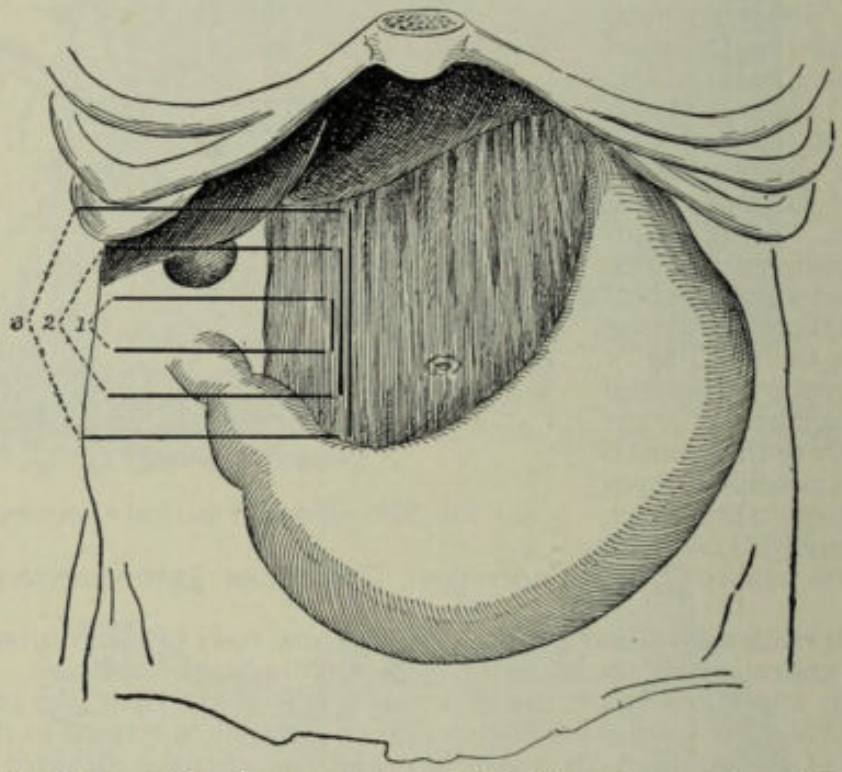


FIG. 850.—Beyea's operation for gastroptosis: 1, Position of one suture of first row; 2, one suture of second row; 3, one suture of third row. Others of each row introduced at intervals to and including the gastrophrenic ligament.

16 inches from the jejunal origin, introduces a rubber catheter (No. 9 English) "down stream" for about 3 inches, catches it to the wall of the bowel by one suture of chromic gut, infolds it for 1 inch or more as in Witzel's gastrostomy, using mattress-sutures of linen, anchors the gut to the peritoneum by two or three lines of linen sutures at the lower angle of the incision, and closes the abdominal wound (William J. Mayo, loc. cit.). Food can be given at any time.

If the tube slips out it must be put back at once, as the tract may close in a few hours. When the operation has been done for cancer the fistula is permanently maintained. If for ulcer, it can be allowed to close or can be closed surgically if it persist after the ulceration heals. Billon ("Archiv. Prov. de Chir.") has collected 127 cases. The direct mortality was 29 per cent. Sixty-four of the patients lived but three months or less. A single case lived beyond a year. This is not a very gratifying anastomosis.

Maydl does a much more formidable operation (divides the jejunum, attaches the proximal end to a far-away portion of gut, and attaches the distal end in the abdominal wound). He has operated on 25 cases, with 4 deaths.

Enterectomy, or Resection of the Intestine with Approximation by Circular Enterorrhaphy.—How much of the intestine can be removed without the

[1] Jacobson's "Operations of Surgery."

patient dying from lack of nutrition? The length of the small intestine varies from 15 to 25 feet. The report of a case with the number of feet removed tells us nothing as to how many feet remain. The question is not settled. It has been stated that the removal from an adult of more than 6⅔ feet produces nutritional disturbance, and that a child tolerates the removal of a piece relatively large better than does an adult. Senn was of the opinion that excision of more than one-third of the intestine makes inanition inevitable. Certain it is that great lengths have been successfully removed, and the patients have not only lived, but have been well nourished. Ruggi removed 11 feet, Whitall removed 10 feet 8 inches, Von Eiselsberg, 11 feet 8 inches, and Obalinski, 12 feet 2 inches. Brougham removed 11 feet 2 inches for mesenteric thrombosis and the patient recovered. Childe successfully removed 9 feet 6 inches of small intestine for embolism of the mesenteric artery. Hayes removed 8 feet 4½ inches from a boy ten years of age, and the patient was well eight months later. Dressman reported 26 cases in each of which more than 3 feet 3 inches had been removed (Alexander Blaney in "Brit. Med. Jour.," Nov. 16, 1901). Turck removed successfully 10 feet 3½ inches of ileum together with the cecum, ascending colon, and part of the transverse colon because of adhesions, sinuses, and fistulæ. Blaney adds 7 cases from literature, and tells us that in 9 of the 33 cases death occurred soon after operation. Doerfler ("Abstract in Brit. Med. Jour.," Nov. 24, 1923, from "Zentralbl. f. Chir.," Oct. 6, 1923) in one case removed nearly all of the small intestine for gangrene, leaving less than 5 inches of the jejunum and 8 inches of the ileum. Six years after the operation the man was well and strong, having but two bowel movements a day. In another case he removed all of the colon but 14 inches of the descending colon. The patient became perfectly healthy.

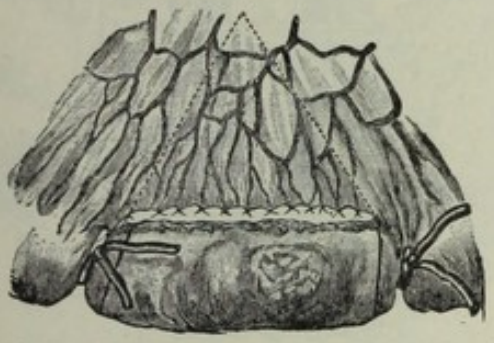


FIG. 851.—Excision of bowel: First step (Esmarch and Kowalzig).

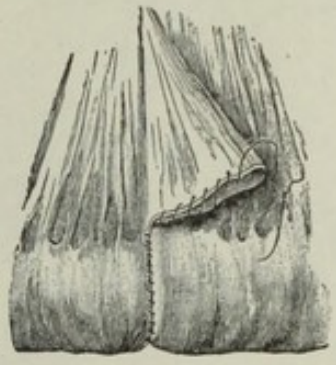


FIG. 852.—Excision of bowel with enterorrhaphy and stitching of the redundant mesentery: Second step (Esmarch and Kowalzig).

Alexander Blaney, in a previously quoted article, reviews the subject of the resection of great lengths of intestine. He tells us that how much remains after a resection is important, but uncertain. It is uncertain because, as Treves has shown, the length of the intestine varies from 15 feet 6 inches to 31 feet 10 inches.

Could end-to-end anastomosis be done as safely as lateral anastomosis it would usually be the preferred method. The great danger is infection from soiling. "Occasionally, the circular suture is the only feasible one" (Halsted, "Jour. of Exper. Med.," No. 3, 1912).

Resection of the jejunum is much more dangerous than resection of an equal length of ileum. Resection of the ileum is more dangerous than resection of the colon. If resection be employed, all diseased or injured bowel must be removed irrespective of ultimate bad consequences (Blaney). The operation is performed as follows: After opening the abdomen isolate the loop of intestine we intend to resect. Push a rubber tube through the mesentery close to the bowel, above the seat of operation, and pass a rubber tube through the mesentery below the seat of operation. Instead of tubes strips of aseptic gauze may be used to encircle the bowel. Empty this segment of bowel by squeezing and stroking, tighten the rubber tubes, and clamp them to keep the bowel empty (Fig. 851). The diseased intestine is resected, each incision being carried through a healthy segment, and care being taken that the cuts are so arranged that at each end a blood-vessel from the mesentery reaches the edge of the cut bowel. Otherwise repair can scarcely occur. The lumen of each end of the divided gut is irrigated with salt solution. The divided surfaces are approximated by a row or a double row of inversion sutures; a continuous inversion suture

is often used (Cushing's or Dupuytren's). Some use Lembert or Halsted sutures. Thoroughly satisfactory approximation can be effected by one row of Halsted mattress sutures (Fig. 853). If a redundant fold of mesentery is left, it can be stitched at its raw edge (Fig. 852). Many surgeons remove a V-shaped piece of mesentery, tie the divided mesenteric vessels (Fig. 851), and introduce sutures so that no mesenteric vessel will be constricted (Fig. 853). The tubes are removed and the wound is cleansed, closed, and dressed.

Senn effected invagination by means of a bone ring (Fig. 854).

If the two segments of bowel are unequal in size, it was formerly the custom to cut the smaller bowel obliquely and the larger part transversely. To meet this complication Billroth devised *lateral implantation*, end to side. Suppose the cecum has been resected: its lower end is closed by Lembert sutures, an opening is made in the long axis of the periphery of the colon opposite the attachment of the mesocolon, and the end of the ileum is sutured into this incision. This is called *end-to-side approximation*, or implantation. It is used in the sigmoid, in the cecum, and in any intestinal segment in which the circulation is deficient. Eugene A. Smith ("Amer. Med.," May 10, 1902) sums up the advantages of end-to-side approximation as follows: The strain of peristalsis is less than in end-to-end union; the circulation of each end of the bowel and the parts of bowel adjacent is better; each cut edge of mesentery is free to recover its circulation, and there is no dead space at the mesenteric border to lead to leakage.

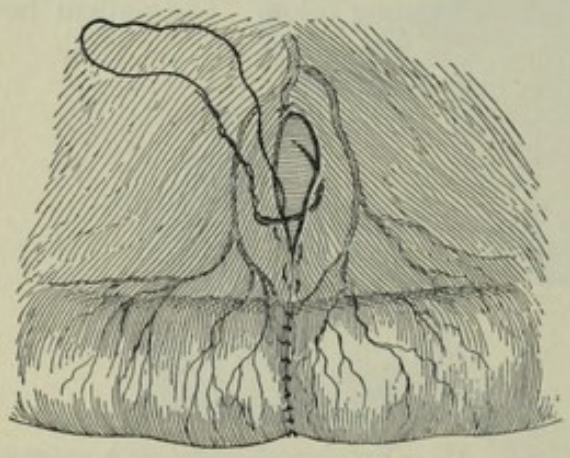


FIG. 853.—Suture of the mesentery after circular enterorrhaphy (Halsted).

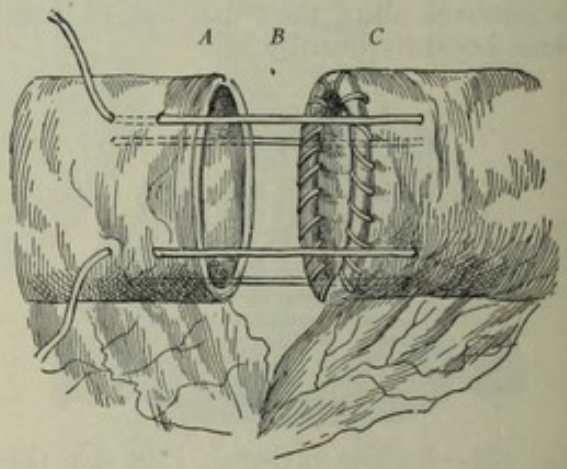


FIG. 854.—Senn's modification of Jobert's invagination method: *A*, Upper end lined with ring; *B*, invagination sutures in place; *C*, lower end.

Senn advised the insertion of an anastomosis ring of decalcified bone into the ileum, the invagination of the colon as the ring is pulled into place, and firm suturing of the line of junction. By Senn's method the ileum may be implanted into the end of the colon or into a slit in the wall of the large bowel after the end of the colon has been closed. In some cases, in which one portion of bowel is larger than the other, lateral anastomosis is the preferable method. For a full week after an intestinal resection the patient is fed chiefly by nutrient enemata. During the first twenty-four hours nothing is given by the stomach but small amounts of hot water, and for the next six days only water and a little liquid food is allowed to be swallowed.

The use of *Murphy's button* (Fig. 856) permits of rapid approximation after resection (Fig. 855). This button closely approximates the portions of the intestine within its bite, rapid adhesion taking place. The diaphragm of tissue undergoes pressure atrophy and liberates the button, which is passed per anum. It is claimed that the button opening contracts but slightly. For end-to-end or side-to-side approximation of the small intestine a No. 3 button is used. For similar operations on the large intestine a No. 4 button is employed (Murphy). After the resection one-half of a button is inserted into each segment, and is held in place by a purse-string suture of silk which passes through all the coats (Fig. 855). The redundant mucous membrane is tucked in or clipped off, so that it will not be interposed between the serous surfaces. The serous surfaces are scratched with a needle and the halves of the button are locked (Fig. 855). It is not necessary to surround the margin of junction with

sutures. To do so might keep the button from passing. Murphy said that liquid nourishment should be given as soon as the patient had recovered from the effect of

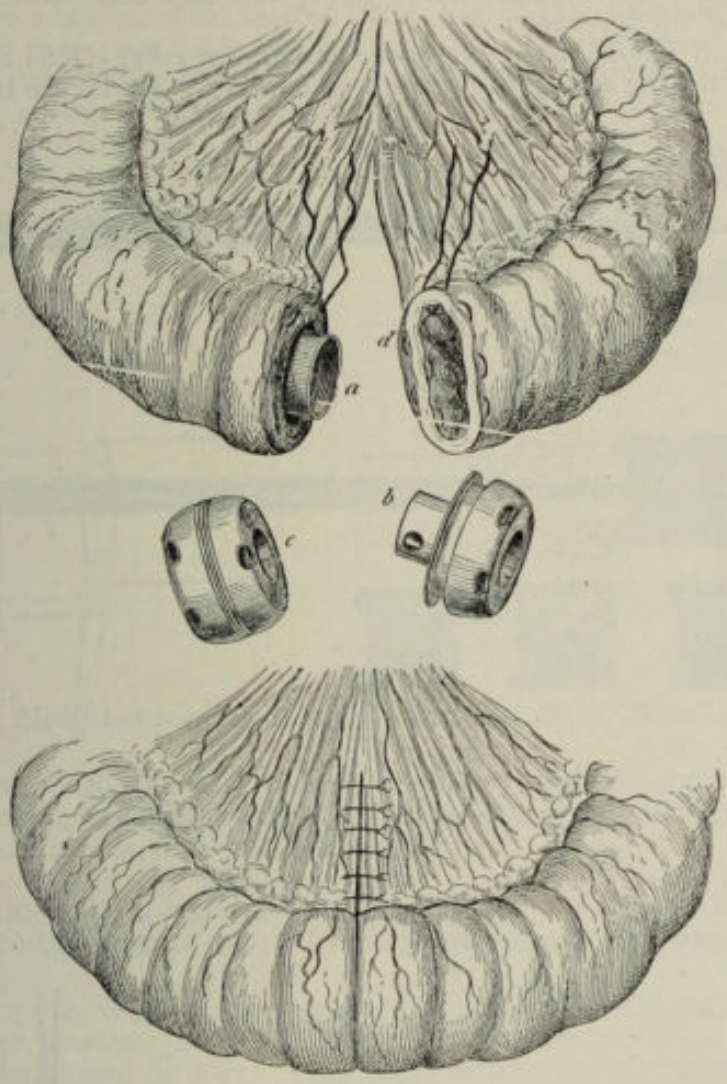


FIG. 855.—Resection of intestine: *a*, *b*, The two halves of the button; *c*, the two portions clamped together; *d*, introduction of the sutures for holding each half of the button in place. The lower figure shows the completed union of the intestine by the Murphy button; the slit in the mesentery has been closed by linear union (after Zuckerkandl).

the ether, and that the bowels should be moved at an early period, and frequent evacuations should be maintained. If the button does not pass in four weeks, examine the rectum for it.[1] The situation of the button can be ascertained by the *x*-rays. An objection to the button is that it is a foreign body which must pass per rectum to complete the operation successfully. It may not pass, but trouble does not of necessity follow. In some cases its retention does lead to trouble, and intestinal obstruction ensues. If the caliber of the button blocks before dislodgment, obstruction follows, hence the rule to give saline purgatives the day after the operation.

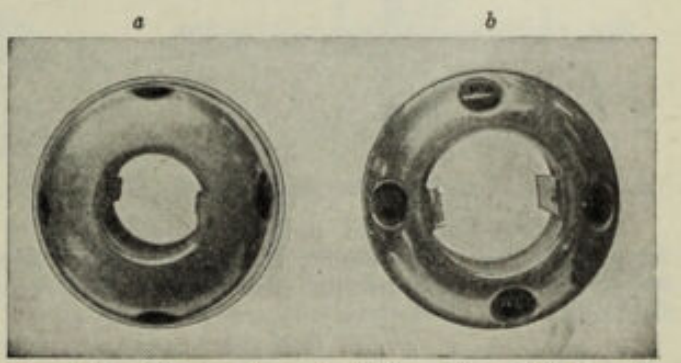


FIG. 856.—Comparison of old (*a*) and new (*b*) Murphy buttons.

Some surgeons have sought to make a button which would come apart and be absorbed after it had accomplished its purpose. One of these appliances is Frank's coupler, which is made of bone, the compression being furnished by rubber.

[1] John B. Murphy in "Med. News," Feb. 9, 1895.

In this apparatus, however, the amount of pressure obtained is always uncertain and the rubber is apt to wear out. The Murphy button gives a lower mortality than the suture operation, and some surgeons now use it who once condemned it. Czerny is a strong advocate of the button.

Harrington and Gould use a *segmented aluminum ring*. This ring collapses into small segments after the anastomosis has been effected. By its use the authors believe

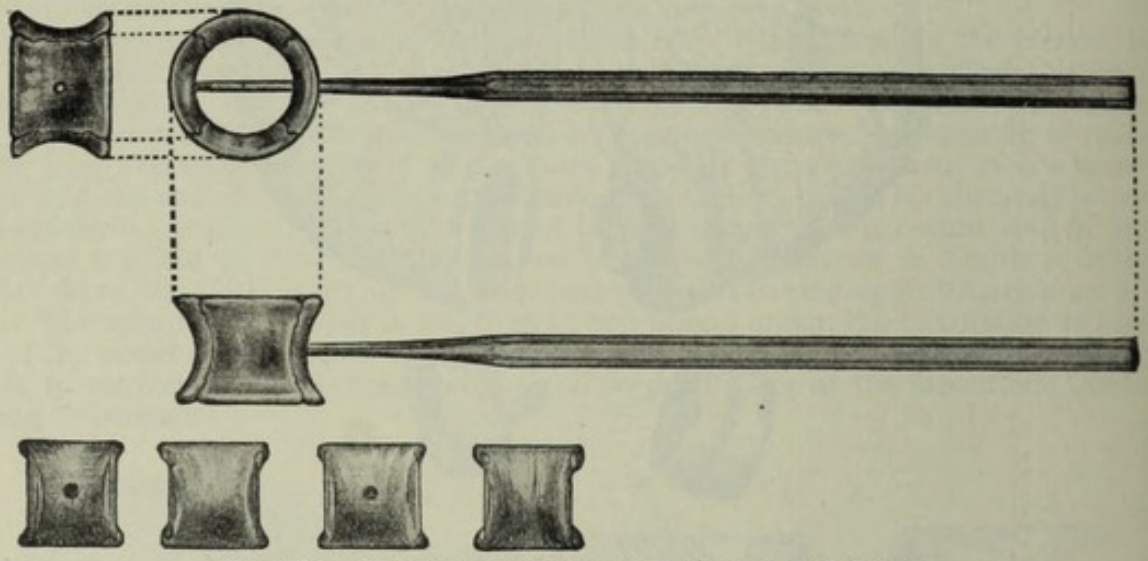


FIG. 857.—The segmented ring of Harrington and Gould.

that the operation is made more rapidly and safely ("Annals of Surgery," Nov., 1904). During the suturing the ring is held by means of a handle, which, after the anastomosis has been effected, is removed. The ring in the handle is shown in Fig. 857 and the operation in Figs. 858 and 859.

Maunsell, of New Zealand, devised a most ingenious method of circular enterorrhaphy. The two portions of bowel are attached by two fixation sutures which penetrate

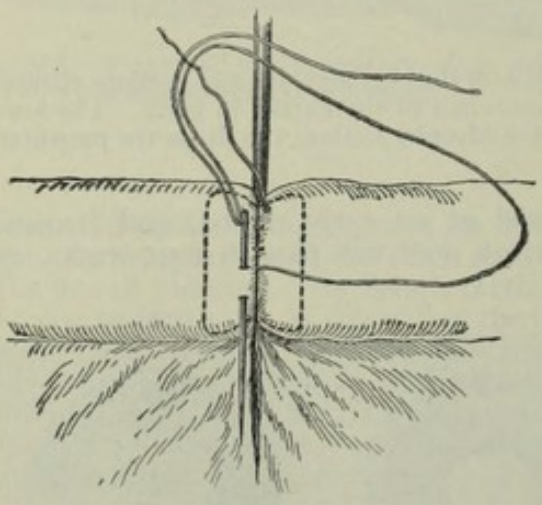


FIG. 858.—End-to-end union with aid of segmented ring. Continuous stitch beginning at one side of the handle (Harrington and Gould).

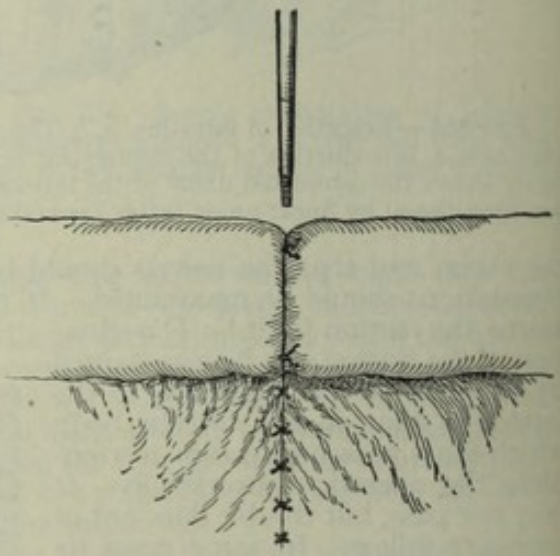


FIG. 859.—End-to-end union with aid of segmented ring. Handle unscrewed, suture completed (Harrington and Gould).

all the coats (Fig. 860). An incision 1½ inches in length is made through the wall of the proximal segment of gut, about 1 inch from its edge. The fixation sutures are brought through this opening, traction is made upon them, the distal portion of the bowel is invaginated into the proximal portion, and the ends emerge from the opening, their peritoneal surface being in contact (Fig. 860). Sutures of silk are passed through both sides of the area of invagination, the threads are caught up in the center, cut, and tied

on each side. The fixation sutures are cut off. The invagination is reduced by traction. The longitudinal cut is closed by Lembert sutures.

A. W. Mayo-Robson performs circular enterorrhaphy and brings the ends of the gut together over a bobbin of decalcified bone (Fig. 861). Allingham uses a bone bobbin the shape of two cones joined at their apices. The bobbin is decalcified, except an area at the center (Fig. 862, *a*). Kocher performs circular enterorrhaphy as follows: A fixation suture is introduced through the bowel at the mesenteric attachment and another is inserted at an opposite point. The intestinal ends are approximated by a continuous silk suture, which passes through all of the coats, but which includes more of the serous than of the mucous coat. The suture-line is overlaid by a continuous Lembert suture which includes the serous and a portion of the muscular coat.

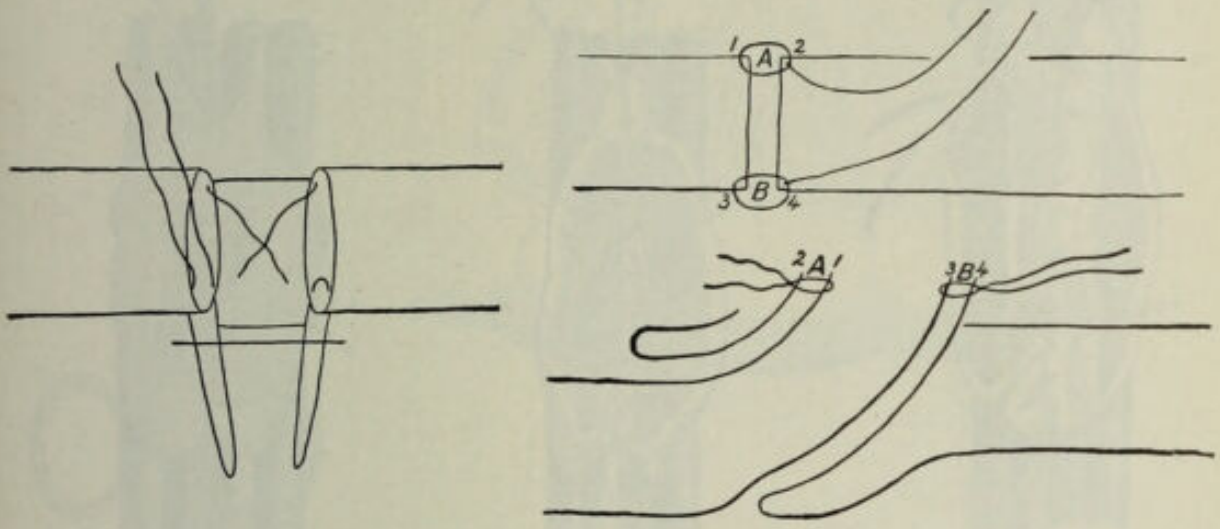


FIG. 860.—Maunsell's method of anastomosis (after Wiggin).

In doing an end-to-end approximation I prefer to use the clamp of Moynihan (Fig. 837), and operate as shown in Figs. 863–865. We thus are able to hold the parts and keep them clean, rapidly make an even and secure stitch line, and have no free-edged septum.

Some surgeons have used inflatable rubber cylinders in making an end-to-end anastomosis (Halsted, Downes, and others). The method was devised by Treves, but was subsequently abandoned by him. Halsted gave up the inflatable cylinders.

Connell has devised a method which places the knots in the lumen of the bowel (F. Gregory Connell, "Medicine," April, 1901). He maintains that the placing of the

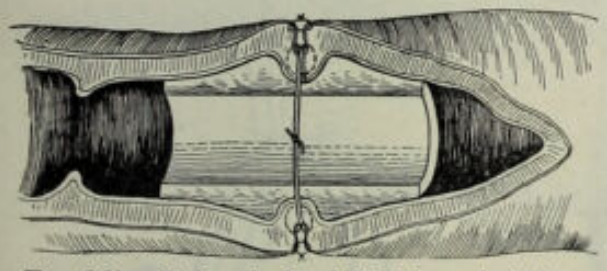


FIG. 861.—Robson's decalcified bone bobbin.

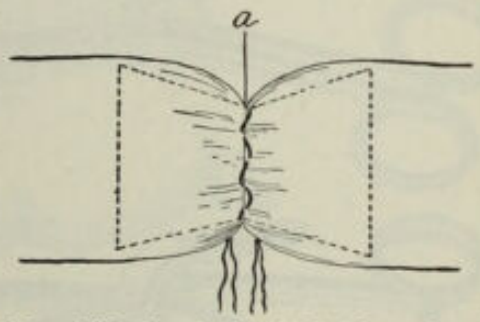


FIG. 862.—Allingham's decalcified bone bobbin.

knots within the lumen of the gut has the following advantages: there is no foreign body; the suture passes away early; adhesions to neighboring organs are few; the serous approximation is perfect; the suture line is more secure; the septum is smaller and the danger of necrosis is less. The suture is shown in Fig. 796.

Laplace devised forceps which greatly facilitate suturing, which make it easy to obtain an even suture line, and which can be withdrawn after the suturing is finished, the small opening through which the instrument has emerged being closed by a stitch (Figs. 866, 867). By aid of Laplace's forceps the operation can be neatly and rapidly performed, but a large diaphragm is formed, a considerable area is exposed to infection, the tissues of the diaphragm are bruised and may slough, the raw ends may grow

together and cause obstruction, and it seems probable that considerable contraction will follow. Another objection is that an infected instrument is withdrawn from the bowel and may contaminate the peritoneum. O'Hara's forceps (Fig. 868) permit of



FIG. 863.—Moynihan's method of end-to-end anastomosis (Moynihan).

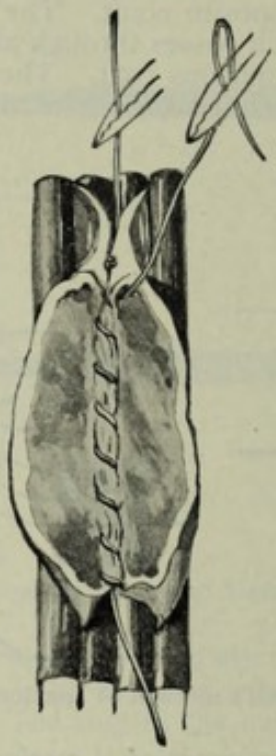


FIG. 864.—Moynihan's method of end-to-end anastomosis continued (Moynihan).

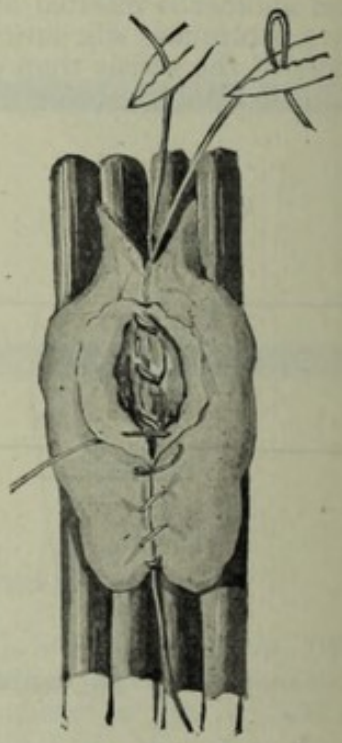


FIG. 865.—Moynihan's method of end-to-end anastomosis continued (Moynihan).

rapid and accurate suturing, but possess the same disadvantages as the Laplace forceps. In 1 case within my knowledge absolute obstruction from adhesion of the raw edges of the septum followed its employment. Figures 869 and 870 show the use of

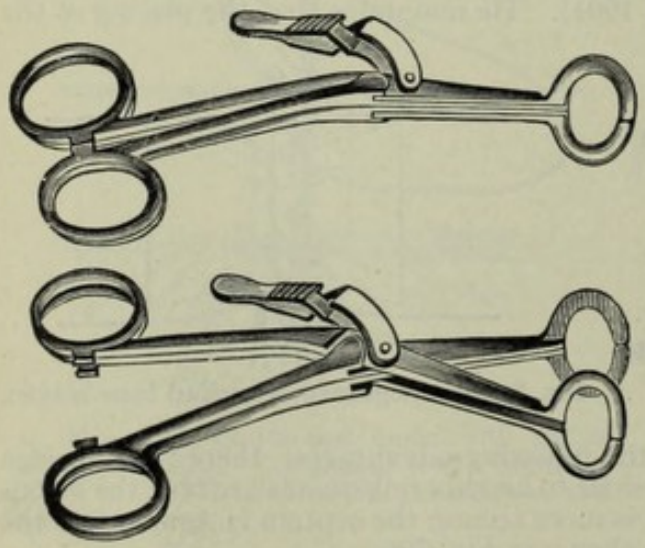


FIG. 866.—Laplace's forceps for intestinal anastomosis.

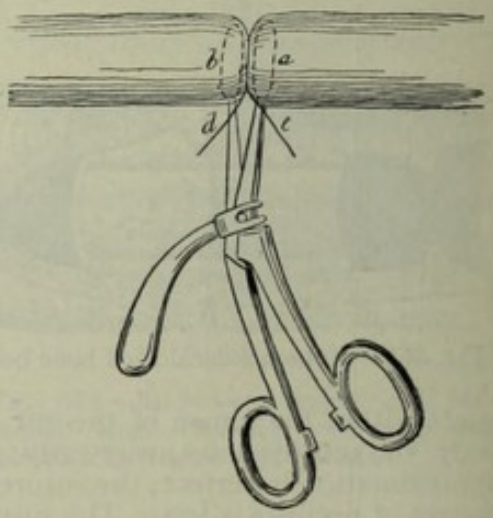


FIG. 867.—End-to-end anastomosis with the aid of Laplace's forceps.

O'Hara's forceps. Of the operations previously set forth, I prefer the clamp and suture as employed by Moynihan, the operation of Halsted by mattress-sutures and without mechanical aids, and in some cases the operation with the Murphy button.

Lateral Intestinal Anastomosis.—Approximation may be effected by other methods than by end-to-end junction or by implantation. In fact, I prefer in most cases of resection to close each end of the divided gut and perform lateral anastomosis. It is a safer operation than end-to-end anastomosis and by it we can obtain as large an opening as we desire. Again, after lateral anastomosis the parts obtain a better blood-supply than after end-to-end suturing, because in the former operation the mesenteric vessels are not interfered with. Further, in lateral anastomosis there is

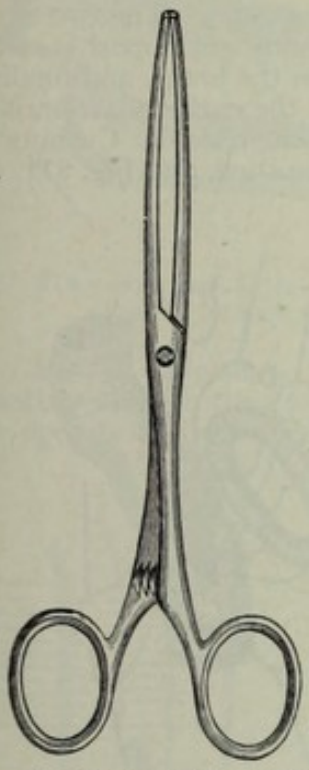


FIG. 868.—O'Hara's anastomosis forceps (about one-third original size).

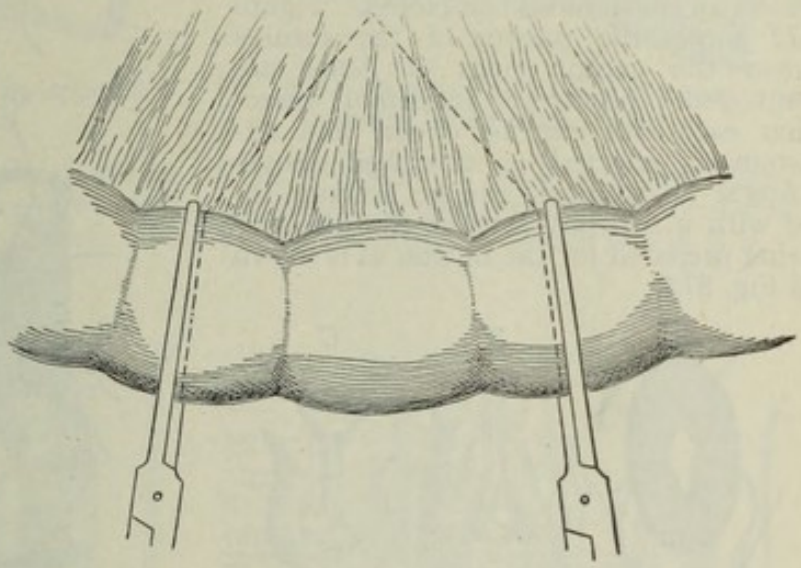


FIG. 869.—Showing the manner of placing forceps in resection of bowel; dotted lines show the incision to be made (O'Hara).

little tendency to cicatricial contraction. Lateral anastomosis may be performed in some cases without a preliminary resection for the purpose of short-circuiting the fecal current, throwing a diseased portion of the bowel out of action, and thus avoiding obstruction (Fig. 871). This operation has the disadvantage that the diseased structure is not removed.

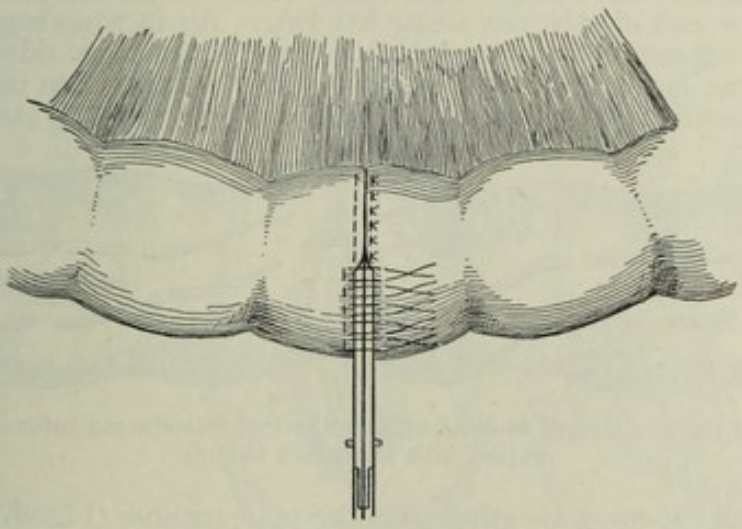


FIG. 870.—End-to-end anastomosis. Forceps brought together and held by serre-fine (not shown); sutures introduced, some of which are tied (O'Hara).

Lateral Anastomosis with Rings.—In this operation a portion of bowel above the obstruction and a loop below the obstruction are brought into the wound. These segments are emptied, and are kept empty by fastening around them rubber tubes or gauze stips. Two tubes are needed for each loop of bowel. Pack gauze pads about the parts. Make an incision in one loop, in the long axis of the bowel, on the surface away from the mes-

entery; permit the contents to escape externally; irrigate this segment with saline solution, and introduce the bone plate of Senn (Fig. 871, *A*) or Abbe's catgut ring (Fig. 872). Calix-eyed needles are used to pass the silk, and the threads of the ring are carried through the coats of the bowel and are gathered together in the bite of a pair of forceps. The other loop of intestine is treated in a similar manner. The two segments of intestine are so brought together that the two wounds are opposite each other, the posterior sutures being tied first, the upper next, then the lower, and finally the anterior threads. The ends of the threads are cut off, and the entire anastomosis is surrounded by a layer of Lembert or Halsted sutures or is encircled by Cushing's suture. Figure 871, *B* shows an intestinal anastomosis partly finished, and Fig. 871, *C* shows an anastomosis completed. Figure 872 shows the passing of the sutures when the catgut rings of Abbe are employed. After an intestinal resection each end can be closed and anastomosis effected as described above. Lateral anastomosis can be accomplished with a Murphy button, the intestine being prepared for the button as is shown in Fig. 873.

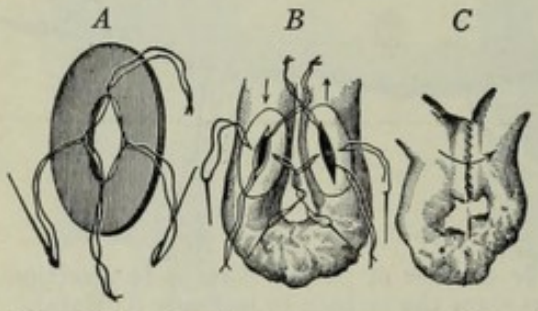


FIG. 871.—Senn's entero-anastomosis: *A*, Senn's bone plate; *B*, intestinal anastomosis; *C*, operation complete.

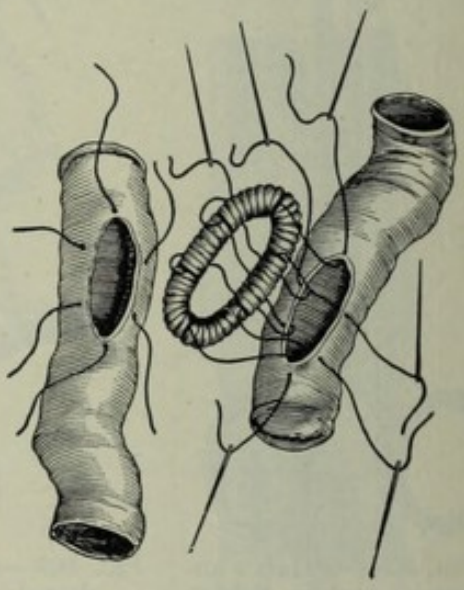


FIG. 872.—Method of passing the silk sutures in inserting the rings of Abbe.

Abbe's Method of Lateral Anastomosis Without Mechanical Aid.—After having resected the bowel and mesentery and closing the ends of the bowel he places the extremities side by side and applies two rows of a Dupuytren suture, ¼ inch apart. These rows of sutures are 1 inch longer than the slit in the bowel will be (Fig. 874), the thread at the end of each row being left long. An incision is made in the bowel ¼ inch from the sutures, both rows of threads being on the same side of the cut. This incision is 4 inches long. The other portion of the bowel is then incised in the same way. The adjacent cut edges are united by a whip-stitch which goes through all the

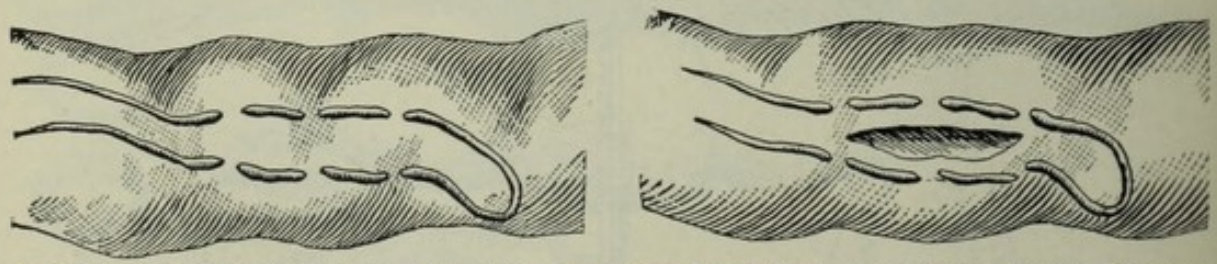


FIG. 873.—Showing relative size of incision and method of introducing sutures in lateral approximation with Murphy's button.

coats, and the free cut edges are stitched in the same manner (Fig. 875). The surgeon now utilizes the long threads of the first sutures, and brings the serous surfaces of the opposite sides together by means of Dupuytren's suture. Halsted performs anastomosis as follows: He places the two portions of bowel with their mesenteric borders in contact. Six quilted sutures of silk are introduced, tied, and cut off (Fig. 876, *a*). At each end of this row of sutures two quilted sutures are introduced, tied, and cut (Fig. 876, *b*). A number of quilted sutures are introduced, as is shown in Fig. 876, *c*. The intestinal openings are made with scissors, and the sutures last introduced are tied and cut off (Fig. 876, *d*).

Bodine's method of intestinal anastomosis is referred to on page 1105.

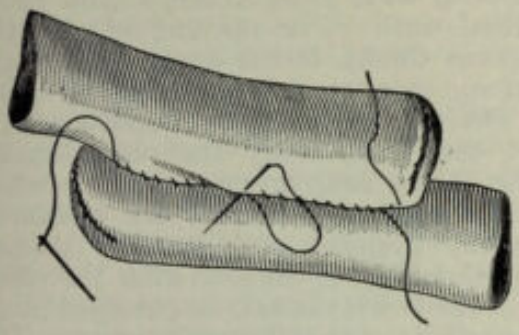


FIG. 874.—Suturing intestines in apposition before incision (Abbe).

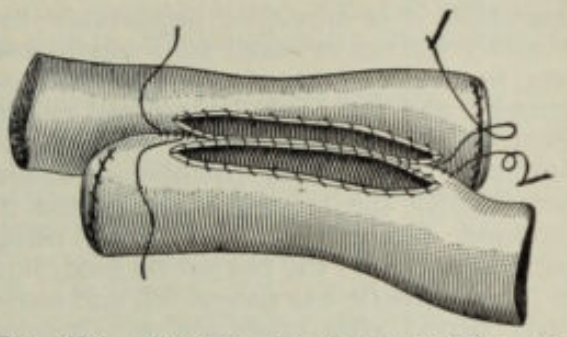


FIG. 875.—Showing the 4-inch incision and sewing of the edges (Abbe).

Lateral Anastomosis by Laplace's Forceps, (Figs. 877, 878). I usually perform lateral anastomosis with the assistance of Moynihan's clamps, the method being identical with the operation of gastro-enterostomy. Moynihan's operation is shown in Fig. 879.

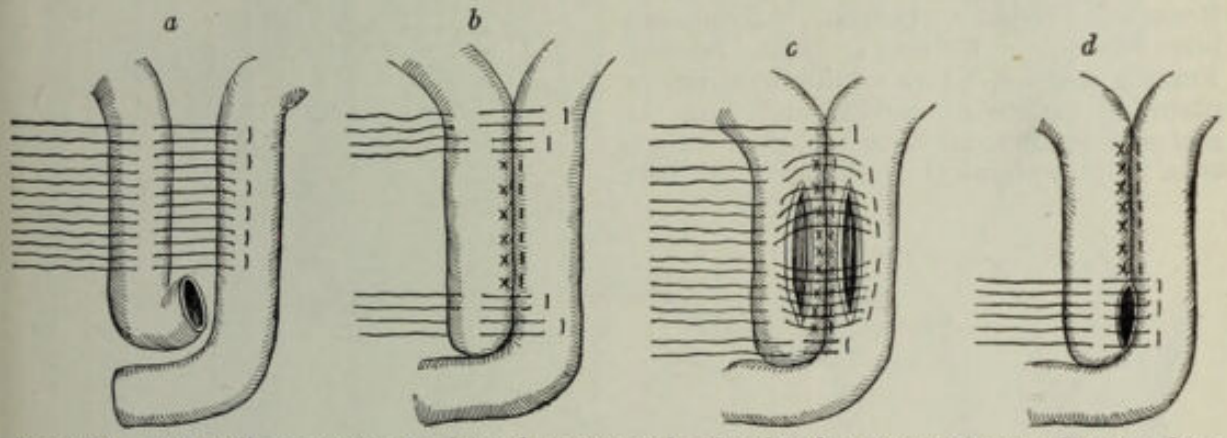


FIG. 876.—Halsted's operation for lateral anastomosis, showing four steps of same (Jessett, from Halsted).

Consideration of Methods of Intestinal Approximation.—Some of the methods described above are obsolete. Today we usually operate with aid of Moyni-

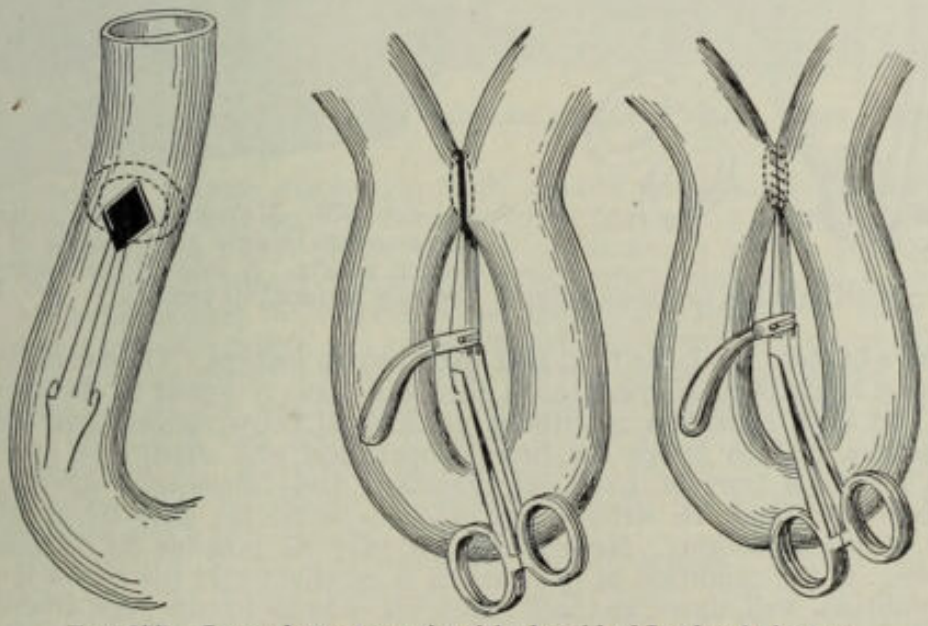


FIG. 877.—Lateral anastomosis with the aid of Laplace's forceps.

han's forceps or with no mechanical acid. At least 250 methods of uniting a divided intestine have been devised, and the best method is a matter of dispute. The essentials of a good method are: rapidity of execution, the formation

of an even and reliable line of junction, and the absence of any considerable permanent septum. The Murphy button can be applied with great rapidity, and rapid operation is of immense importance in intestinal work. The opening left by the Murphy button is small (too small, some surgeons think), but it does not strongly tend in most instances to contract because the tissue diaphragm is separated by tissue atrophy and not by inflammatory gangrene. The separation of the diaphragm is a most valuable feature. No other instrument thus cuts away the objectionable septum. Occasionally the opening made by the button contracts and gives trouble; occasionally the lumen of the button blocks with feces; occasionally the button is retained, this latter complication being especially frequent after anterior gastroenterostomy. If the button be used, liquid food should be given soon after the effect of the anesthetic has passed off, and movement of the bowels should be obtained at an early period after operation and frequent evacuations should be maintained. The button gives better results in end-to-end approximation than in lateral anastomosis. Moynihan's forceps, Laplace's forceps, O'Hara's forceps, the decalcified bone plates of Senn, the catgut rings of Abbe, the segmented ring of Harrington, the catgut strands inside of rubber tubing of Brokaw, Chaput's button, Allingham's bone bobbin, Robson's bone bobbin, Frank's coupler, Clark's bobbin, tubes or plates of potato or carrot, and rings or plates of leather, all have had their adherents. Of mechanical appliances, the best

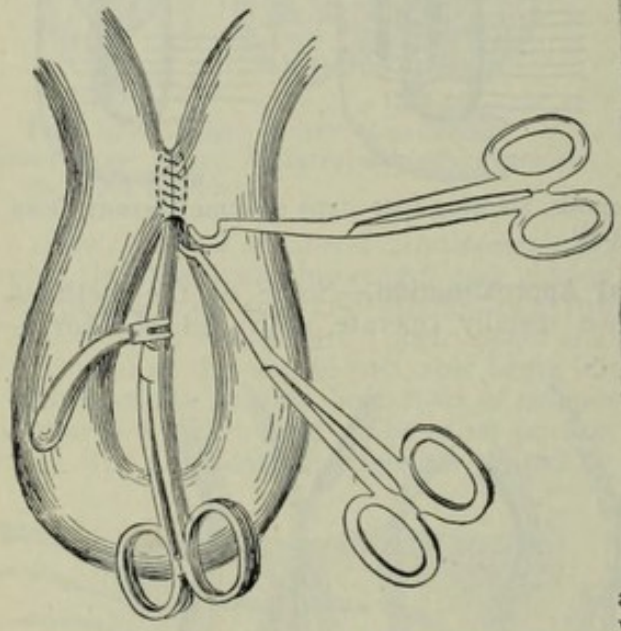


Fig. 878.—Withdrawal of Laplace's forceps.

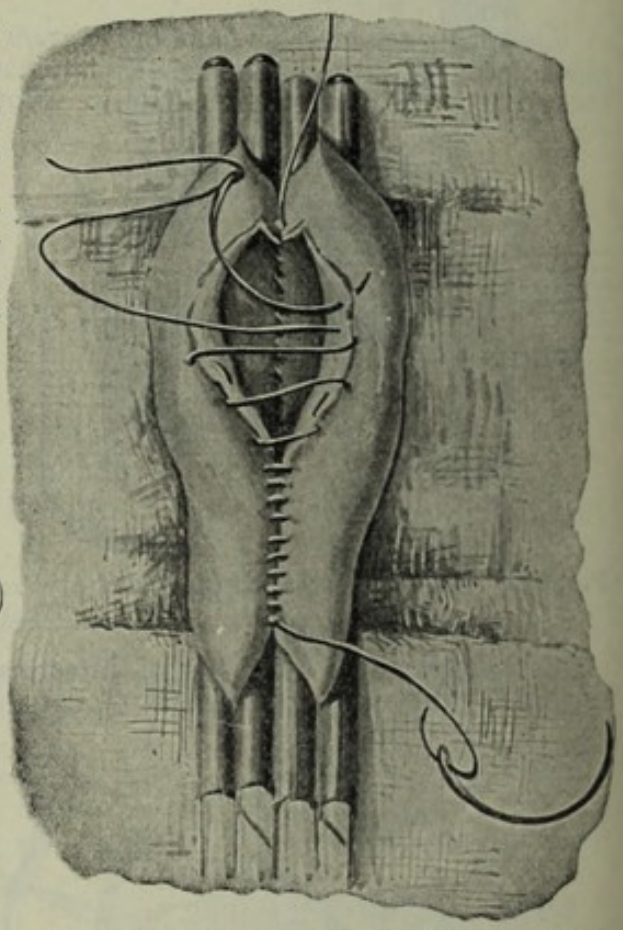


Fig. 879.—Moynihan's inner suture in lateral anastomosis to show the infolding of the mucosa which results. A loop of the suture lies on the mucous surface (Moynihan).

are Murphy's button, the bone ring, and Moynihan's forceps. Of recent years many surgeons have abandoned all mechanical aids, and have returned to closure by simple sutures. The ideal operation is without mechanical contrivances, but such devices are time savers, and to lessen the time of operation will often save life. Further, Moynihan's forceps prevent fecal extravasation and consequent infection. What method to follow must be determined in each particular case by a study of the necessities of the situation. Nevertheless, it may be possible to formulate a few general rules: If the condition of the patient is excellent and the bowel is in a fairly healthy condition, well above and well below the seat of trouble, end-to-end approximation should be performed by circular enterorrhaphy with the aid of Moynihan's clamp, or each end can be closed after resection and a lateral anastomosis be effected with the aid of the clamp. If the condition of the patient is such as to make haste necessary, use a Murphy button. If the bowel below the seat of trouble is much contracted and haste is necessary, do not use a Murphy button, but use Senn's bone plate

or Robson's bobbin. If haste is not imperatively necessary, do simple enterorrhaphy. If the surgeon is obliged to join a very much distended bowel to a very much contracted bowel, perform end-to-side approximation (implantation) with the bone plate of Senn or by simple suturing, or else effect side-to-side junction by the method of Abbe or of Moynihan.[1]

Aseptic Resection of Intestine.—Many surgeons have been striving for years to attain an aseptic technic in resection of the intestine. In 1908 Walker employed a purse-string suture to create a bulkhead in the performance of an aseptic end-to-end operation. In 1912 Gatch devised a plan in which each end of the divided intestine was kept closed by a clamp while the gut was being sutured. Horine ("Annals of Surgery," Dec., 1922) set forth a method by use of a purse-string suture to make the bulkheads, no mechanical aid being employed. In the performance of this operation the needle never enters the lumen of the gut. Other methods have been described by Warbasse, Gatch, Bidgood, and others.

The final activities of the late Professor Halsted were devoted to devising a successful method. He made a diaphragm at each end, made a splint end-to-end suture,

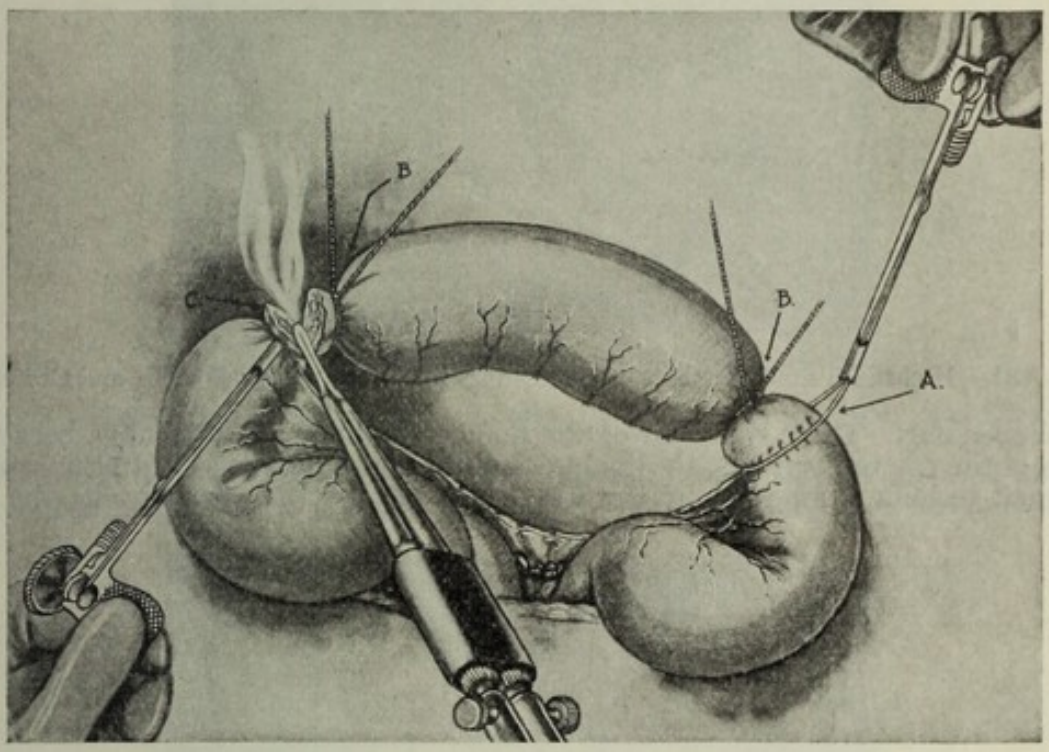


FIG. 880.—Highsmith's method of aseptic intestinal resection ("Surg., Gynec., and Obstet.").

and punctured the double diaphragm with a knife introduced per rectum. This method, of course, was only applicable to the lower part of the great intestine. Doctor Halsted's article will be found in the "Annals of Surgery," March, 1922.

Foster K. Collins ("Annals of Surgery," Dec., 1922) endeavored to improve this method. He believes that the success of the operation is dependent upon the proper application of a looped ligature. A single looped end of strong linen or silk holds the ends of the intestine until such a moment as the end-to-end anastomosis is completed, when a gentle pull of this looped ligature removes it and the lumen of the intestine is restored. Of course this operation leaves long ends of gut protruding into the lumen of the bowel, but these ends do not seem to be the source of hemorrhage or any other trouble. For the details of the operation see the article above quoted. It seems to promise much in simplicity and safety.

E. D. Highsmith ("Surgery, Gynecology, and Obstetrics," Feb., 1923) suggests a very ingenious plan for aseptic resection of the intestine. He points out that many surgeons use lateral anastomosis because the operation can be partly completed before the lumen of the bowel is opened, but he prefers end-to-end suturing because the lateral operation divides circular muscular fiber and because the overlapped and sutured ends produce a splint which destroys peristalsis. Highsmith uses a looped clamp (Fig.

[1] See the discussion of this subject by the late J. Greig Smith in his "Abdominal Surgery."

884) to carry out a blind end-to-end anastomosis (Fig. 881). He is able to hold the ends tightly closed while the diseased area is cut away with a cautery. The ends are sutured together. The operation is practically ended before the clamp is loosened and the liga-

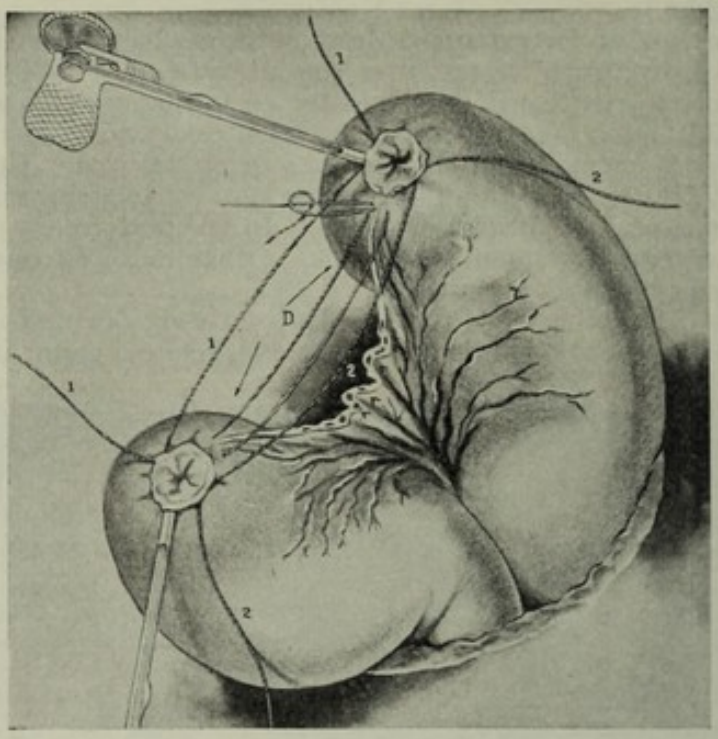


FIG. 881.—Highsmith's method of aseptic intestinal resection ("Surg., Gynec., and Obstet.").

ture slipped out. There is no fear of the double diaphragm not opening, because, by means of the traction sutures, the double diaphragm is pulled apart. In this operation the usual technic is followed by ligation of the blood-supply and freeing the bowel

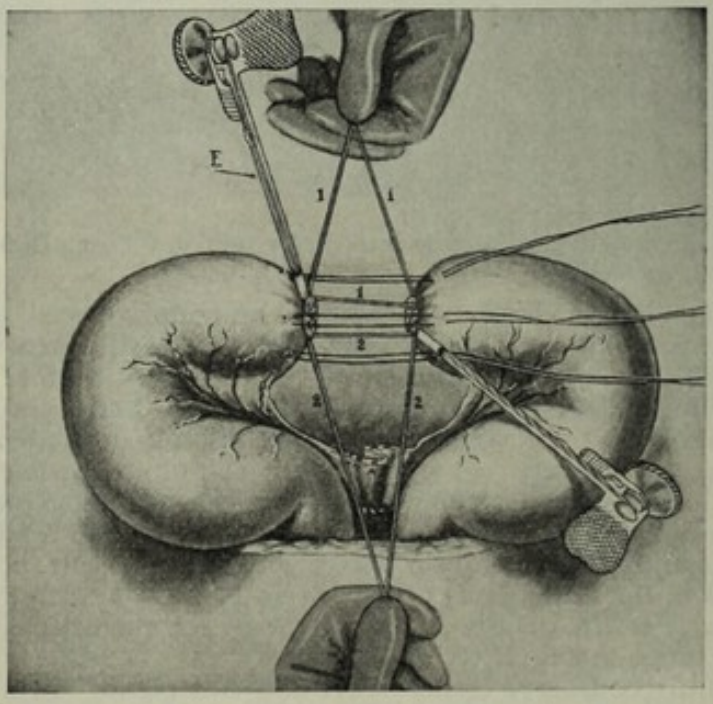


FIG. 882.—Highsmith's method of aseptic intestinal resection ("Surg., Gynec., and Obstet.").

from the mesentery. Each end of the piece to be removed is crushed with thin serrated forceps, a strand of thick silkworm-gut or plain catgut or a small flexible wire is thrown about the crushed region and threaded in the looped clamp in such a way that an assistant can hold a clamp in each hand (Figs. 882–884).

Another method is described by John Fraser and Norman M. Dott ("British Jour. of Surgery," Jan., 1924). In this ingenious method each splint end is ligatured, a purse-string suture being employed for the purpose. The ligature guillotine is

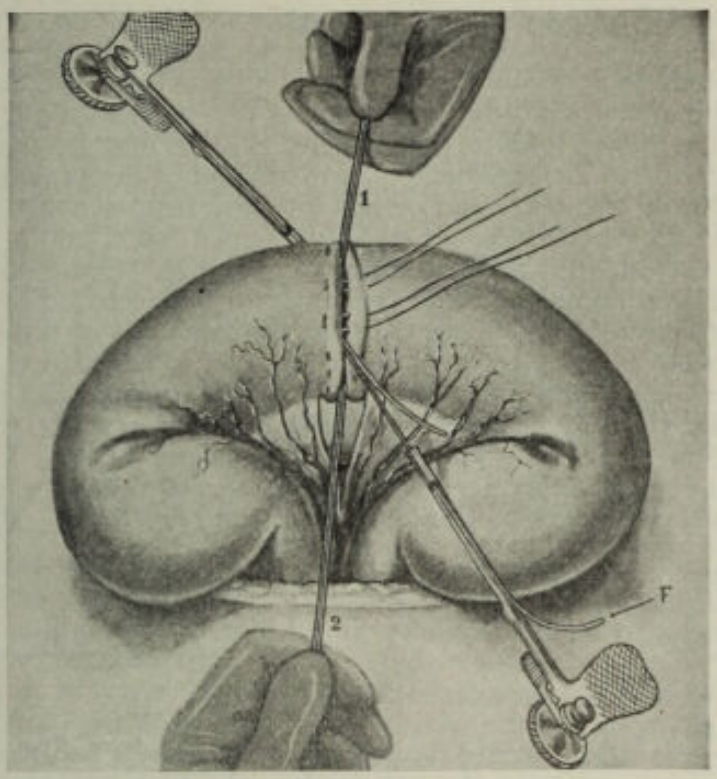


FIG. 883.—Highsmith's method of aseptic intestinal resection ("Surg., Gynec., and Obstet.").

threaded upon and placed about the middle of a strand of strong catgut and each end of the latter is armed with a needle. When the ligature is divided the end is at the

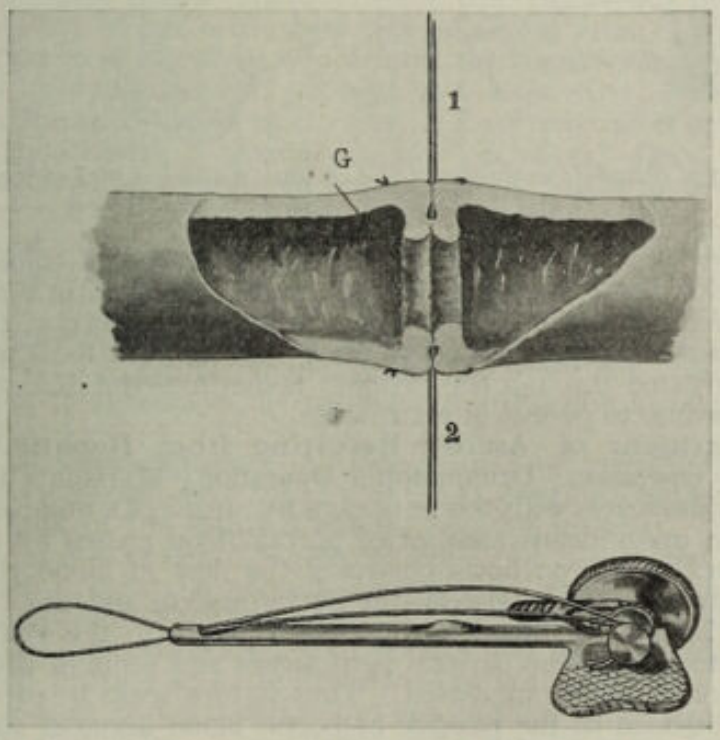


FIG. 884.—Highsmith's method of aseptic intestinal resection ("Surg., Gynec., and Obstet.").

border toward the mesentery and the guillotine is fixed to the border farthest away from the mesentery. As the clamp on each end is closed the ligature is divided and a bulkhead is formed on each end with a very minute clamp. Each end is inverted.

Closure is effected by continuous circular suture. The stump is cut by means of the guillotine, the instrument is withdrawn, and a stitch which was left loose is now tied. It will be necessary to read the original articles and to study the cuts to appreciate the ingenuity of these promising methods.

Local Intestinal Exclusion.—This operation was introduced by Salzer in 1891. It excludes the fecal current from a portion of the intestine. In complete exclusion the intestine is cut through above and below the diseased portion, and the ends of the healthy gut are united to each other or the end of one portion of gut is implanted into the side of the other. Both ends of the excluded portion may be fastened to the skin, making a double fistula (von Eiselsberg); the distal end or the proximal end alone may be fastened to the skin, the other end being closed by sutures and replaced within the abdomen. Sometimes each end is closed and dropped back, and a fistula is made in the middle of the excluded portion to permit of drainage. Some operators close each end by suture and drop them back, and do not drain the excluded portion; and others, with the same purpose in view, suture together the two ends of the excluded part. It seems wisest to suture both ends, or at least one end to the skin (LeDentu in "Rev. de Gyn. et de Chir.," Jan. and Feb., 1899). It is true this makes a permanent fistula, but if it be not done, the loop may become distended with secretion containing virulent bacteria, a condition which may lead to perforation and death. Exclusion is rarely performed upon the small intestine. It is best suited to the large intestine. If it be done at all, complete exclusion is the best operation (Fig. 885). Partial exclusion is

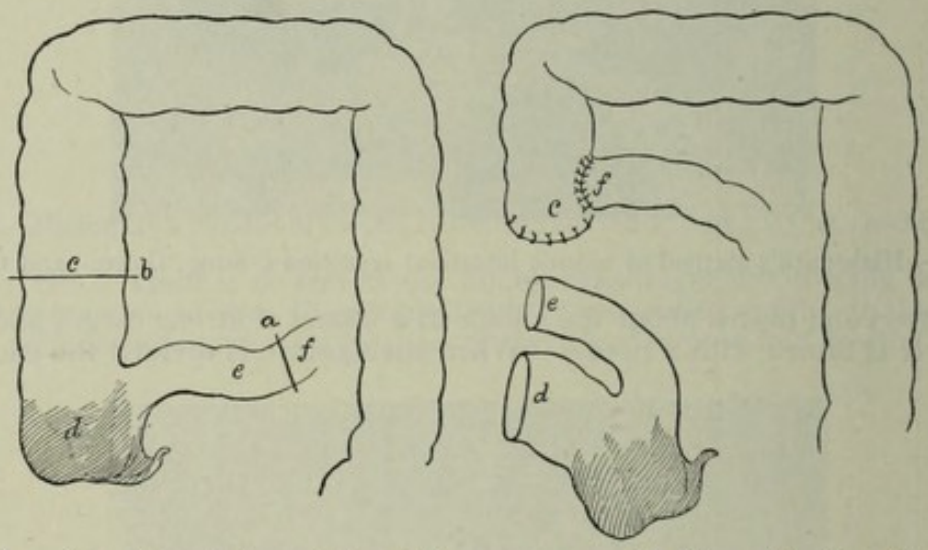


FIG. 885.—Operation of complete exclusion of the cecum: *a* and *b*, Lines of incision; *f* is implanted into *c*; *e* and *d* are sutured to the abdominal wall.

rarely satisfactory. Exclusion has been performed instead of colostomy in cases of intestinal obstruction, but it is best suited to inflammatory areas or tumors, irremovable because of adhesions or some other cause. After the operation the diseased area may improve because of drainage and freedom from irritant fecal matter. In many cases it can be irrigated through the fistula. Sometimes the diseased part improves sufficiently after a time to permit of extirpation.

Surgical Treatment of Ascites Resulting from Hepatic Cirrhosis (Epiplopexy; Talma's Operation; Drummond's Operation; Morison's Operation).—The portal system communicates with the vena cava by means of a number of small vessels. Normally, only an insignificant amount of portal blood passes by this route to the general circulation. When cirrhosis obstructs the flow of blood through the liver, the radicles of communication between the portal system and the vena cava enlarge and an increased amount of blood is thus sent directly to the systemic circulation. Adhesions develop between the parietal peritoneum and some of the viscera and the collateral circulation is further increased. Thus nature seeks to prevent ascites. If, however, the obstruction to the passage of portal blood becomes so great that "the collateral circulation is no longer able to maintain an equilibrium in the blood-pressure in the portal radicles, the pressure thus rises to a point at which transudation takes place and ascites develops" (M. L. Harris, paper read before Chicago Medical Society, Feb., 1902). The theory above set forth is the "mechanical theory"; but, as Harris points out, increased portal tension is not the only factor concerned in the production

of ascites, chronic inflammatory changes in the peritoneum being "materially instrumental" in maintaining ascites by lessening the absorbing power of the peritoneum. Influenced by the mechanical theory of causation Talma, of Utrecht, devised an operation to cure ascites by establishing more free communication between the portal system and the systemic circulation. Drummond and Morison about the same time independently devised a like procedure.[1] This operation is called *epiplopexy*. In some cases the abdomen has been opened and the omentum sutured into the abdominal wound; in others, between the layers of the anterior abdominal wall. The results are slightly better when the omentum is sutured between the layers of the abdominal wall. The gall-bladder may be sutured to the abdominal wall as well as the omentum. The liver and spleen, under surface of the diaphragm, and parietal peritoneum about the liver and spleen are usually rubbed harshly with a piece of gauze. Drainage is not used by most operators. It does not appear to contribute any favorable chances and it exposes the patient to the danger of infection. Morison, however, advocates it, and makes suprapubic drainage, a glass tube being carried into the rectovesical or recto-uterine pouch ("Brit. Med. Jour.," Jan. 20, 1912).

The operation ought to be performed early, before the onset of chronic inflammation of the peritoneum. In a great majority of cases the operation proves futile, and not uncommonly death soon follows from complications or because the disease is very far advanced. In exceptional cases the operation proves of distinct benefit. The operation shows the least mortality and the greatest number of apparent cures when the liver is large; the greatest mortality and the fewest cures when the liver is contracted. The greatly lowered vital resistance of these patients is the imminent danger. Renal disease, cardiac disease, other grave complications, and the absence of sufficient functionating liver substance to maintain life contraindicate operation (Greenough in "Amer. Jour. Med. Sciences," Dec., 1902).

Harris, in the paper previously quoted, collected 46 cases; 23 of these were instances of alcoholic cirrhosis; 30 per cent. were dead within fourteen days; 52 per cent. were dead within two months; 56 per cent. were dead within six months. Ascites had returned in all of those who died late. At the end of one year or longer 13 per cent. had recovered from ascites. The remaining 30 per cent. were either unimproved or were said to be improved with some ascites.

Of the group of mixed cases constituting the remainder of those Harris collected, 10 per cent. were dead in four days, 25 per cent. were dead in four months. In 40 per cent. no improvement took place. In 10 per cent. the report was too early to give any information. About 15 per cent. were free of ascites after one year or longer, and 5 per cent. were cured of intestinal hemorrhage, ascites never having been present. Greenough collected 105 operations: 42 per cent. were improved; 58 per cent. were not improved; 29.5 per cent. died within thirty days. Two years after operation 9 cases were apparently in good health ("Amer. Jour. Med. Sciences," Dec., 1902). One of Morison's cases was alive and well eleven years after operation; another was well for six years, when an attack of pneumonia led to death; another patient remained well for two years, but died after an operation for ventral hernia (Morison in "Brit. Med. Jour.," Jan. 20, 1912). The results of the Talma operation are disappointing. William J. Mayo ("N. Y. Med. Jour.," June 22, 1918) performed the operation 28 times, with 4 deaths; 8 died at various times following operation, the rest were benefited. Mayo suggests that we divert the portal circulation by removing the spleen. Blood will then be diverted from the portal to the pulmonary circulation through the channels described by Sappey.

Operation for Intussusception.—Air distention and hydrostatic pressure are uncertain; in an advanced case may rupture the gut; even in a recent case may fail or may reduce the bulk of the intussusception, but not its apex. Russel ("Intercolonial Med. Jour. of Australasia," March 20, 1902) alludes to the uncertainty of the method. He used hydrostatic pressure in 5 cases. Two died and 2 recovered. In 1 case the method failed and operation was then performed. It is safer and better to operate early, but if the conservative plan is tried and fails, operation should certainly be done at once, because an early operation enables the surgeon easily to effect reduction, and also because early complications are unusual. The incision is made in the midline above the umbilicus. The surgeon endeavors by manipulation to reduce the intussusception by pushing it back, not by pulling it out. If the intussusception is gangrenous, perform intestinal resection and circular enterorrhaphy. The same rule maintains when malignant disease of the gut exists (D'Arcy Power). It is inad-

[1] "Brit. Med. Jour.," Sept. 19, 1896.

visable to make an artificial anus. *Maunsell's operation* is suited to cases of irreducible intussusception. It is performed as follows: A longitudinal incision is made in the intussuscipiens. The intussusceptum is gently pulled upon and is caused to protrude from this opening. Two straight needles threaded with horsehair are passed so as to transfix the base, and ¼ inch above the needles the intussusceptum is cut off. The needles are carried completely through, the sutures are hooked up in the middle and cut, and the two ends are tied on each side. These sutures unite the intussusceptum to the intussuscipiens. The two surfaces are now carefully approximated by sutures. The sutures are cut. The stump is replaced. The longitudinal incision is closed with Lembert sutures.[1]

Russell (Ibid.) reports 16 cases operated upon: 12 recovered and 4 died. In every one of the 4 fatal cases the diagnosis was not made until the disease had lasted several days. In only 2 of the successful cases the diagnosis was made late. If operation is done in the first twelve hours the mortality, even in infants, will probably be comparatively small. If gangrene exists the mortality is enormous (at least 90 per cent.).

Senn's Operation for Fecal Fistula.—Suture the cutaneous opening transversely with Czerny sutures of silk in order to prevent infection. Cleanse the surface thoroughly. Open the abdomen and separate the edges of the bowel from the parietes. Deliver the portion of bowel which contains the fistula and apply Lembert sutures over the Czerny sutures. Another method is to open the abdomen above the fistula, insert the fingers, cut out the skin and tissues around the fistula in an elliptic course, leaving them attached to the bowel, draw the bowel from the abdomen, pack gauze around, remove the tissues adherent to it, and suture the fistula transversely.

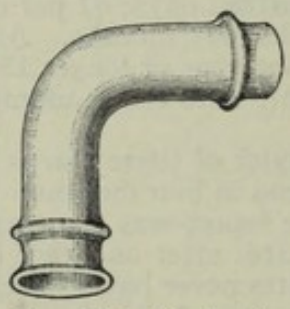


FIG. 886.—Paul's tube.

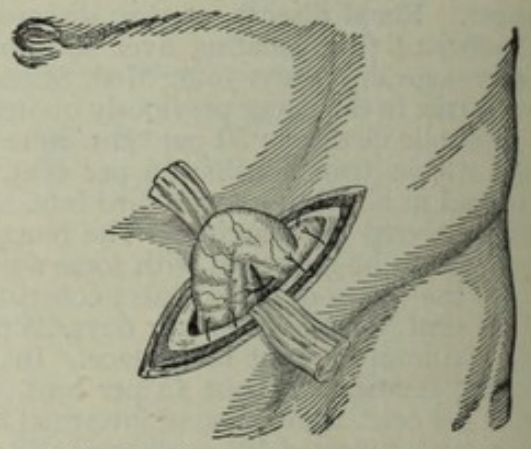


FIG. 887.—Inguinal colostomy (after Zuckerkandl).

Enterostomy is the making of an artificial anus. If performed in the large bowel, it is called *colostomy*. In some cases of intestinal obstruction it is necessary to open the small intestine, and if this is required, the artificial anus should be made as near as possible to the cecum. The higher above the cecum it is made, the more apt is the patient to die of lack of nourishment. A small intestinal anus may be made in the middle line or in the right iliac region. The bowel is fixed and opened as directed under Colostomy. In acute intestinal obstruction it may be necessary to open the bowel at once. In such a case Paul's tube (Fig. 886) is very useful. It is made of glass, is bent to a right angle, and has a rim near each end. The large tube is used in the colon, the small tube in the small intestine. A small opening is made in the intestine, the tube is introduced, and is tied in place by a silk suture which surrounds all the coats of the bowel, a gush of feces is caught in a basin, a rubber tube is fastened to the glass tube, and fluid feces are collected in a bottle and beneath an antiseptic fluid.[2] In from three or four days to a week the tube becomes loose and can be removed. Stewart's method of enterostomy was outlined on page 977.

Valvular Cecostomy (Gibson's Operation).—This operation was devised in 1900 by Charles L. Gibson, of New York. It is used in chronic dysentery. It allows us to flush the large intestine and to apply remedies to it. The incision is made over the caput coli, a small puncture is made in the latter, a soft catheter (No. 30 Fr.) is introduced well into the bowel, and is fixed there as is the tube in Kader's gastrostomy (see page 1069). After ten or twelve days the tube is not kept in place, but is introduced

[1] T. Pickering Pick, "Quarterly Med. Jour.," Jan., 1897.
[2] Paul in "Liverpool Med.-Chir. Jour.," July, 1892.

when needed. The fistula closes spontaneously on the discontinuance of introducing the catheter daily. Appendicostomy has, to a certain extent, replaced cecostomy because, as a rule, it is easier and safer. "The appendix may, however, not be of a suitable size or position (it may be retrocecal) to lend itself properly to the procedure" (Gibson, paper read before the Internat. Surg. Assoc. at Brussels, Sept., 1911).

Inguinal Colostomy (Maydl's Operation — Fig. 887).— In this operation a vertical or oblique incision is made over the portion of colon to be incised. In all cases when possible do a left inguinal colostomy. In right inguinal colostomy it is more difficult to deliver the bowel than in a left inguinal colostomy because of shortness or absence of mesocolon at this point of the colon. Right inguinal colostomy has been performed for chronic amebic dysentery. It puts the colon at rest and permits of free irrigation. It is kept open until the dysentery is well. Appendicostomy and valvular cecostomy have replaced it for dysentery. It has also been employed for the treatment of ulceration of the colon. After the incision on the left side the colon usually bulges into the wound, but if it does not, it may easily be found by following with the finger the parietal peritoneum outward, backward, and inward, the first obstruction it encounters being the mesocolon. Draw the colon out of the wound until its mesenteric attachment is level with the abdominal incision. Push a glass bar through a slit in the mesocolon near the bowel, and wrap the ends of the bar with sterile gauze to prevent slipping. Instead of the bar, a piece of gauze can be employed (Fig. 887), or a bridge of skin can be made under the bowel by suturing the



FIG. 888.—Shows the mode of wrapping the ends of the bowel and the dressing lying under the patient ("Keen's Surgery," vol. viii).

two skin edges. In order to make a spur the two parts of the flexure are stitched together by sutures which penetrate to and catch the submucous coat. Stitch the serous coat of the bowel to the parietal peritoneum (Fig. 887). Whenever possible, wait from twenty-four to forty-eight hours before opening the gut. The colon is opened by the cautery or by scissors. If the artificial anus is to be permanent, make a transverse incision through the bowel. Cut one-fourth way across the colon when it is first opened, and entirely across at a later period. If the artificial anus is to be temporary, the incision should be longitudinal. Maydl's operation has great advantages: it is quick, certain, reasonably safe, satisfactorily prevents fecal accumulation below the opening, and is rarely followed by absolute fecal incontinence. In many cases the bowels move but two or three times a day. The movements, however, come quickly, with but little warning. Sometimes there is no warning. If diarrhea develops, there will be fecal incontinence as long as it lasts. No bag of any sort is satisfactory. A bag soon ceases to fit and always becomes foul. A truss, as shown in Figs. 888–891, is very satisfactory. Place layers of cotton over the artificial anus and over them rubber cloth. Fix the binder in place and adjust a truss while standing (see "Keen's Surgery," vol. viii).

Bodine's Operation (Figs. 892, 893).—Bodine's method of colostomy permits of a future restoration of the fecal current by an easily performed anastomosis. This surgeon maintains that the spur after colostomy should reach to and remain at the level of the skin, a condition impossible of attainment by hanging the bowel over a

rod or piece of gauze, because a spur thus formed is not thick and rigid and is inevitably dragged below the skin level, and when this dragging has taken place, some fecal matter will pass into the bowel below the artificial anus. Bodine opens the abdomen, sutures the parietal peritoneum to the skin, seeks for the lesion, and draws it with 6 inches of healthy bowel out of the incision. He lays the limbs of the loop side by side. He inserts a silk stitch, beginning at the point where exsection is to be made, and for 6



FIG. 889.—Abdominal bandage and T-bandage applied ("Keen's Surgery," vol. viii).

inches unites the two segments close to their mesenteric borders. The loop is dropped into the abdomen until the beginning of the suture is on a level with the skin, and at this point it is fastened to the abdominal wound with a continuous catgut suture. The protruding lesion is cut off along the dotted line (Fig. 892). The artificial anus is thus established. When it is desired to close the artificial anus, divide the septum with scissors or a Gant clamp (Fig. 893) and close the abdominal wound.[1]

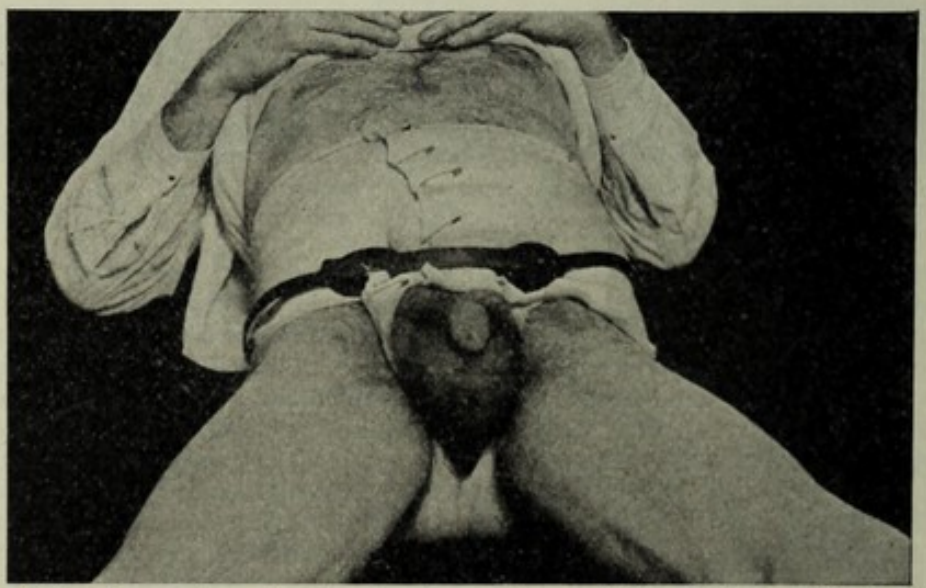


FIG. 890.—Front view, showing dressing and truss ("Keen's Surgery," vol. viii).

Lumbar colostomy is a most unsatisfactory operation. It does not completely intercept the fecal current, and it leaves the patient in a condition of wretched discomfort because fecal incontinence is inevitable. A patient who has had lumbar colostomy performed upon him either obtains little benefit, because the feces pass into the bowel below the opening which was made to intercept them, or else they pour out of the opening uncontrolled, making the poor unfortunate a living horror to himself and others. It is rarely performed at the present day.

[1] "New York Polyclinic," Feb. 15, 1897.

The **healthy gall-bladder** has a capacity of about 1 ounce, and its hue is bluish. If a gall-bladder contains calculi or has contained them, its hue is grayish white or yellowish (Moynihan).



FIG. 891.—Back view, showing truss and dressing. The lower edges of the back flanges are caught in the horizontal slit ("Keen's Surgery," vol. viii).

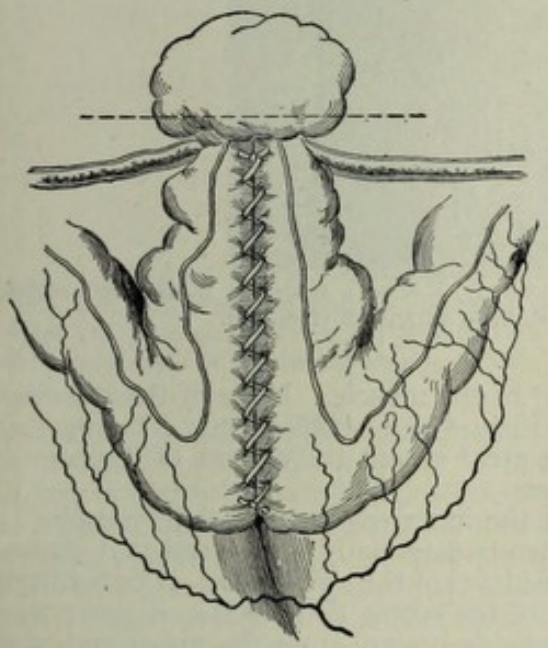


FIG. 892.—Bodine's method of colostomy, showing one side of the loop after it has been sutured, passed back into the cavity and stitched into the abdominal wound. The lesion is left protruding, and the dotted line indicates where the protrusion is to be clipped off.

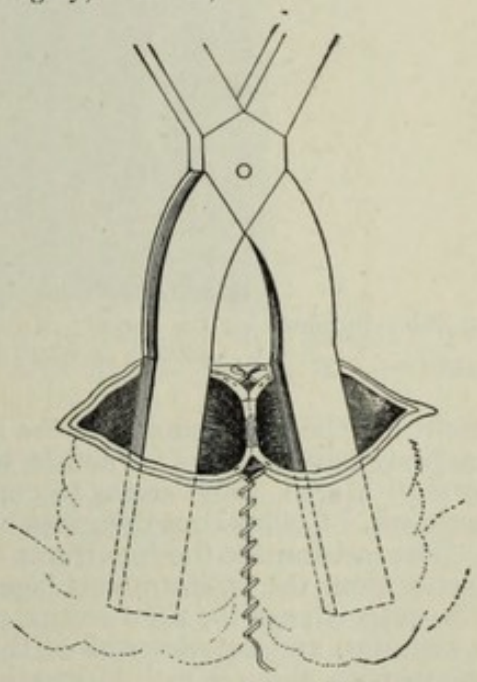


FIG. 893.—Bodine's method of colostomy, showing the septum to be divided in restoring the fecal current; Gant's clamp in position for the division. (In permanent colostomy this septum remains as a rigid and effective spur.)

Congenital Absence of the Gall-bladder.—When the gall-bladder is shrunken and buried in adhesions it is very difficult to find it at operation. Sometimes it is

not found and one may jump to the conclusion that it is congenitally absent. This is occasionally, but very seldom, the case. Gray collected 19 instances of congenital absence of the gall-bladder ("Trans. of Chicago Path. Soc.," 1902). When it has been absent the subject seems to have done perfectly well without it.

The Incisions for Operations Upon the Gall-bladder and Bile-ducts.—I have employed several methods, and have frequently used Bevan's incision (Fig. 894, B). The primary portion of the incision is shaped like the italic letter *f*. It is by the side of or through the right rectus muscle, and is shown by the double line in Fig. 894, B. The primary incision is used for exploration and cholecystostomy. The primary incision is from 3 to 4 inches long, and the extended portions, shown by heavy lines in Fig. 894, B, are added if required (Arthur Dean Bevan, "Annals of Surgery," July, 1899). This incision gives most satisfactory exposure, its edges can be separated without tension, and it injures but few of the nerves of the abdominal walls.

Kocher's incision (Fig. 894, A) gives a very satisfactory exposure. It cuts the two obliques and the transversalis muscle and divides intercostal nerves, but can be sewed up evenly and is seldom followed by hernia. Mayo-Robson's incision (Fig. 894, D) gives an admirable exposure of the common duct, although it damages the right rectus

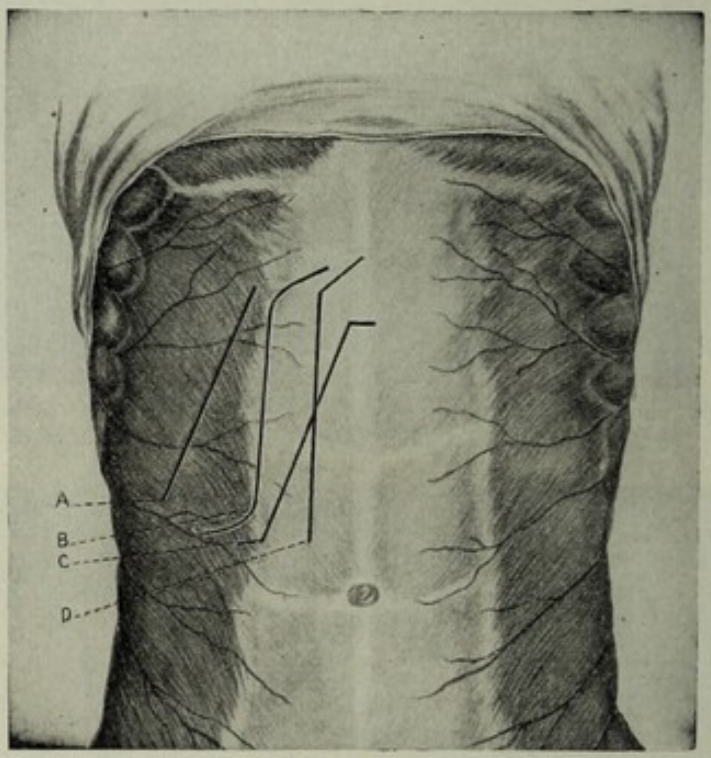


FIG. 894.—Incisions for the surgery of the bile-tracts: A, Kocher's incision; B, Bevan's incision; C, Collins's incision; D, Mayo-Robson's incision (Collins).

muscle and the nerve supply of the inner part of the muscle. None of these incisions is entirely satisfactory. Collins's incision (Figs. 894, C, 895—"Surg., Gynec., and Obstet.," March, 1909) seems to correct to a great extent the defects of the previous operations. Collins thus describes his incision:

"The incision for the bile tracts begins at the inner edge of the right muscle, 1 or 2 inches from the ensiform cartilage, and extends diagonally downward and outward to the outer edge of the right rectus, close to the level of the umbilicus. It cuts through the skin, fat, and anterior wall of the sheath of the rectus (Fig. 895). A short transverse incision about 1 inch in length may be made inward from the upper end of the diagonal incision through the skin, fat, and linea alba; and a similar one through the linea semilunaris at the lower end. In case more room is required the upper transverse incision may be extended further into the anterior and posterior walls of the sheath of the left rectus.

"The rectus muscle is then separated from its sheath. It is easily separated from the posterior portion of its sheath by blunt dissection, but the anterior portion presents some difficulty at the insertion of the lineæ transversæ, one of which is found about midway between the ensiform cartilage and umbilicus and is crossed by this incision.

The attachment of the muscle to the anterior wall of its sheath is very close at this linea transversa, and requires sharp dissection with knife or scissors.

"When the muscle is thoroughly freed from its sheath except at its outer border it is easily retracted outward and allows the posterior wall of its sheath and the peritoneum to be incised in the same direction as the skin and anterior wall. The upper end of this diagonal incision through the posterior wall extends into the short, transverse incision across the linea alba. When this last cut is made the incision pulls open and gives ready access to the right upper abdomen." This incision does not damage the intercostal nerves, hence muscular atrophy is avoided. The openings through the different planes of the abdominal wall are not continuous, hence closure will be more solid. The opening in the posterior portion of the rectus sheath is protected by uninjured muscle.

Cholecystostomy or, as many call it, **cholecystotomy** is the operation of opening a gall-bladder in order to extract gall-stones or secure the removal of infectious

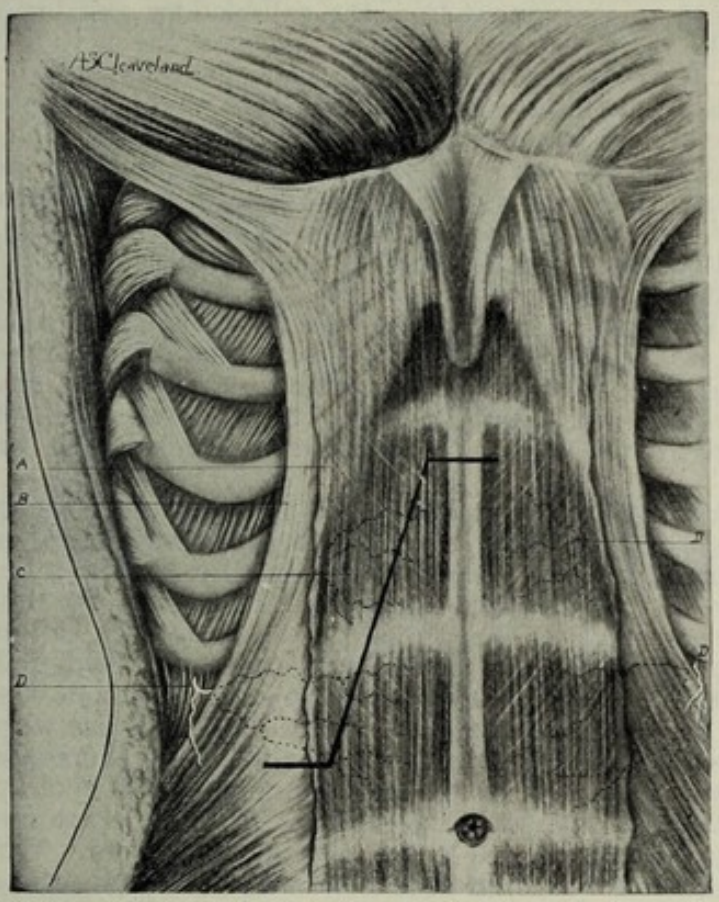


FIG. 895.—A, Anterior wall of sheath of rectus muscle; B, posterior wall of sheath; C, rectus muscle; D, intercostal nerves. The direction of the incision through the skin, fat, and anterior wall of the sheath of the rectus muscle (Collins).

material. The gall-bladder is drained by means of a tube. The first modern operation was performed in 1867 by John S. Bobbs, of Indianapolis. Long before that date gall-stones had been found in pus liberated from the right hypochondriac region and had been extracted from biliary fistulæ, and surgeons had advocated creating adhesions and then opening the gall-bladder—puncture, crushing, and irrigation in the presence of adhesions or without waiting for adhesions (Richter in 1798). Sims suggested the name "cholecystotomy." As the mouth of the fistula remains open for some time in order to secure drainage many prefer the suffix "-ostomy" to "-otomy." In the hands of the Mayos operations for stone exhibit a mortality of less than 1 per cent.; Kocher's mortality was 2 per cent. When death follows an operation on the gall-bladder or ducts, in about one-half the cases it is due to duct infection and is preceded by grave nervous symptoms (Mayo). Cholecystostomy is performed in some cases of acute cholecystitis, hydrops and empyema of the gall-bladder, and in many gall-stone cases. It is the operation of choice in order to obtain drainage in duct obstruction; in cases of obstructive cirrhosis, which arose in the gall-bladder and spread to the ducts; in

very obese or very ill patients, and in cases with kidney disease. In some patients with violent gangrene it may be used, the gall-bladder being packed off with gauze. I am satisfied that some gangrenous cases which would die after cholecystectomy live after the simpler procedure. It is true that cholecystostomy leaves a thickened, adherent, and probably functionless gall-bladder, and that secondary cholecystectomy is sometimes necessary, but in certain cases a secondary cholecystectomy is safer than the primary removal. In a case of gall-stones in which the ducts are free and the disease is limited to the gall-bladder and in which the condition of the patient is good, cholecystectomy is the better operation. Cholecystostomy completed in one stage is performed as follows: The patient is placed recumbent with a sand-pillow beneath the liver and the incision is made. The peritoneum is opened. If the gall-bladder is distended, it is surrounded with pads and aspirated, and is then opened. Gall-stones are removed by forceps, the scoop, or irrigation. The gall-ducts are examined by the fingers external to them before opening the gall-bladder, and are sounded, if possible. If a stone is wedged in the duct, try to manipulate it back into the gall-bladder. If this fails, introduce an instrument from the gall-bladder and break up the stone; if this fails, open the duct, remove the stone, and close the incision in the duct (A. W. Mayo-Robson). The only way to be certain that stones have been removed entirely from the cystic ducts is to insert a finger and dilate. Sounds are unreliable. After the removal of all stones and fragments pass a rubber tube which has no side perforations into the gall-bladder, purse up the cut in the gall-bladder around the tube by means of a catgut suture, and suture the gall-bladder to the abdominal aponeurosis. If sutured to the skin a permanent biliary fistula is apt to follow. It will seldom follow if the gall-bladder is sutured to the aponeurosis. A small piece of gauze is retained under the gall-bladder in case there should be a leak into the peritoneum and in case the peritoneum may have been soiled. If gauze causes no trouble it is retained in place from five to eight days. It can then be removed easily and without breaking encompassing adhesions. The drainage-tube, which drains into a bottle outside of the dressings and below the level of the bed, can usually be dispensed with in from one week to ten days. It should not be dispensed with until the bile becomes sterile.

Sir Spencer Wells suggested immediate suture of the gall-bladder after removing a stone (*cholecystendesis* or *ideal cholecystotomy*). I believe this is never advisable when the stones are active for harm, because small calculi may be in the ducts and minute fragments of stone are often left in the bladder, and the drainage will remove them. Drainage also relieves the diseased condition of the gall-ducts and bladder. In Kocher's 31 operations by this method gall-stones re-formed in 3 cases. Further, the operation with immediate suture is decidedly more dangerous when infection exists. The Mayos only employ it in latent cases of gall-stone disease when the existence of stones is discovered during the performance of an abdominal operation.

Formerly it was advised by some that the operation of cholecystostomy be performed in *two stages*. Thudicum suggested a two-stage operation in 1859. First, the bladder is exposed and sutured to the parietal peritoneum. When adhesion takes place the gall-bladder can be opened without risk of infecting the general peritoneal surface. Riedel advocated operation in two stages, and so did Christian Fenger in certain cases. The two-stage operation is objectionable because it does not permit of satisfactory exploration of the ducts. The *biliary fistula* which is left by cholecystostomy usually closes spontaneously, but may not. If it does not close and the secretion is pure mucus, it is evident that the cystic duct is absolutely blocked and cholecystectomy should be performed.

If the secretion from a persistent fistula is bile and if the common duct is not obstructed, separate the edges of the gall-bladder opening from the parietal peritoneum, endeavoring to avoid entering the abdominal cavity, and close the fistula with Lembert or Halsted sutures. If the secretion is bile and the common duct is obstructed permanently, perform *cholecystenterostomy* or *cholecystgastrostomy*. If the secretion does not contain bile and the cystic duct is blocked, remove the gall-bladder. At the end of 1907 Hans Kehr placed his mortality at 2 per cent. ("Jour. de Chir.," Oct., 1908). In the Mayo Clinic from Jan. 1, 1907 to Jan. 1, 1918 there were 5655 operations for gall-stones, with a mortality of 2.4 per cent. (personal communication to the author).

The McArthur Drip.—In 1909 Lewis L. McArthur suggested using a biliary fistula as a way for the introduction of fluid or food into the duodenum. He proved that if a tube draining bile from the gall-bladder is connected to an irrigator containing salt solution (elevated not more than 20 inches and giving a rate of flow not over 5 or 6

drops a second) there will be a continuous flow of fluid into the duodenum without any discomfort to the patient (McArthur in "New York Med. Jour.," Jan. 27, 1912). Matas has improved the method by introducing into the duodenum at the time of operation and by way of the common duct a ureteral catheter, through which food, fluid, or medicine can be at any time carried into the duodenum (Rudolph Matas in "New Orleans Med. and Surg. Jour.," Oct., 1911). The method is used in many cases of obstructive jaundice (after removal of the obstruction). The salt solution relieves thirst, removes toxins, and stimulates the kidneys. It relieves postoperative vomiting, favors intestinal peristalsis, combats flatulent distention, and causes movements of the bowels. Matas points out that liquid food and medicines (strychnin, castor oil, Hunyadi water, etc.) can be given by the biliary route. McArthur believes that the method can be used instead of jejunostomy in certain cases of pyloric obstruction and stomach ulceration.

Cholecystenterostomy was suggested by Nussbaum. It was first performed by von Winiwarter in 1882. It consists in making an anastomosis between the gall-bladder and intestine, preferably the duodenum, or, if this cannot be done, the jejunum.

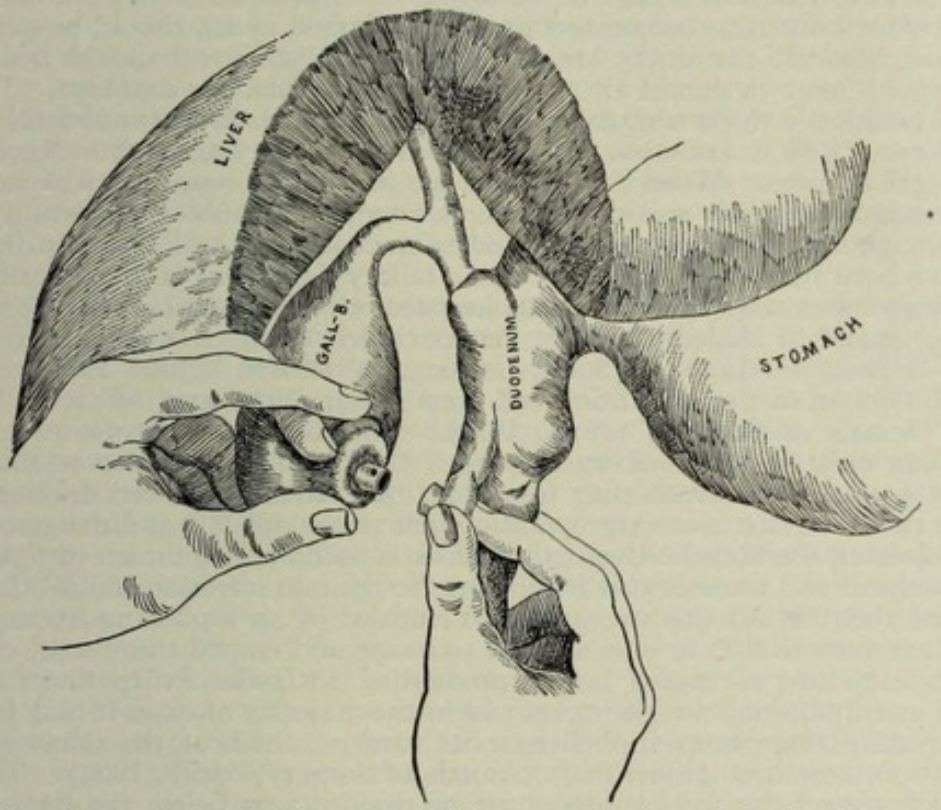


FIG. 896.—Showing method of holding parts while approximating a Murphy button in cholecystenterostomy.

It is employed in cases of irremovable obstruction of the common duct. It is done chiefly in cases of malignant obstruction. It is not a suitable operation for gall-stones impacted in the common duct, because it does not remove the cause of trouble, infection of the bile-passages may follow, and the fistula is liable to contract. In those rare cases of common duct obstruction from gall-stones, in which the gall-bladder is distended and the patient is desperately ill, it may be done (Robson). In such a case Robson attaches the gall-bladder to the colon because the operation is easier and because he considers it as useful as the attachment to the duodenum. Cholecystenterostomy can be done most rapidly and successfully by means of a small Murphy button. Before the gall-bladder is incised it is aspirated. Murphy's operation is shown in Fig. 896, and is similar in performance to intestinal anastomosis. I believe that Brentano is right and that it is best to do posterior cholecystenterostomy, bringing the jejunum through an opening made in the transverse mesocolon.

Cholecystectomy is the extirpation of the gall-bladder. It was first performed by Langenbuch in 1882. The operation is done much more commonly than formerly because we know that in many cases symptoms persist after simple drainage and that an infected gall-bladder is a danger to the gall-ducts, pancreas, and to the organism.

Sometimes primary extirpation is performed; at other times cholecystectomy is performed as a secondary operation, cholecystostomy for drainage having been first performed. Its performance may be demanded by the existence of phlegmonous inflammation or gangrene; ulceration; empyema; hydrops; rupture; bladder fistula; chronic cholecystitis with uninfected ducts; stones in the bladder with uninfected ducts, and in chronic relapsing pancreatitis without jaundice. The operation must not be done if there is obstruction of the common duct. If the duct is obstructed by stone, remove the stone, drain the duct and gall-bladder, and probably do a secondary cholecystectomy. In obstruction of common duct by chronic pancreatitis with jaundice drain the gall-bladder first and later remove that viscus. In obstruction of the common duct by cancer of the pancreas use the gall-bladder to drain into the stomach or intestine (cholecystgastrostomy or cholecystenterostomy). In obstructive cirrhosis biliary drainage is imperative. Later, if the infection originated in the bladder, perform cholecystectomy. When jaundice exists cholecystectomy is contraindicated. Not a few patients upon whom cholecystostomy had been performed develop a great mass of adhesions. In them the bladder becomes practically functionless, remains as a source of infection, and should be removed. If a patient is very ill, obese, or the victim of kidney disease, cholecystectomy, if performed at all, should be secondary to cholecystostomy. If the ducts are involved, cholecystectomy should never be the primary operation. It should always be preceded by bladder drainage. The strawberry gall-bladder is thickened, the mucous membrane is thrown into folds, and contains numerous yellow granules. It is treated by cholecystectomy. Never remove a normal gall-bladder. When there is a stone in the common duct why not remove the stone and the bladder and drain from the duct? Because the mortality is lower if the drainage is by cholecystostomy, and in duct cases it is not certain that all the stones have been removed. Most persisting biliary fistulæ are in persons upon whom duct drainage was associated with cholecystectomy (those who wish for clear-cut notions in regard to cholecystostomy versus cholecystectomy should read the summary by William J. Mayo in "Surg., Gynec., and Obstet.," Jan., 1924; the address of John H. Gibbon in the "Atlantic Med. Jour.," Jan., 1924; and the article by George Crile in "Annals of Surgery," Aug., 1923). Objections to the operation are that drainage can only be obtained by putting a tube into the hepatic or the common duct, that a permanent fistula may form, and that, should renewed drainage be subsequently required, the necessary operation will prove difficult and dangerous.

After opening the abdome then gall-bladder is found and is drawn into the wound. If it is distended and tense or if it is thought "to contain infectious fluid" (Lilienthal), it is packed about with iodoform gauze and emptied by an aspirating trocar. "When the walls are very friable it is even wise to incise and empty the viscus, closing the opening by ligature or clamp before proceeding with the extirpation. The gall-bladder is usually quite a tough organ, and in the majority of cases it may be grasped with an ovarian ring-clamp applied near its fundus, which at the same time closes the aspiration puncture" (Lilienthal, "Annals of Surgery," July, 1904). The peritoneum which covers the gall-bladder must be divided just below the liver, the gall-bladder is dissected from the liver until the cystic duct is reached, the cystic artery is tied and divided, and if the liver ducts are healthy, the cystic duct is ligated with silk and divided, the stump is touched with pure carbolic acid and is covered with a layer of peritoneum fastened by sutures of fine silk. In cases free from infection it is not necessary to drain the bile-ducts. In cases with cholangitis external drainage is necessary by the short stump of the cystic duct or by placing a tube in the common duct. Those who believe in removing the gall-bladder in such a condition, drain. I do not believe in incising the common duct and inserting a drainage-tube up into the hepatic duct. It is better to leave the stump of the cystic duct open. Occasionally after cholecystectomy the stump of the cystic duct gradually dilates and forms a new gall-bladder which may be the seat of pain because of adhesions, blocking, or stone formation. It would seem that the cystic duct should be divided at its origin. Howard Lilienthal (Ibid.) reported 42 cases, with 1 death. Hans Kehr's mortality at the end of 1907 was 3.6 per cent. ("Jour. de Chir.," Oct., 1908). In the Mayo Clinic from Jan. 1, 1907 to Jan. 1, 1918 there were 4064 cholecystectomies, with a mortality of only 1.2 per cent. (personal communication to the author). Dr. Charles H. Mayo, in a personal communication (July 14, 1923), gives the mortality as 1.36 per cent. Surgeons until recent years were rather disposed to do cholecystostomy than cholecystectomy. At present the tendency is to follow William J. Mayo when he says that without obstructive jaundice and cholangitis the value of surface drainage "has been overrated"

and that after cholecystostomy the gall-bladder is a liability rather than an asset. Cholecystectomy should not be done if the ducts are blocked or infected. It has been shown experimentally that after high ligation of the cystic duct a gall-bladder tends to re-form. Surgeons have found stones in such a small and newly created gall-bladder. Hence, gall-stones may form even after cholecystectomy.

Removal of the Mucous Membrane of the Gall-bladder.—Mayo, years ago, suggested the removal of the fundus and of all the mucous membrane of the gall-bladder as an occasional substitute for cholecystectomy. By this operation we are enabled to drain the cystic duct and through it the hepatic ducts. A serious objection to the operation is that, as glands pass from the mucous coat to and through the muscular coat, it is impossible absolutely to move the mucous membrane of the gall-bladder alone (Emil Reis).

Drainage of the Hepatic Duct.—This operation has been employed for certain hepatic infections. It was first performed by Cabot in 1892. If the cystic duct is dilated throughout, it may be carried out through that. After opening the gall-bladder a tube is passed through the cystic and into the hepatic duct. It is often done after opening the common duct, a tube being carried up into the hepatic duct. The hepatic duct may be exposed and opened directly, a tube being carried into it for a short distance and stitched to the edges of the incision in the duct by catgut. The tube should be surrounded by iodoform gauze. It is wiser, if possible, to drain by way of the gall-bladder.

Supraduodenal choledochotomy or **choledochostomy** is the operation of incising the common bile-duct above the duodenum for the removal of a stone. It is also called *choledocholithotomy*. If drainage is used it is *choledochostomy*. It was suggested by Langenbuch in 1884 and was performed by Kümmel during the same year. In 1889 Sir Knowsley Thornton performed the first successful operation. Courvoisier did his first operation in 1890.

Cases upon which this operation is done are often deeply jaundiced and there is grave danger of infection and perhaps of fatal oozing of blood. In one of my cases this happened. The patient was suffering from stones in the common duct, associated with cancer of the head of the pancreas. In every case in which operation is contemplated for obstruction of the bile-ducts take the coagulation time of the blood. Normal coagulation time (taken by Wright's coagulometer) is from three to six minutes. Prolongation to seven or eight minutes calls for preoperative treatment to hasten coagulability. If jaundice exists, it is customary to endeavor to prevent hemorrhage by employing Robson's plan: Give by the mouth from 30 to 60 gr. of chlorid of calcium three times a day during the twenty-four or forty-eight hours preceding operation, and 60 gr. by enema three times a day for the forty-eight hours following operation. I have followed this course in a number of cases, but am not convinced of its value. Instead of this method we may follow the plan of giving thyroid extract (5 gr. three times a day) for several days preceding operation.

The plan I now pursue I am certain does reduce the coagulation time distinctly. I give an injection of horse-serum the day before operation and another the morning of the operation. In a jaundice case due to infection perform cholecystostomy as a preliminary and later do choledochostomy. If jaundice is due to stone in the common duct, remove the stone and add duct drainage to the preliminary gall-bladder drainage.

When ready to operate, a sand-bag should be placed under the lower ribs. This will bring the liver at least 2 inches nearer to the abdominal wound. The abdominal incision must be longer than that employed for cholecystostomy. The pylorus and stomach are drawn to the left, the colon and omentum are drawn downward, and the liver and ribs are lifted strongly upward. Gauze packs are inserted.

"The operator should now, after having separated adhesions, have a good view of the common duct within the free border of the lesser omentum, and on inserting his left index-finger into the foramen of Winslow, or on grasping the duct between the index-finger and thumb, he can, without difficulty, bring the duct well within reach, the concretion making a distinct projection."[1] A longitudinal incision is made, the stone is removed, and a probe is introduced into the duct to determine whether other stones are present.

Stones in the second and third portions of the duct are often missed and the second portion of the duodenum should always be palpated with the utmost care. If the supposed lowermost stone removed from the common duct is faceted, we should always search most carefully to find a concretion which is lower still (F. Gregory Connell, "Annals of Surgery," April, 1908).

[1] A. W. Mayo-Robson's "Treatise on Diseases of Gall-bladder and Bile-ducts."

If a calculus is found in the lower part of the common duct, the surgeon tries to push it up so that he may reach it. This can usually be accomplished. Failing to push the stone up into reach, some try and force it into the duodenum—a bad procedure. It will seldom succeed and may jam a stone in the duodenal outlet. If it does not succeed, the surgeon must perform a transduodenal or a retroduodenal operation.

I have entirely abandoned suturing the duct, hence the operation is a *choledochostomy* (although this term is used by some only when the incised duct is stitched to the abdominal wall). The surgeon carries a tube down to the opening and surrounds it with iodoform gauze, or inserts a rubber drainage-tube into the opening and carries it up toward the hepatic duct, or makes an incision into the right loin after the plan of Rutherford Morison, and carries a tube into the right kidney pouch, which is the most dependent part of the peritoneal cavity when the patient is recumbent. Personally I always drain the duct, when I have opened it for stone, carrying the tube up toward the hepatic duct. I also drain the gall-bladder. It is unwise to remove the gall-bladder at this time. If infected, and probably it will be found to be, remove it later. With associated gall-bladder drainage, duct drainage is less dangerous and less apt to be followed by biliary fistula. The same reasons which cause us to drain the gall-bladder after removing stones should influence us in this case.

Robson ("Lancet," April 22, 1902) has performed the operation of choledochotomy 60 times. In 10 cases of stone in the common duct he manipulated the stone back into the gall-bladder and removed it through an incision in that viscus by means of a scoop. The above maneuver is impossible unless the cystic duct be dilated. In 30 cases he crushed the stones between his finger and thumb, but this is only possible when the stones are soft, and it has the objection that it may leave fragments. If a stone is lodged in the common duct and cannot be manipulated back into the gall-bladder, choledochostomy should be performed. Robson's mortality in 60 cases of choledochostomy was 16.6 per cent. Since 1900 his mortality has been 7.1 per cent. Before that it was 23.8 per cent. Kehr's mortality is 4.1 per cent. During 1912 the Mayos performed choledochotomy 96 times, with 5 deaths ("Report of St. Mary's Hospital for 1912").

Hepaticotomy.—By this term we mean the opening of the hepatic duct. If the opening be drained the procedure is, in reality, *hepaticostomy*, although this term is seldom used to designate it. Hepaticotomy is performed for stone in the hepatic duct. The operation was first performed by Kocher in 1889. There were 7 cases on record in 1903 (Delagenière in "Bull. et Mém. de Chir. de Paris," No. 10, 1903).

Duodenocholedochotomy (McBurney's Operation; the Transduodenal Route).—This operation is seldom necessary. In the more than 2000 operations performed by the Mayos on the gall-bladder and ducts, it was only required in 4 cases. I have never performed it. In 1891 McBurney proposed the method for the removal of gall-stones impacted near the papilla ("Annals of Surgery," Oct., 1898). McBurney's original suggestion was to open the duodenum, dilate or incise the papilla, remove the stone, and suture the duodenum. The duodenum must be mobilized so that it may be lifted into the wound. If the stone be located in the diverticulum of Vater, it may, in some few cases, be removed by simply stretching the opening of the duct with forceps (Collins's method). If this be not possible, the opening in the papilla may be enlarged by cutting, or the duodenal mucous membrane over the stone may be incised. When the stone is not impacted at the outlet, but is lodged a little higher up, and when dense adhesions render access by the ordinary supraduodenal route difficult or impossible, the anterior wall of the duodenum may be opened longitudinally, the posterior wall of the duodenum and the common duct incised over the stone, the stone removed, the duodenum and common duct sutured together (Kocher's method, or *internal choledochoduodenostomy*), and the anterior wall of the duodenum closed. (See Charles Otto Thienhaus in "Annals of Surgery," Dec., 1902.) After finding and removing a stone by the transduodenal route we must make a careful search to see that no stones are left before closing the duodenal incision. Robson opposes the transduodenal route and says he has abandoned it because of the danger of sepsis. Thienhaus (Ibid.) opposes this view of Robson and shows that in 29 operations by the transduodenal route there were but 2 deaths.

Connell ("Annals of Surgery," Jan., 1908) has collected 77 cases in which stones were removed by the transduodenal route. There were 10 deaths. In 2 of these cases duodenal fistula preceded death. In common duct cases with jaundice drainage of the gall-bladder should be secured by cholecystostomy. This procedure makes McBurney's operation safer.

Retroduodenal Choledochotomy.—In this operation the second portion of the common duct is incised back of the duodenum without opening the gut. That this may be done the duodenum must first be drawn toward the midline of the body, and this can be done only by "mobilizing" the duodenum, incising the posterior layer of the parietal peritoneum 1 inch to the right of the descending portion of the duodenum. After freeing the gut and retroperitoneal structures the duodenum becomes sufficiently free to lift toward the left with a rotation. We thus expose the posterior aspect of the duodenum, the head of the pancreas, and the common duct.

The duct is opened, the stone removed, the duct sutured, and a drain inserted.

This operation has been successfully performed by a number of surgeons, but there is a great objection to it. In nearly all cases the common bile-duct passes *through* the pancreas rather than back of it. Büngner found this to be the case in 55 out of 58 dissections ("Gray's Anatomy," Seventeenth American edition, p. 1352). Hence, incision of the common duct in this situation means in nearly all cases incision of the pancreas and all the grave dangers of leaking of pancreatic fluid. The transduodenal operation is a much better procedure.

Total Splenectomy.—This operation is performed for wounds and rupture of the spleen, tumors, cysts, floating spleen, pernicious anemia, hemorrhagic purpura, splenic anemia, and non-leukemic splenic hypertrophy. Twisting of the pedicle of an ectopic or wandering spleen calls imperatively for operation. It should not be performed for hypertrophy in leukemia. Splenectomy does not interfere with the development of a young child. An extraordinary thing after splenectomy is how rapidly the normal proportion of red blood-corpuscles is restored (Sir J. Bland-Sutton in "Proc. Royal Soc. of Med.," 1914).

Vedova (quoted in "Practical Medicine Series," 1913, vol. ii) collected 134 cases of splenectomy for traumatic rupture of the spleen. There were 40 deaths. He adds these to Berger's 60 cases, with 25 deaths. This makes a total of 194 cases, with 65 deaths (33.5 per cent.).

In view of the bone-marrow changes in splenomyelogenous leukemia, we cannot hope to cure a patient by removing the spleen. In a leukemic patient the operation has a very high mortality from shock and hemorrhage. George Ben Johnston ("Annals of Surgery," Jan., 1908) has collected 49 splenectomies in leukemia with only 6 operative recoveries (a mortality of 87.7 per cent.). One of the 6 cases lived eight months, 1 lived four years, and it is claimed that 1 was cured. Sir J. Bland-Sutton states that the removal of a leukemic spleen can do nothing but harm ("Proc. Royal Soc. of Med.," 1914).

Splenectomy has been performed for malarial hypertrophy (ague-cake). The operation has been advocated on the theory that by removing the spleen we get rid of the lurking place of the malarial parasites, but they also lurk in the bone-marrow and in the capillaries of the liver. The operation should not be performed for malarial spleen unless the organ is movable, unless it greatly interferes with the patient's comfort or occupation, or unless we fear rupture, and then, if it is done, it is for the movability, the discomfort, or the danger of rupture, and not for the malaria. It is to be noted that the operation does not cure the malaria. Johnston ("Annals of Surgery," Jan., 1908) collected 58 splenectomies performed for malarial hypertrophy since 1900. There were 50 recoveries and 8 deaths. To these he adds 3 successful ones of his own, making 61 cases, with 8 deaths (a mortality of 13.1 per cent.).

A number of operations have been done for splenic anemia or its terminal stage, which is known as Banti's disease. Those who believe that the splenic enlargement and anemia result from some underlying condition common to both do not operate. The theory of the operation is that removal of the spleen stops the production of some toxic material which causes anemia and cirrhosis of the liver, in other words, that the splenic disease causes the anemia. There seems ample evidence that splenectomy, if done early, may save the patient. Cushing's case was alive and well eight years after the operation. I had a case alive and well three years after operation, at which time he died of cerebrospinal meningitis. Splenectomy may cure hemolytic jaundice (Peck in "Jour. Amer. Med. Assoc.," Sept. 9, 1916). Banti reported the first cure in 1911. The operation should be done in Hanot's cirrhosis and in hypertrophic cirrhosis of the liver. Primary pernicious anemia is probably due to a toxin which is intensified by splenic action. Hence, splenectomy may be done. It produces, at the least, great temporary improvement.

Johnston (Ibid.) has collected 61 splenectomies for splenic anemia of Banti's disease. There were 49 recoveries and 12 deaths, a mortality of 19.5 per cent. I have

performed splenectomy three times for Banti's disease, with 2 recoveries and 1 death.

Johnston (Ibid.) notes 12 splenectomies for sarcoma of the spleen, with 9 recoveries. One lived eight and a half years and died of heart disease; 3 are known to have died from recurrent sarcoma.

It is stated that there are on record 4 splenectomies for cancer. Moynihan doubts the diagnostic accuracy of the three earlier reports. Mary A. Smith records a case of colloid cancer occurring in a woman who had been operated on ten years before for ovarian cyst associated with pseudomyxoma of the peritoneum. The pathologist reported that the growth in the spleen was a metastasis of colloid carcinoma. This patient died seven months after the splenectomy from peritoneal and omental cancer ("Annals of Surgery," Jan., 1908).

In Johnston's table of 708 splenectomies for various causes (Loc. cit.) the mortality is 27.4 per cent. In the cases operated upon from 1900 to 1907 inclusive the mortality is 18.5 per cent. In anemias transfusion before splenectomy may prove of great service. In a series of 249 cases of splenectomy in the Mayo Clinic the mortality was 10 per cent.

In order to remove the spleen most operators make an incision from the antero-superior spine of the ilium to the ribs. I prefer to make an incision below the left costal margin like Kocher's incision on the right side to reach the gall-bladder. This incision can be extended to any necessary degree, and posterior drainage of the pancreas region can emerge from its outer end. Open the peritoneum and divide adhesions between ligatures. If the spleen be adherent to the pancreas, it may be necessary to remove a fragment of the last-named organ. It is a very undesirable thing to have to do, and I lost a case from pancreatic leakage after having done it. Ligate the suspensory ligament and divide it. Bring the spleen well out of the wound. Surround it with gauze pads. Transfix the pedicle with stout silk. Tie it firmly, leaving the ends of the ligature long for a time, and cut through the pedicle beyond the ligature. Ligate the vessels separately with catgut. Cut off the long ends of the silk ligature and drop the pedicle back, unless apprehensive of bleeding, when it may be fastened to the surface. The wound is closed without drainage, unless the pancreas has been injured, in which case posterior drainage is employed. Traction upon and ligation of the vessels in the pedicle may cause profound shock by injuring the splenic plexus, which is in close relation to the solar plexus (Jordan in "Lancet," Jan. 22, 1899).

If splenectomy is found to present great difficulties the splenic artery may be tied and the spleen left in place (Lanz). John C. Gerster ("Jour. Amer. Med. Assoc.," Aug. 7, 1915) suggests tying the splenic artery and the gastro-epiploica sinistra where it reaches the stomach wall, before removing the spleen. Then after splenectomy the hemorrhage will be venous only. For the "Technic of Splenectomy" as practised in the Mayo Clinic, see Donald C. Balfour in "Surgery, Gynecology, and Obstetrics," July, 1916.

Changes After Splenectomy.—About two weeks after the removal of a normal spleen certain definite changes happen in adults, but not in children. These changes last for several weeks, and are manifested by enlargement of the lymph-glands, pain in and tenderness of bones, blood changes, loss of weight, weakness, thirst, polyuria, abdominal pain, elevation of temperature, and rapid pulse.[1] Tizzoni says that these changes are not obvious in children, because in them compensatory organs act at once, whereas in adults compensatory organs act slowly and with painful effort. Such symptoms are noticed when the spleen is removed because of a wound or a rupture, but rarely after removal of a diseased spleen. It is likely that compensating organs become active when the spleen is diseased, and consequently are in full operation when such a spleen is removed. After partial splenectomy these changes are not noted (Jordan). Changes can be prevented after splenectomy by the administration of tablets of extract of spleen and red bone-marrow (Ballance), and iron (especially in foods) is of value.

The blood changes after splenectomy consist of diminution in hemoglobin and red blood-cells. The coloring-matter and cells do not become normal for two or three months.

Splenopexy.—This is the operation of anchoring a movable spleen. It should only be used when the spleen is not enlarged and is not diseased. Rydygier in 1895 published the first case, although both Tuffier and Kouwer operated before this date.

[1] Ballance in "Practitioner," April, 1898; W. Martyn Jordan in "Lancet," Jan. 22, 1898.

Sutures should not be passed through the spleen: the structure is so soft that stitches are bound to loosen and the insertion will cause bleeding. A promising method is to create adhesions by the use of iodoform gauze, as is done for movable kidney, and as was done by Kouwer. Some advocate making a pocket outside of the peritoneum and bringing the spleen into this pocket, making it extraperitoneal.

Hernia.—(Dr. Hubley R. Owen, Professor of Clinical Surgery in the Woman's Medical College, Surgeon to the Philadelphia Hospital, and Chief Surgeon of the Departments of Fire and Police in Philadelphia, did me the favor to revise this section.[1]) The term "hernia" is probably derived from a Greek word meaning an off-shoot.

A hernia is a protrusion of a viscus through an abnormal opening in the walls of the cavity within which it is naturally contained (Ashhurst).

MacCormac says the term implies that the protruded viscus is covered with integument; hence a protrusion of viscera through a wound does not constitute a hernia.

The term may apply to the hernia of a muscle through its sheath or a hernia of the brain, *i. e.*, hernia cerebri.

The term "hernia" when unqualified has come to be synonymous with *rupture*, and is applied only to protrusions of abdominal viscera. If this protrusion occurs through a normal opening it is not called a hernia, but a prolapse; as a prolapse of the rectum through the anus, or of the uterus through the vagina (Ashhurst).

The term "rupture" used commonly by the laity is misleading, since it rests upon a false conception of the etiology. The term originated at a time when it was generally believed that traumatism, or a tearing of the muscular structures by some direct or indirect violence, was a frequent and important cause (Coley).

It is realized now that hernia is a disease, not an accident. It is usually due to a congenital defect, *i. e.*, an open funicular process of peritoneum, or an abnormal size of some normal opening in the abdominal wall. The congenital defect is the main cause of a hernia, while the immediate or exciting cause plays but a minor rôle (Coley).

Structures Composing a Hernia.—A typical hernia has three parts—the sac, the contents of the sac, and the coverings of the sac.

The *sac* is formed of peritoneum. A typical sac comprises a neck, a mouth, and a fundus or body. The neck of the sac is due to the constriction through which the sac passes. It is that part which communicates with the peritoneum (Ashhurst). The body or fundus of the sac surrounds the protruding viscus. The mouth is the opening into the sac.

The sac is composed of peritoneum, but may be wholly or in part deficient, *i. e.*, hernia of the cecum or sigmoid (sliding hernia), or hernia of the bladder. In diaphragmatic hernia no sac is present. The sac may be congenital or may be acquired.

These terms have caused much confusion, and even now the question is not satisfactorily settled. Some writers have held that congenital hernias are those in which the sacs are preformed, while the acquired are those which develop after birth. Coley says that "this would be an excellent rule were it possible to apply it practically," but, as he points out, the only way to definitely tell that a sac is preformed of (prenatal origin) is by the fact that it communicates with the tunica vaginalis testis. It has, therefore, been a rule with most writers to class as congenital hernias only such as showed this connection. "This test, however, rules out not only a very large number of cases in the male, in which by reason of the appearance of a hernia in earliest infancy the presence of a preformed sac is practically proved, but it also rules out all cases of inguinal hernia in the female."

In the vast majority of oblique inguinal hernias in the male, and in practically all in the female, the sac existed at birth, even though the hernia may not have developed until adult life.

Some writers have recently classified all inguinal and femoral hernias, with the exception of certain direct inguinal hernias, as congenital.

Sacs of direct hernias as well as sacs of femoral hernias have been found in cadavers when there was no history or evidence of hernia during life (R. Hamilton Russell, "Lancet," May 12, 1902; "Brit. Jour. Surg.," 1921–22, p. 502).

In the congenital type of hernia the sac is a preformed pouch or diverticulum of peritoneum, at first empty. Increased abdominal pressure caused by chronic coughing

[1] It would be impossible to write an article on hernia without going to the admirable work on "Hernia" by Dr. Leigh H. Watson. We have used his great book freely.

or straining finally forces some abdominal viscus into the sac. The large majority of hernias are of this type, *i. e.*, inguinal indirect and many of the femoral, and sometimes the umbilical.

It was formerly stated that femoral hernia was never congenital, but Russell (Loc. cit.) and Coley (Loc. cit.) both say that a femoral hernia may have a congenital sac. In 100 necropsies Murray found 20 potential femoral sacs (sacs into which a viscus had not entered).

In the acquired hernias, the best examples of which are some forms of direct hernias, epigastric and ventral hernias, the parietal peritoneum is forced by intra-abdominal pressure through some congenital defect in the abdominal wall. In the epigastric region it is the result of a congenital slit in the transversalis fascia.

Size and Shape of Sac.—The sac is at first small, fusiform, and thin. As the hernia increases in size the sac becomes larger, thickened, and opaque. The sac may stretch irregularly and become sacculated. The sac soon becomes adherent to the surrounding structures. The irritation of a truss greatly increases these adhesions. Inflammation may result from an injury or from constant pressure, as from a badly fitting truss. Hemorrhage into the sac may result from violence.

Relations of the Sac to Other Structures.—In the oblique inguinal hernia the spermatic cord is always posterior to the sac, and both of these structures are surrounded by thin, infundibuliform fascia. In direct hernia the sac enters the lower part of the inguinal canal below and internal to the deep epigastric artery. Some writers call direct hernias "ventro-inguinal hernias." In direct inguinal hernia the cord is separate from the sac or attached to it loosely, while in oblique inguinal hernia the cord is usually very adherent to the sac the entire length of the inguinal canal. In oblique inguinal hernia in the female the round ligament is commonly found in front of the sac and adherent to it (Watson, "Hernia").

A ventral hernia following abdominal operation may be without a sac.

The body or fundus varies in size and shape. It is the part of the sac lying below the neck. The mouth is that portion of the sac which connects the interior of the sac and the abdomen.

The *contents of the sac* depend chiefly on the situation. Any abdominal viscus, even the pancreas, may enter a hernial sac (pancreas in umbilical hernia). The viscera having the greatest range of movement constitute the most common contents of the sac and, in order of their frequency, are; omentum, ilium, jejunum, sigmoid, cecum, ascending colon, descending colon, appendix, bladder, ovary, Fallopian tube, stomach, etc.

The first foot of ileum above the ileocecal valve is the portion of small intestine most frequently found in the sac.

An *enterocele* contains intestine only; the small intestine is much more frequently involved than the large. If omentum alone is found in a hernial sac the condition is known as an *epiplocele*. An *entero-epiplocele* contains both omentum and intestine. A *cystocele* contains a portion of the bladder. In *sliding hernia* (*hernie par glissement*) a portion of the large intestine, usually the sigmoid, or cecum, enters the hernia by slipping with the peritoneum. The sac is present in front, but absent posteriorly. The appendix is occasionally found in a hernial sac on the right side. This type of hernia is unusually painful and pressure may cause pain referred to the umbilicus. The ovary and Fallopian tube are occasionally found in the sac. They are more frequently found in a child than in an adult and may give rise to an irreducible swelling, pressure on which causes sickening pain (Rose and Carless, "Manual of Surgery," p. 1200).

Foreign Bodies in Sac Contents.—Foreign bodies are occasionally found in a hernial sac. Such foreign bodies have included pins, needles, tacks, nails, shot, pieces of glass, fish bones, etc. Such bodies must have worked their way through the wall of the intestine into the sac.

Diseases of Hernial Sac.—When the hernial contents are diseased the sac may be involved. This is especially true in cases of tuberculous and malignant growths. The sac of an old hernia occasionally becomes tuberculous. Renault believes that tuberculosis of a hernia is manifested by increase in size, pain on pressure, and loss of body weight. Adrenal rests may be found in the sac wall.

Diseases of Hernial Contents.—The hernial contents may be affected by tuberculosis, mesenteric and intestinal cysts, benign and malignant growths. A person living in a tropical country may develop an echinococcus cyst in a hernial sac. Carcinoma of the hernial contents is rare.

Causes of Hernia.—The causes of hernia are predisposing and exciting.

Predisposing Causes.—Heredity plays but a small rôle in the cause of hernia.

Age.—Hernia occurs at all periods of life.

Sex.—The male sex is nine times more liable to inguinal hernia than the female sex, while femoral hernia occurs three times more often in females than in males. The relative frequency of the varieties is as follows:

	Males.	Females.
Inguinal hernia	96.33	50.60
Umbilical hernia	1.14	15.90
Femoral hernia	2.53	33.50
	100.00	100.00

According to Macready (quoted by Watson, a treatise on "Hernia") the following is the frequency in 100 cases:

Female, inguinal	8.5
Male, inguinal	83.5
Female, femoral	5.9
Male, femoral	2.1

Bilateral hernia occurs in 4.6 per cent. of males and in 3.1 per cent. of females who have hernia. The tendency to double inguinal hernia and double femoral hernia is greater in males than in females.

Obesity is an important etiologic factor in hernia. Fat is not only deposited in the subcutaneous tissues but also in the omentum, mesentery, and subperitoneal tissues. The deposit of fat within the abdomen lessens the capacity of that cavity, increases intra-abdominal pressure, and subperitoneal fat protrudes from any weak spot in the abdominal wall. The protruding mass of fat adheres to and makes traction upon the peritoneum, and this membrane is drawn upon to form a sac surrounded by fat. Extra weight and the strain of intra-abdominal fat causes a general relaxation and atony of the abdominal muscles. This muscular relaxation may also occur from ill health, the removal of a large tumor, tapping for ascites, and wounds or abscesses of the abdominal wall.

Increase in size or weight of abdominal viscera may produce a hernia, for instance, an enlarged liver or spleen or new growths which increase the intra-abdominal pressure.

Pregnancy increases intra-abdominal pressure, causes atrophy of the muscles, and is often followed by increasing obesity, thus producing hernia.

Length of Mesentery.—It was formerly thought that a long mesentery was a predisposing factor, but, with our present knowledge of congenital sacs, this idea has been abandoned (Watson, Ibid.). At the present time it is generally accepted that the chief cause of inguinal and femoral hernia is a preformed or congenital sac.

Other Predisposing Causes.—A hernia may appear gradually or suddenly. Berger and Coley state that 70 per cent. of hernias in adult males appear gradually. The sac of an acquired hernia exists for a longer or shorter time before the hernia enters it. The sac of a congenital hernia is present at birth. The sac of an acquired hernia forms gradually. The sac may exist, but remain empty for years. When either bowel or omentum enters it from some strain or effort the sac has long been prepared to receive the extruded mass. This extrusion may occur immediately or may occur gradually. If it occurs suddenly the patient believes that his hernia was formed then and there, but, as a matter of fact, the extrusion and entrance into the sac of bowel or omentum were but the last of a long series of antecedent and preparatory changes. Finally a hernia appears, and often does so, during effort.

Exciting Causes.—Increased abdominal pressure: This is commonly assigned as the exciting cause of hernia. Such increased abdominal pressure may result from repeated muscular effort coincident with constant coughing, as in whooping-cough, bronchitis, tuberculosis, emphysema, and asthma; straining at stool, especially resulting from chronic constipation; lifting; and straining during micturition because of calculus, cystitis, phimosis, enlarged prostate, or stricture. Hernia is frequently due to chronic strain. Occupations requiring the constant lifting of heavy weights are a causative factor in the etiology of hernia. Certain occupations in which the workman bends forward, such as tailors, weavers, and bootmakers, favor the production of hernia (J. Hutchinson, "Hernia and its Radical Cure," p. 4).

External violence, such as a blow or squeeze of the abdomen, or a fall from a height, may cause hernia into a preformed sac.

Traumatic Hernia.—This plays an important part in our medicolegal work because of the many claims made upon employers for alleged hernia coincident with various occupations.

True traumatic hernias may be divided into two main groups:

1. A hernia caused by direct trauma to the inguinal canal, such as a fall upon a pointed object which tears the tissues of the inguinal region.

2. Self-produced hernias by those wishing to escape military service. Such a hernia is usually made by stretching the external inguinal ring and enlarging the inguinal canal by digital dilatation or by means of a pointed stick.

Watson states that violent sneezing, induced by inhaling snuff, has produced a well-developed hernia.

The "hernia of weakness," spoken of by the French writers, is due to a deficiency or malformation of the muscles or fascia of the abdominal wall in the hernial region. This deficiency is the result of faulty development or disease. In the inguinal region these hernias are always of the direct variety.

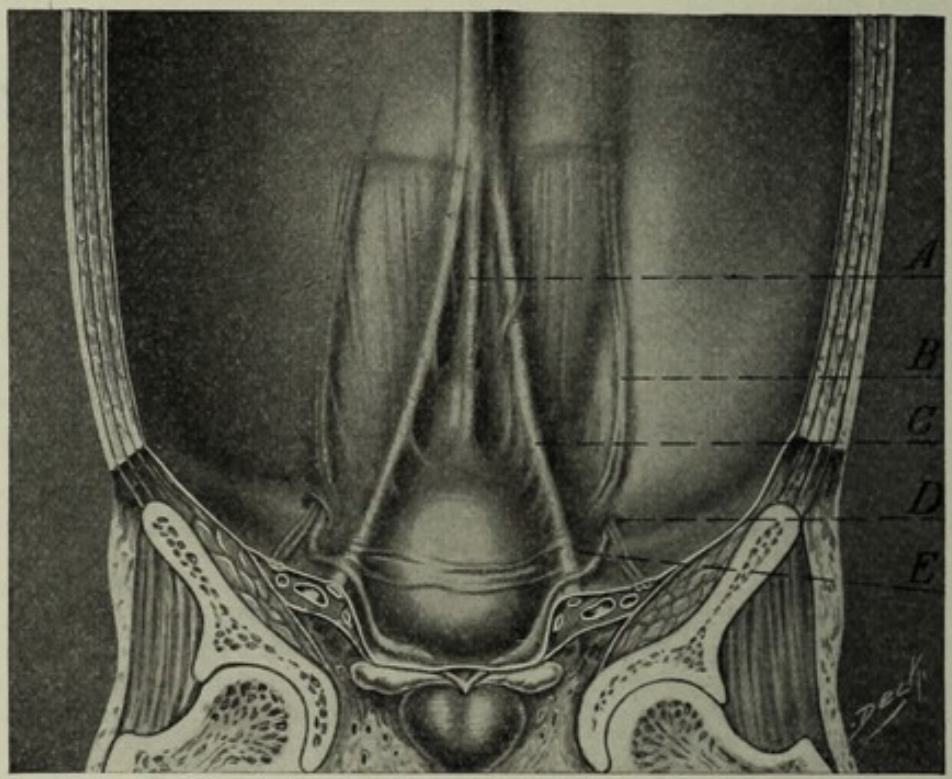


FIG. 897.—Anterior abdominal wall, viewed from behind, showing the peritoneal fossæ: *A*, Obliterated urachus; *B*, fold of deep epigastric artery; *C*, obliterated hypogastric arteries; *D*, fossa at the internal abdominal ring; *E*, fossa behind the external abdominal ring. (Campbell, adapted from Sobotta.)

The "hernia of effort" is the occupational hernia, and is due to a sudden or gradual increase in intra-abdominal tension caused by a fall from a height, a misstep, hard manual labor, or a sudden strain. As a result of such effort there is a descent of abdominal viscera, usually omentum, intestine, or both, into a *preformed* sac.

It is generally agreed that by far the most important cause of all varieties of hernia is the presence of a congenital sac or peritoneal diverticulum at the hernial orifice or in the canal. Nearly all industrial hernias are inguinal. Consequently they overshadow in importance all other varieties.

The usual predisposing causes of inguinal hernia—anatomic weakness and congenital or preformed sac—combined with the common exciting cause, such as a sudden or prolonged strain, are the etiologic factors that lend themselves admirably to legal controversy (Watson, "Hernia," p. 602).

A true traumatic hernia, which arises immediately from a violent force, is in at least a temporary state of irreducibility, and is accompanied by violent pain, collapse, nausea, vomiting, and inability to walk or stand.

For discussion see "Prog. Med.," June, 1923, p. 56.

Anatomy and Varieties of Inguinal Hernia.—Inguinal hernias are divided into *direct* and *indirect* varieties, depending on their relation to the deep epigastric artery. The indirect hernia, known also as the external hernia or oblique hernia, leaves the abdomen through the internal ring, passes down obliquely through the inguinal canal, external to the deep epigastric artery. The direct hernia or internal hernia emerges between the deep epigastric artery and the edge of the rectus muscle. It is known as direct hernia because it passes directly through the abdominal wall internal to the deep epigastric artery.

The inguinal canal is about 1½ inches long in the male and 2 inches long in the female. The greater length in the female is due to the wider separations of the iliac bones. The descent of the testis begins at about the sixth month. The canal in the male contains the ilio-inguinal nerve, the genital branch of the genitocrural nerve, and the spermatic cord, while in the female it contains the round ligament, the ilio-inguinal nerve, and the genital branch of the genitocrural nerve.

The internal abdominal ring is about ¾ inch above the middle of Poupart's ligament. The external abdominal ring is located just above and external to the crest of the pubis. The hypogastric branch of the iliohypogastric nerve pierces the internal oblique muscle on a level with the anterosuperior spine of the ilium and runs downward and inward about ½ inch above and internal to the inguinal canal, and finally pierces the aponeurosis of the external oblique just above the external ring. The ilio-inguinal nerve pierces the internal oblique below and 1 inch to the inner side of the anterosuperior spine of the ilium, and runs downward and inward over the cremaster muscle just above Poupart's ligament, and emerges at the external ring.

The genital branch of the genitocrural nerve accompanies the cord or the round ligament and supplies branches to the cremaster muscle. If this nerve is tied in a suture it will cause pain along the cord, while if the iliohypogastric or the ilio-inguinal nerve is included in the suture, there will be persistent pain in the inguinal region. The deep epigastric artery runs upward from a point midway between the anterosuperior spine of the ilium and the symphysis pubis and inward toward the umbilicus.

During the seventh and eighth months of fetal life the testis is drawn down into the inguinal canal and through it, and reaches its position in the scrotum shortly before birth. For a time free intra-abdominal communication is maintained by the now tubular processus vaginalis. Usually, however, by the time of birth or shortly thereafter this canal is obliterated, the isolated, lower end of the peritoneal process persisting as the pouch of the tunica vaginalis which almost surrounds the testis (Watson, "Hernia").

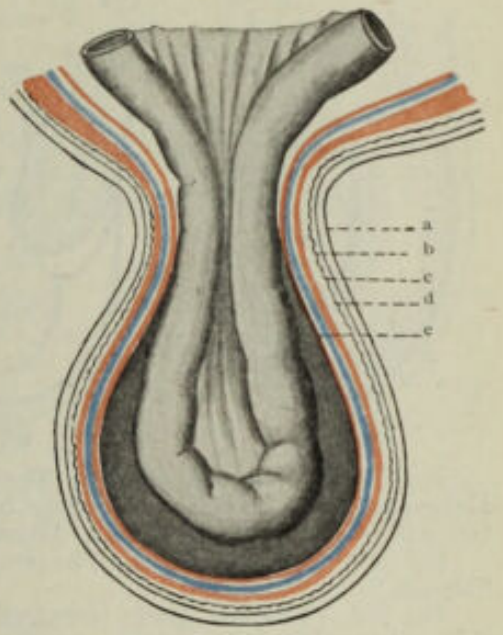


FIG. 898.—A diagrammatic representation of the coverings of a hernia: *a*, The skin; *b*, the superficial fascia; *c*, the muscular layer—*e. g.*, the cremaster muscle in an inguinal hernia; *d*, the transversalis fascia; *c*, *d*, have also been called the fascia propria herniæ; *e*, the peritoneum—*i. e.*, the sac of the hernia (Sultan).

The processus vaginalis, which is the entire process of peritoneum accompanying the testis and cord, is divided into two portions—the funicular portion, which invests the cord, and the tunica vaginalis, which surrounds the testis. The funicular process tends to become obliterated after birth. In women the patency of the canal of Nuck may be a causative factor of congenital hernia.

Russell ("Lancet," London, 1899, 2d vol., p. 1353) stated that all inguinal hernias in adults and children were congenital in origin, due to a persistent patent funicular process.

The processus vaginalis should become obliterated at two points: at the internal abdominal ring and at a point just above the epididymis. Between these two points the walls of the vaginal process should become fused and become a small fibrous cord. If the vaginal process does not become obliterated, a congenital hernial sac results.

The testis and spermatic cord, in their descent, carry with them parts of the abdominal wall. From without inward the coverings of a congenital inguinal hernia

are skin, superficial fascia, intercolumnar fascia from the aponeurosis of the external oblique, fibers of the cremaster muscle, infundibuliform fascia, subserous tissue, and peritoneum (Fig. 898).

Varieties of Inguinal Oblique Hernia.—An oblique hernia may be complete or incomplete. In incomplete oblique inguinal hernia (bubonocele) the sac remains in the inguinal canal. In complete oblique inguinal hernia the sac emerges from the inguinal canal at the external ring and in the scrotal form the hernia passes down into the scrotum or labium (scrotal or labial hernia).

The oblique inguinal hernias are also classified into congenital, infantile, and funicular varieties, according to the patency of the vaginal process (Figs. 899–902).

Moschcowitz ("Surg., Gyn., and Obst.," Dec., 1922, p. 711) has urged us to eliminate another subdivision—*i. e.*, encysted—stating that there is no anatomic difference between the infantile and the encysted. Moschcowitz also urges a new nomenclature for the varieties of hernia. The congenital variety is a misnomer, in that it pre-empts the word "congenital" in this one particular subvariety of a congenital hernia, whereas there are a number of other hernias which are also congenital inasmuch as they depend on an antenatal formation. Moschcowitz suggests the name of "hernia into the vaginal process" for this variety of hernia, because in the congenital inguinal hernia the vaginal

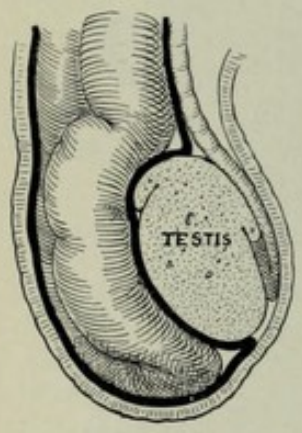


Fig. 899.

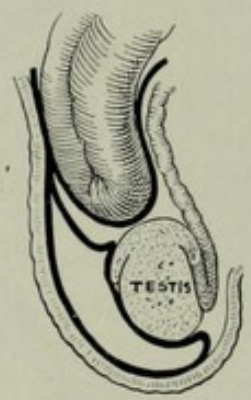


Fig. 900.

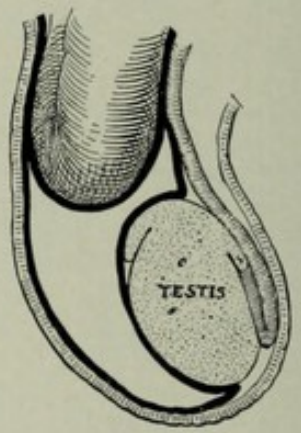


Fig. 901.

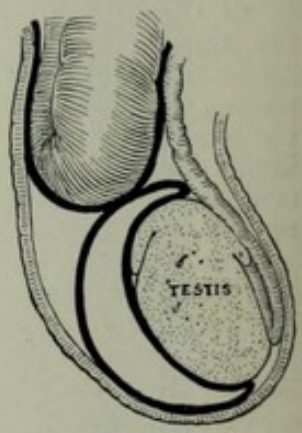


Fig. 902.

Fig. 899.—Congenital hernia. The vaginal process is entirely open and continuous with the abdominal cavity. The sac envelops both the hernial contents, and the testes which lie in contact with each other. (Watson's "Hernia.")

Fig. 900.—Infantile hernia. The processus vaginalis is closed only at the upper end. (Watson's "Hernia.")

Fig. 901.—Infantile hernia (encysted type). This condition is usually caused by the invagination of a hernial sac into the sac of a hydrocele. (Watson's "Hernia.")

Fig. 902.—Funicular hernia. The processus vaginalis is closed only at its lower end. The hernial contents are separated from the testis by the obliterated portion of the processus vaginalis, the normal tunica vaginalis. (Watson's "Hernia.")

process is open and continues with the abdominal cavity, and the hernial sac envelops both the hernial contents and the testis. Congenital hernia is rarely present at birth, but is first observed in infancy; as a rule following a strain which forces the intestine down into the sac (Watson, Figs. 903, 904).

Infantile and encysted hernia are identical. In this variety of hernia the vaginal process is closed only at the internal ring. The sac may descend back of the vaginal tunica, or there may be an invagination of the hernial sac into the sac of a hydrocele.

Funicular Hernia.—In this variety of hernia the vaginal process closes only at its lower end above the epididymis, while the funicular process is continuous with the peritoneal cavity, and is open from the deep abdominal ring to the epididymis. The hernial contents are separated from the testis by the septum at the point of obliteration (Watson).

Moschcowitz (Ibid.) believes that this term also is a misnomer, and this variety should be termed "hernia into the supratunical vaginal process."

The Canal of Nuck.—The peritoneal diverticulum in the canal in woman corresponding to the vaginal process in man is called the canal of Nuck. This should be normally obliterated about the seventh month of intra-uterine life. This process remains patent in about 20 per cent. of women, and is a cause of oblique inguinal hernia in females.

Direct or Internal Inguinal Hernia (*Hesselbach's Hernia*).—In direct hernia the

contents pass out through Hesselbach's triangle, internal to the deep epigastric artery. Because this hernia passes internal to the deep epigastric artery it is occasionally called internal hernia. The contents pass through only the lower fifth of the inguinal canal and pass down outside the conjoined tendon, or force the conjoined tendon before them, or split through the tendon. They seldom enter the scrotum. Direct hernias are never congenital, as they have no pre-existing path (Watson). The coverings of this hernia when it passes external to the conjoined tendon are the same as those of an indirect hernia, except that the transversalis fascia instead of the infundibuliform

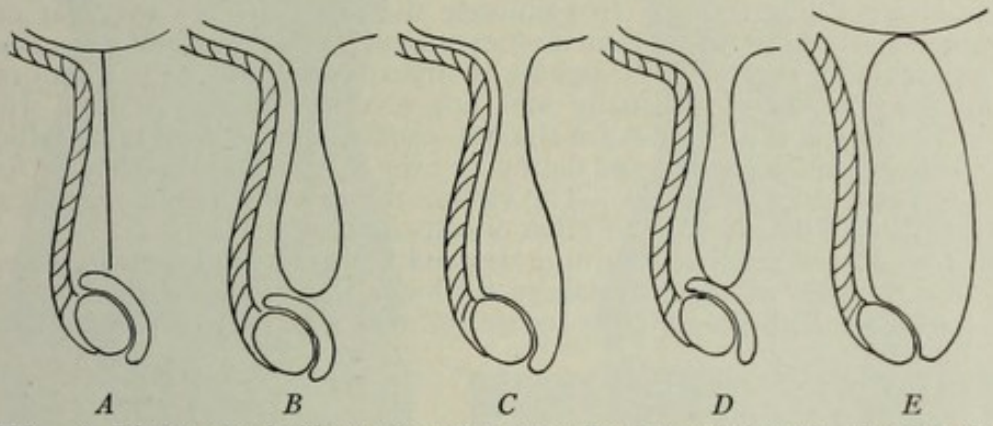


FIG. 903.—*A*, Diagrammatic illustration of a normally descended testis, showing the shut-off peritoneum, normal tunica vaginalis and cord remaining after the obliteration of the processus vaginalis. *B*, An ordinary scrotal hernia. *C*, Congenital hernia. *D*, Hernia into the funicular process. *E*, The condition as it exists prior to the formation of an encysted hernia. (A. V. Moschcowitz.)

process of the transversalis fascia is one of the coverings. When a direct hernia pushes before it the conjoined tendon its coverings are skin, superficial fascia, intercolumnar fascia, conjoined tendon, transversalis fascia, subserous tissue, and peritoneum.

A direct hernia usually develops slowly, and occurs most frequently in adults. The spermatic cord does not accompany the direct hernia, but lies on the outer side of the sac.

Finochietto ("Surg., Gyn., and Obst.," 1916, vol. 22, p. 544) divides direct hernias into three varieties—the saccular, lipomatous, and visceral. He terms the saccular

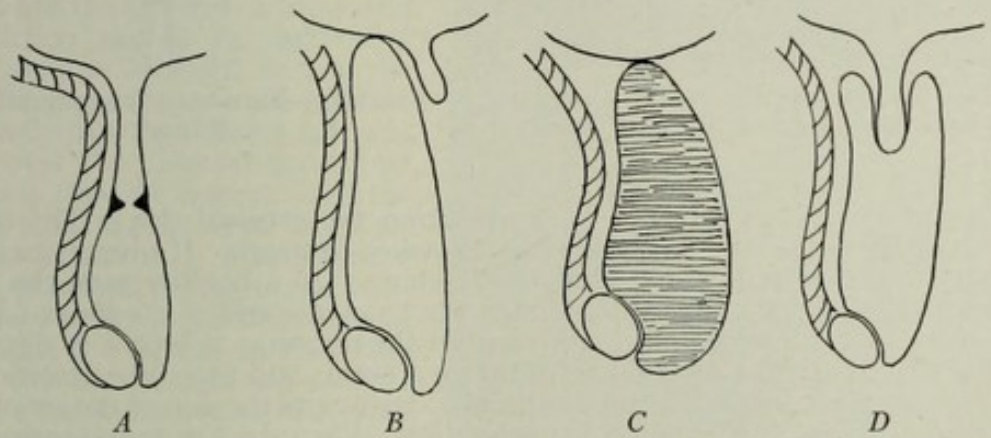


FIG. 904.—*A*, Processus vaginalis with congenital ring formation. *B*, Hernia in front of an encysted hydrocele. *C*, Encysted hydrocele. *D*, Encysted hernia. (A. V. Moschcowitz.)

type one in which the hernia is hemispheric in shape and the transversalis fascia and paraperitoneum are found at the base of an empty peritoneal sac. The lipomatous type is usually a small hernia with a thin layer of peritoneum covered by a very thick layer of fat, and the visceral type is one in which a viscus, usually the bladder, is found in the sac.

Watson states that in some instances the hernia begins as a lipoma, and as it increases in size the fat disappears and finally viscera enter the sac.

The direct inguinal hernia is less common in women than in men, because the

external ring in a woman is smaller and the aponeurosis of the external oblique covering the internal canal is stronger.

Reducible Hernia.—In this form of hernia the contents of the sac can be reduced into the abdominal cavity. At a known hernial opening the patient has a smooth enlargement (narrower above than below), which began to grow above and extended downward. A distinct neck can often be felt. In enterocele, straining, lifting, or standing enlarges the mass; the protrusion becomes smaller and may disappear on lying down; cough causes impulse (succussion), the protrusion is elastic, and may be tympanitic on percussion, and on reduction the mass suddenly disappears and there is a gurgling sound. In epiplocele the mass is often irregular and compressible, and feels boggy rather than elastic; muscular effort does not have much influence in enlarging it; impulse on coughing is slight; percussion gives a dull note, and reduction is accomplished gradually and produces no gurgling sound. In entero-epiplocele some parts of the mass are smooth, elastic, and perhaps tympanitic; others are dull on percussion, irregular, and flabby, but the diagnosis of this especial form from the other forms is often uncertain. The victims of reducible hernia complain of some pain on exertion, of dyspepsia, and often of constipation.

When a hernia is beginning to form or descend there is often *premonitory uneasiness;* the patient complains of muscular pain in the lower abdomen, and this condition may exist for weeks or months before it is recognized that a hernia is present. An inguinal



FIG. 905—Tuberculous abscess of os pubis, giving some signs of an inguinal hernia ("Keen's Surgery").

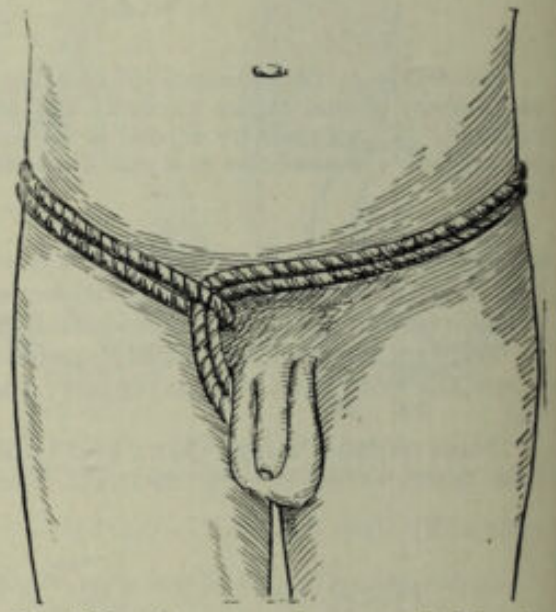


FIG. 906.—Yarn-truss for congenital hernia (Mumford).

hernia can be recognized before it protrudes from the external ring. The tip of the finger is inserted in the ring and the patient is asked to cough. If a hernia has entered the canal, succussion will be detected on coughing. In a healthy man the external ring should admit the tip of the little finger, but not the end of the index-finger. If the end of the index-finger can be made to enter the ring that aperture is dilated, and even if there is no hernia in the canal, in future a hernia will probably descend. In a man, if the surgeon desires to examine the ring, he inverts the skin of the scrotum over the finger and carries the finger to or in the ring. When the hernia suddenly appears there will often be pain, faintness, and some sick stomach, but often there is no pain or any discomfort.

A reducible hernia must be diagnosed from a hydrocele, adenitis, and psoas abscess.

A hydrocele is translucent, there is usually no impulse on coughing, there is a dull note on percussion, and the lump is not reducible.

Adenitis in the inguinal and femoral regions may somewhat simulate the swelling of a hernia. The adenitis, of course, cannot be reduced into the abdominal cavity; there may be isolated glands to assist in the diagnosis; there is no impulse on coughing; the percussion note is dull.

Psoas abscess, pointing either in the inguinal or femoral region, may be mistaken for hernia. A psoas abscess pointing in the femoral region is not uncommon. The

abscess contents may be reducible and may have an impulse on coughing, but the abscess will fluctuate. Percussion note over the abscess is dull. *x*-Ray study of the spine will show tuberculous disease.

Treatment of Reducible Hernia.—*Palliative Treatment.*—Prevent constipation and forbid sudden strains and violent exercise. If operation is refused or inadvisable,

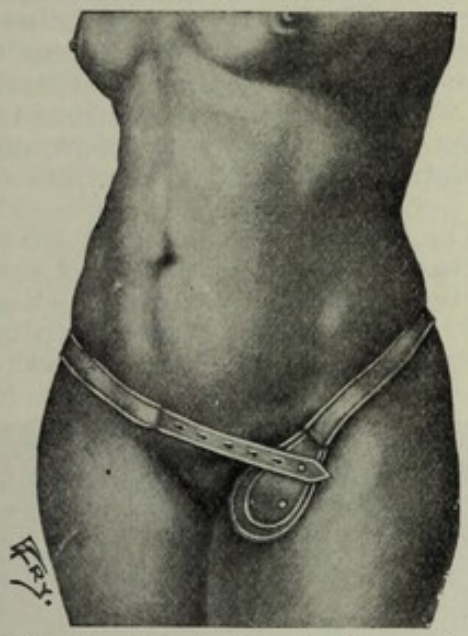


FIG. 907.—The French truss for femoral hernia ("Keen's Surgery").

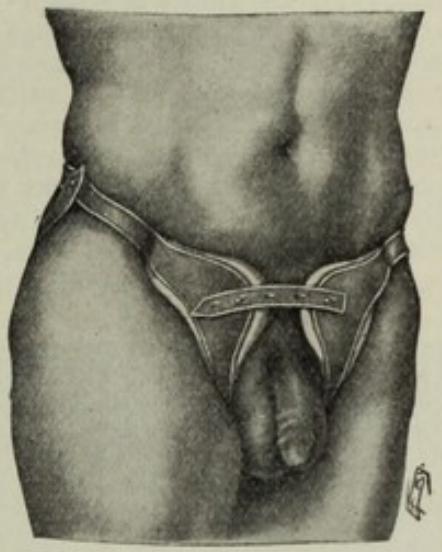


FIG. 908.—The rat-tailed truss for very large hernia ("Keen's Surgery").

order a truss. The continued employment of a truss in young persons may effect a cure. The day truss should be applied before rising in the morning and be removed after lying down at night, when a light truss should be substituted. A special truss is applied before bathing. In very fat people there is always trouble in adjusting a truss. A femoral hernia is more difficult to keep reduced than an inguinal hernia. In a hernia in which the gut is replaceable, but a portion of omentum is irreducible, it is difficult to maintain reduction of the gut with a truss, and an operation should be performed. In an oblique inguinal hernia the pad of the truss fits over the internal abdominal ring; in a direct inguinal hernia, over the external abdominal ring; in a femoral hernia, over the femoral ring at the level of Gimbernat's ligament. MacCormac's method of measuring for a truss is as follows: In either inguinal or femoral hernia start the tape from the *lower part* of the hernial opening, carry it up to the anterior superior iliac spine of the same side, then take it around the body, 1 inch below the crest of the ilium, to the other anterior superior iliac spine, and then to the upper part of the hernial opening. A well-fitting truss will keep the hernia up even when the patient sits in a position to relax the abdominal walls and coughs and strains. A truss is always uncomfortable at first, but a person usually becomes accustomed to it. It should be kept scrupulously clean, and borated talc powder should be dusted upon the skin under the pad at least once a day. A truss which does not keep the hernia up or which causes pain does harm.

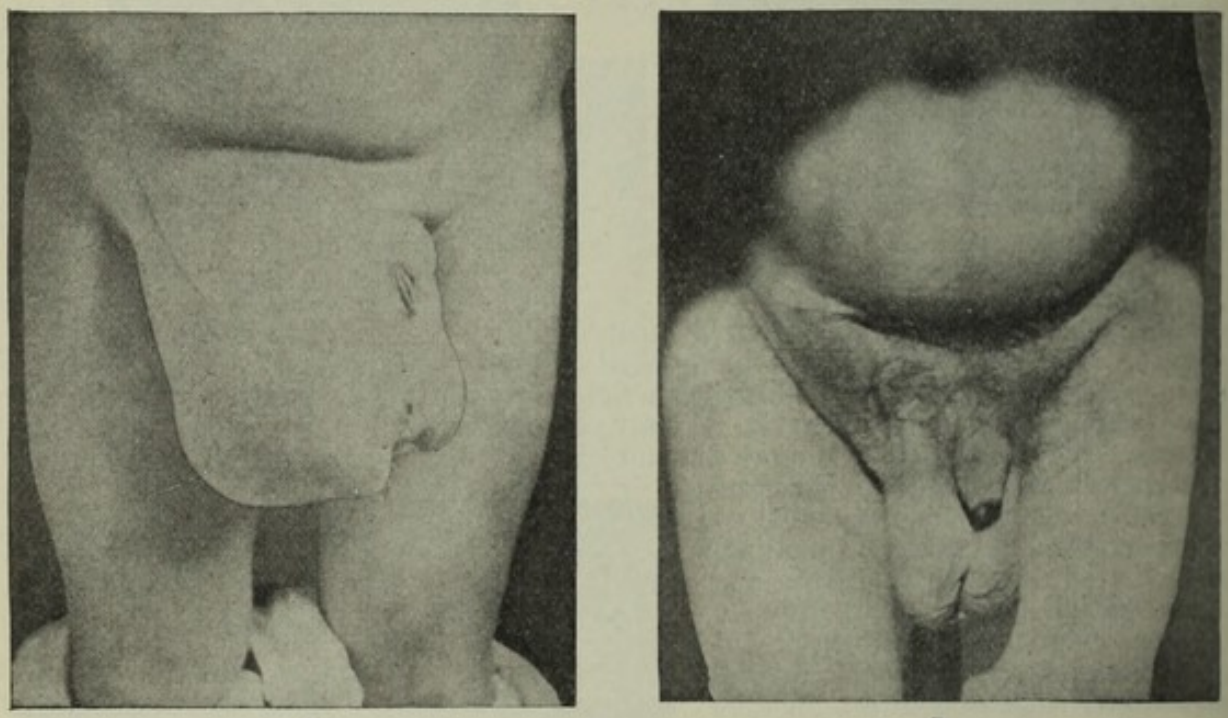


FIG. 909.—Special truss for very large inguinal hernia ("Keen's Surgery").

Too strong a spring or too small a pad may enlarge the hernial orifice and thus aggravate the case. Even after an apparent cure with a truss this device must be worn for a long time.

Children under four years of age should be treated palliatively. Surgeons differ as to the maximum age for operation for reducible hernia. Some surgeons do not operate for hernia on patients of fifty years of age or over; that is, unless the hernia is strangulated, irreducible, or cannot be properly held with a truss, or unless the occupation is such that the wearing of a truss is impracticable. Other surgeons have practically no age limit, providing the patient is in proper condition for operation. Each case must be decided upon its own merits. There can be no fixed rule as to age for operation. It should be remembered, however, that the percentage of recurrence increases with age, and that practically 50 per cent. of all recurrences are those operated upon after forty years of age.

Operative Treatment of Reducible Hernia.—The operative treatment of reducible and non-strangulated hernia seeks to obtain a cure by closing the mouth of the sac and by obliterating the canal through which the hernia has descended. Radical operation should be performed upon strangulated hernia, in ordinary cases of reducible hernia, particularly if a truss is very painful or does not hold the hernia satisfactorily



A *B*

FIG. 910.—*A*, Oblique inguinal hernia of large size (duration sixteen years); *B*, the same case six months after operation.

reduced, in most cases of irreducible hernia, and in any case of hernia in which there are occasional attacks of obstruction. It was formerly believed that an operation for hernia would fail if the subject was under three years of age, but Coley and others have proved that it is a very successful operation in childhood. It is rarely recommended under the age of four because in 75 per cent. of these cases a truss will cure. Operation is strongly advised in children under the age of four when a truss has failed to cure, when there is irreducible omentum, when the hernia is associated with a hydrocele, or with an undescended testicle. Radical operation is almost without danger in properly selected cases. With proper technic it is one of the most successful of surgical procedures. We are justified in advising the operation on any individual under fifty years of age who is free from complications solely to relieve him or her from the annoyance of wearing a truss. If, however, a patient is sixty years of age or over and a truss holds the hernia satisfactorily the operation should not be advised unless demanded by some complication, such as strangulation, etc. Organic disease of the heart, lungs, and kidneys, diabetes, syphilis, and especially conditions such as asthma or chronic bronchitis, causing persistent cough, contraindicates operation at any age except for strangulation, etc.

Mechanical Treatment.—When the operative procedure is contraindicated, a properly fitting truss should be ordered. The surgeon should always examine the truss immediately after its purchase to see whether it fits the patient properly. The patient should be instructed to apply the truss while in the recumbent posture. The patient is then examined in the standing posture, in the sitting posture, and in the squatting posture, and while the patient coughs in each one of these postures the surgeon determines whether or not the truss satisfactorily retains the hernia.

Operative Treatment of Inguinal Hernia.—Any case of inguinal hernia in which operation is contraindicated should wear a truss. The wearing of a properly adjusted truss and operative procedure are the only accepted methods of treatment today. Before the advent of the modern operations inguinal hernia was treated by injections into the inguinal canal. Lannelongue used a 10 per cent. solution of chlorid of zinc. Other substances used were iodin, alcohol, an infusion of oak bark, and paraffin. Among serious accidents following injection of paraffin were injection into the peritoneal cavity, wounding of the intestine with resulting peritonitis, injection of paraffin into the femoral artery or vein causing gangrene of the extremity (Thompson, "Penna. Med. Jour.," 1913, vol. 16, p. 375).

There are many operations for the radical cure of inguinal hernia. We are firmly convinced that no one operation can be used in all cases of hernia, but that an operation must be selected suitable for each individual hernia, because of the fact that each hernia presents a different anatomic condition regarding the musculature, condition of the sac, size of the hernia, presence or absence of varicose veins, presence or absence of hydrocele, etc. A brief outline of the classical operations and those employed today will be given; also the reference of the original article.

Skin Incision.—A straight incision is made nearly parallel with Poupart's ligament, and ½ inch above it, extending from the internal ring to the lower part of the center of the external ring (Fig. 915). It is well to keep the incision above the line of pubic hair when possible. Ferguson used a semilunar skin incision ("Jour. Amer. Med. Assoc.," July 1, 1899). His incision begins over Poupart's ligament, 1½ inches below the anterosuperior spine, and is carried inward and downward in a semilunar curve, and terminates over the conjoined tendon, near the pubic bone (Fig. 911).

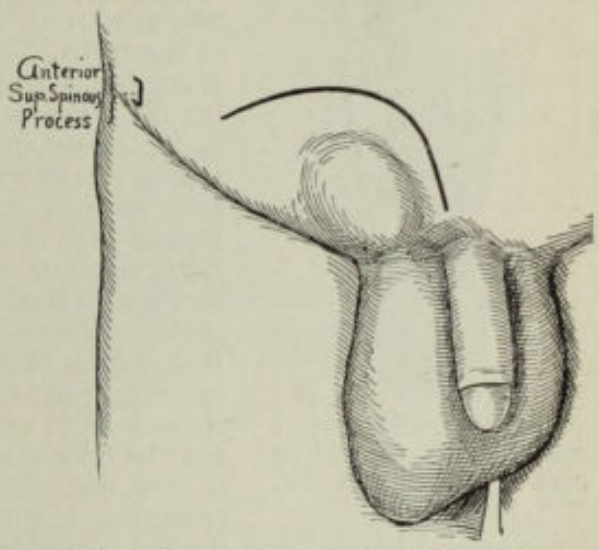


FIG. 911.—Ferguson's operation: The semilunar skin incision ("Jour. Amer. Med. Assoc.").

The superficial epigastric and superficial circumflex iliac veins are usually divided between hemostats and tied. Some operators tie the superficial vessels at once. Others prefer to let hemostats remain until the operation is completed. They can then be removed without further bleeding providing the wound is neither roughly wiped with gauze nor the terminal clots loosened. The edges of the wound should be protected preferably by gauze soaked in hot salt solution and held in place by Moynihan clamps.

After freely exposing the aponeurosis of the external oblique the external ring is located and a retractor is placed in the lower end of the wound. The aponeurosis of the external oblique is incised in direction of its fibers from a point over the internal ring to the external ring. Some surgeons cut directly through the pillars of the external ring, while others prefer to continue the incision of the external oblique from over the internal ring on a line above the pillars of the external ring. The old practice of cutting the aponeurosis on a grooved director inserted upward through the external ring is condemned because of the danger of cutting the ilio-inguinal nerve. The inguinal branch of the ilio-inguinal nerve, the hypogastric branch of the iliohypogastric nerve, and the genital branch of the genitocrural nerve must be preserved.

The ilio-inguinal and the iliohypogastric nerves supply motor fibers to the external and internal oblique, transversalis, and rectus muscles. The genital branch of the genitocrural nerve supplies the cremaster muscle. Inclusion of the latter in the ligature may cause persistent neuralgic pain in the cord and testis for some months after

the operation. If the nerve is cut the cremaster muscle will atrophy and the testis will hang low in the scrotum and may cause a dragging pain, requiring the wearing of a suspensory.

The edges of the aponeurosis of the external oblique are retracted on the inner side until the rectus muscle and fascia are viewed, and on the outer side until the shelving margin of Poupart's ligament is well exposed. The internal oblique muscle is never cut. The sac is now located. Contents of the inguinal canal are elevated and the vas deferens is recognized in order to prevent injury.

In oblique inguinal hernia the sac is usually found to the inner side and in front of the cord. The sac can usually be recognized by its white, glistening appearance. The fundus of the sac may be grasped with forceps and separated from the cord. This dissection should be made by cutting with a scalpel or by the use of Mayo scissors. Rough handling of the tissues by stripping with gauze may so lessen the vitality of the tissues that infection will be inevitable. The sac is freed to a point where it begins to widen out and blend with the parietal peritoneum. The sac is then carefully opened to prevent injury to the contents, as intestine or omentum. All adhesions to the sac are freed, and the contents of the sac reduced to the abdominal cavity. Adherent omentum is ligated, cut, and returned to the abdominal cavity. Great care should be taken to avoid slipping of the ligatures on omentum. Plain catgut is used.

In congenital hernia the sac communicates with the tunica vaginalis testis and cannot be completely removed. The sac may be cut off $\frac{1}{8}$ to 1 inch from the testis all around (Fig. 912). Watson does not recommend an attempt to strip the tunica vaginalis from the testis because of the danger of necrosis of the testis. The upper portion of the sac in the congenital hernia should be largely removed; the lower part, surrounding the testis, is left *in situ*.

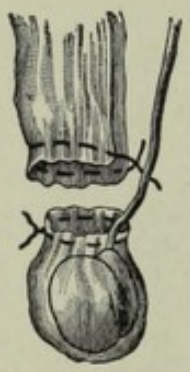


FIG. 912.—Macewen's operation for the radical cure of congenital hernia.

If the sac is small it can be ligated with a ligature, but if the sac is large a purse-string suture is safer because of possible slipping of the ligature from the sac. If the sac is ligated high it will be drawn back into the internal ring by the elasticity of the peritoneum. We usually follow the method of Barker by invaginating the sac high in the ring, underneath the transversalis and internal oblique muscles. If the neck of the sac is wide it may be necessary to make a transverse incision and close it by interrupted or continuous sutures as in closing any peritoneal wound. Occasionally it may be necessary in large scrotal herniæ to leave a portion of the sac. Dehelly ("Internat. Clinics," Phila., 1919) recommends when it is inadvisable to remove the sac in a large scrotal hernia, that the sac should be divided below the ligature, split parallel to the cord, everted and wrapped around the cord, and held in position by interrupted sutures as in operating for hydrocele.

Some surgeons do not remove the sac, but most surgeons depend upon ligation and excision of the structure.

Following ligation of the sac comes the important step of reconstruction of the inguinal canal.

Suture Material.—We prefer No. 2 chromic catgut for all deep sutures. Kangaroo-tendon was advocated by Marcy in 1870 ("Transactions 7th Internat. Med. Congress," 1881, vol. 2, p. 446). Number 2 plain catgut is used by some surgeons. Silver wire has been employed in large hernias. Masson, of Rochester (Mayo Clinic), advocates the use of No. 2 chromic catgut. Coley advocates the use of No. 1 chromic catgut for children. Coley ("Prog. Med.," June, 1923, p. 23) further advocates the use of chromic kangaroo-tendon as being preferable to any other absorbable suture. He calls attention to the fact, however, that it is very important not to use too large kangaroo-tendon, which may require too long a period for absorption, and, therefore, would have the same disadvantage as a non-absorbable suture. Silkworm-gut has been used for deep sutures, but is unsatisfactory, as a sinus may develop. Linen and silk sutures are apt to be followed by the same complication.

Repeated sinus formation is one of the causes of recurrence of hernia.

When the deep sutures are ready to be applied the thigh should be slightly flexed on the abdomen, as advocated by Newman ("Ind. Med. Gazette," Calcutta, 1914, vol. 49, p. 303) and by Lyle ("Surg., Gyn., and Obst.," Chicago, 1920, vol. 31, p. 529).

By flexing the thigh on the abdomen the distance between Poupart's ligament and the conjoined tendon can be reduced from 20 to 70 per cent.

Bassini's Operation for Oblique Inguinal Hernia.—(See E. Wyllys Andrews in "Med. Record," Oct. 28, 1899, who describes from personal observation how Bassini does his operation. We have drawn upon his description in the following section.) Bassini's operation displaces the spermatic cord from the old canal and places it in a new canal, and this new canal is oblique. Curved and rounded needles are employed to insert the stitches. The suture material is kangaroo-tendon or chromicized catgut. Silk or silver wire is apt to make trouble—perhaps long after the operation. The patient is placed supine with the thighs extended. An incision is made parallel to Poupart's ligament and extending from the external ring to a point external to the internal ring. The incision is about 1½ inches above the ligament and is from 5 to 7 inches in length. By this incision the aponeurosis of the external oblique and the pillars of the external ring are exposed. All bleeding is arrested, the aponeurosis is incised in the direction of its fibers and from above downward, and the inguinal canal is opened. The aponeurosis of the external oblique is dissected up with a blunt instrument until the inner surface of Poupart's ligament is exposed. We speak of this part of the ligament as the shelf. A mass containing the sac of the hernia, the cord, the

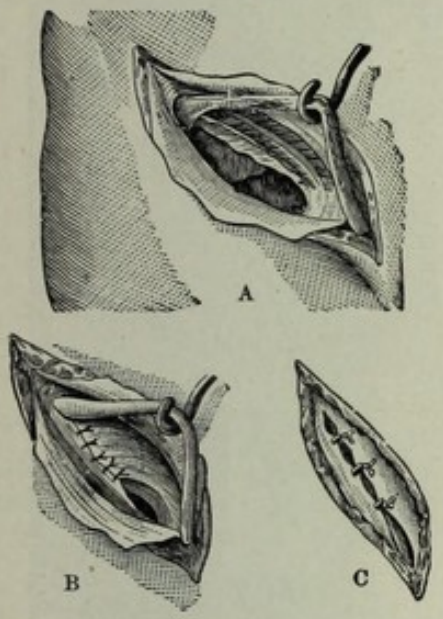


FIG. 913.—A–C, Bassini's operation for the cure of inguinal hernia: B shows first sutures above. First sutures should be below. (Esmarch and Kowalzig.)

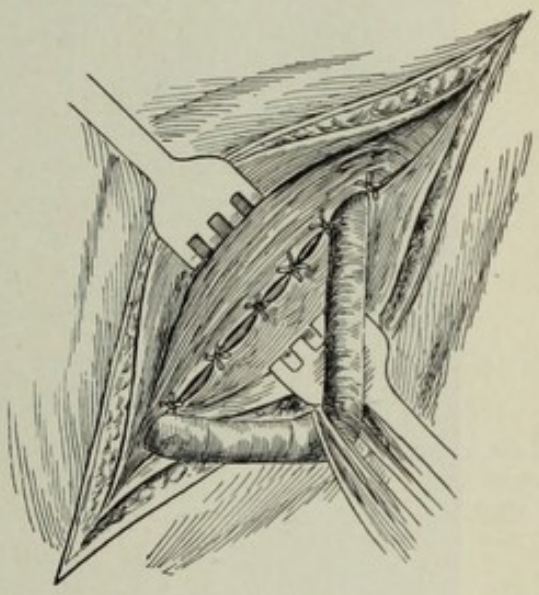


FIG. 914.—Bassini's operation (deep sutures), showing extra suture above the cord, as advised by Coley.

cremaster muscle, and considerable fat is lifted up. Bassini employs blunt dissection. Coley advocates the use of the knife. Masses of fat and usually the cremaster muscle are removed. The sac is isolated first at its neck and the neck is stripped from the inner aspect of the internal ring for the distance of ⅘ inch. The object of this stripping is to permit the removal of the sac at a high level. High removal obviates the leaving of a funnel-shaped depression of peritoneum. Such a depression would predispose to relapse. The sac is opened at the fundus, the interior is investigated, and if the contents are reducible, they are restored to the abdominal cavity and the neck of the sac is clamped high up. If adherent masses of omentum are found, the adhesions are separated, bleeding is arrested, and the omentum is restored to the abdomen unless it is in a hard and thick mass, when it is tied off and removed. Bassini ties off the neck of the sac above the clamp with a strong ligature of silkworm-gut. If the sac is large and thick he also threads both ends of a ligature upon a needle, passes the strand through the stump, and ties around over the first loop. (See E. Wyllys Andrews, "Med. Record," Oct. 28, 1899.) Coley and many other operators prefer to ligate the sac with catgut rather than with silkworm-gut or silk. After ligating the neck of the sac the sac is cut across and removed. The cord is now lifted out of the way, the inner surface of Poupart's ligament is exposed by retraction (Fig. 913, A), and the deep sutures are passed. Bassini uses silk which has been boiled in glycerin. Most American operators use kangaroo-tendon or chromicized catgut. Bassini inserts first

the sutures nearest to the pubes. The first suture—and sometimes also the second—includes part of the rectus sheath and rectus muscle. Each stitch includes the internal oblique and transversalis muscle in the upper edge and the shelf of Poupart's ligament below the lower margin, and from four to six stitches are passed behind the cord (Fig. 913, B). The last stitch narrows the internal ring so that it fits tightly around the cord (E. Wyllys Andrews, Loc. cit.). Coley's rule for passing this suture is to insert it so "that it just touches the lower border of the cord when the latter is brought vertically to the plane of the abdomen" ("Annals of Surg.," June, 1903) He always places a suture above the cord, and believes it tends to prevent relapse (Fig. 914). We prefer to tie the sutures from below upward, as the lower stitch is the most difficult to apply, and if it breaks while being tied after the uppermost suture has been tied it is very difficult to replace. The cord is laid upon this new floor and the aponeurosis of the external oblique is sutured over it (Fig. 913, C). The aponeurosis is closed by a continuous suture of chromic catgut and the skin with interrupted

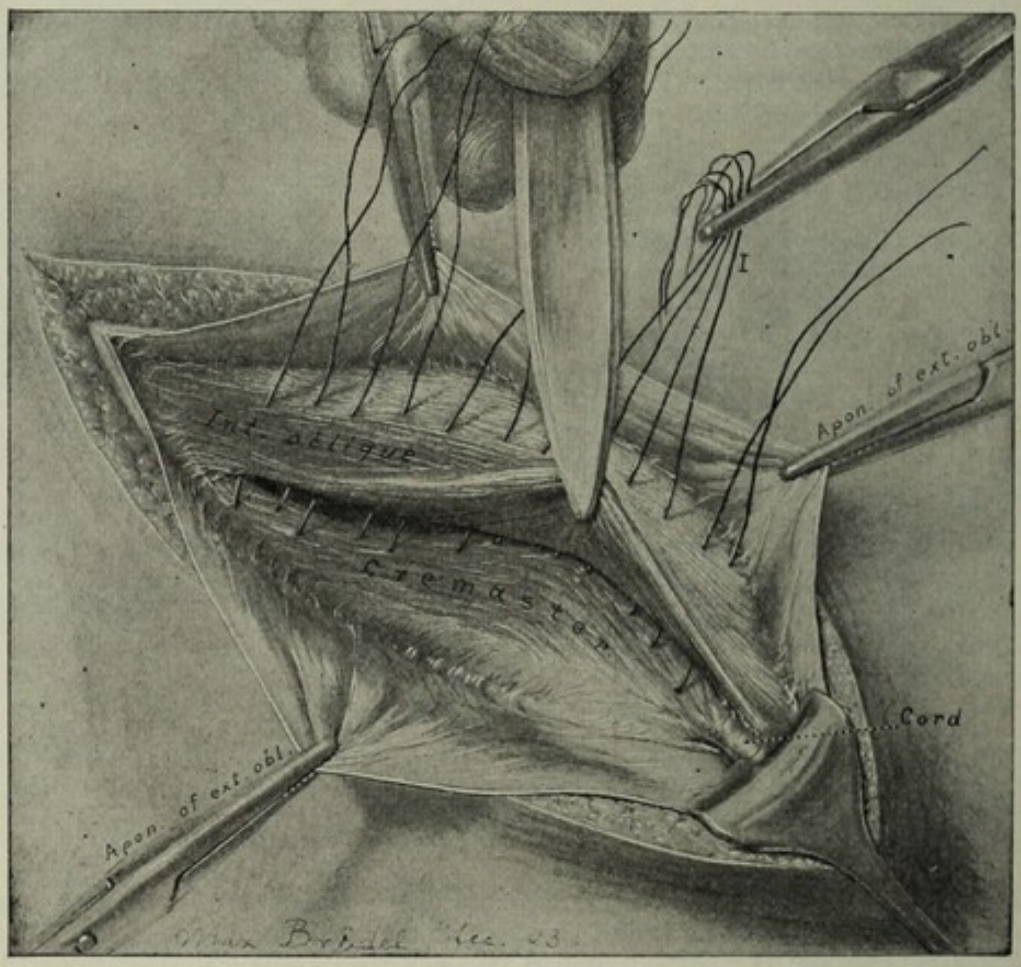


FIG. 915.—Halsted's operation. Mattress-suture in closure of canal (Kelly).

sutures of silkworm-gut or fine silk. Drainage is not employed. The wound is covered with sterile gauze, and compression is made by strips of adhesive plaster running well across the abdomen. The adhesive plaster is overlaid with dry gauze, and this is covered with absorbent cotton and the dressing is retained in place by a firm spica of the groin (Coley's dressing). A piece of adhesive plaster run from one thigh to the other acts as a shelf for the testicles to rest upon, but a suspensory may be worn instead. The wound is dressed on the seventh or eighth day, and the stitches are removed. The patient is kept in bed for about sixteen days for indirect hernia and twenty-one days for direct hernia.

In any operation care must be taken not to tie the deep sutures too tightly for fear of muscle necrosis. Care must also be taken not to handle the cord roughly for fear of the sequelæ of epididymitis and orchitis. It is advisable to retract the cord by an instrument such as a blunt hook rather than by a strip of gauze or tape, which may cause compression or torsion of the cord.

In operating for inguinal hernia in the female some surgeons transplant the round

ligament, while others leave the round ligament undisturbed and neglected beneath the deep sutures.

The Halsted Operation (Figs. 915–917).—The skin and the aponeurosis are incised, as in the modified Bassini operation. The sac is ligated and excised. Halsted in his

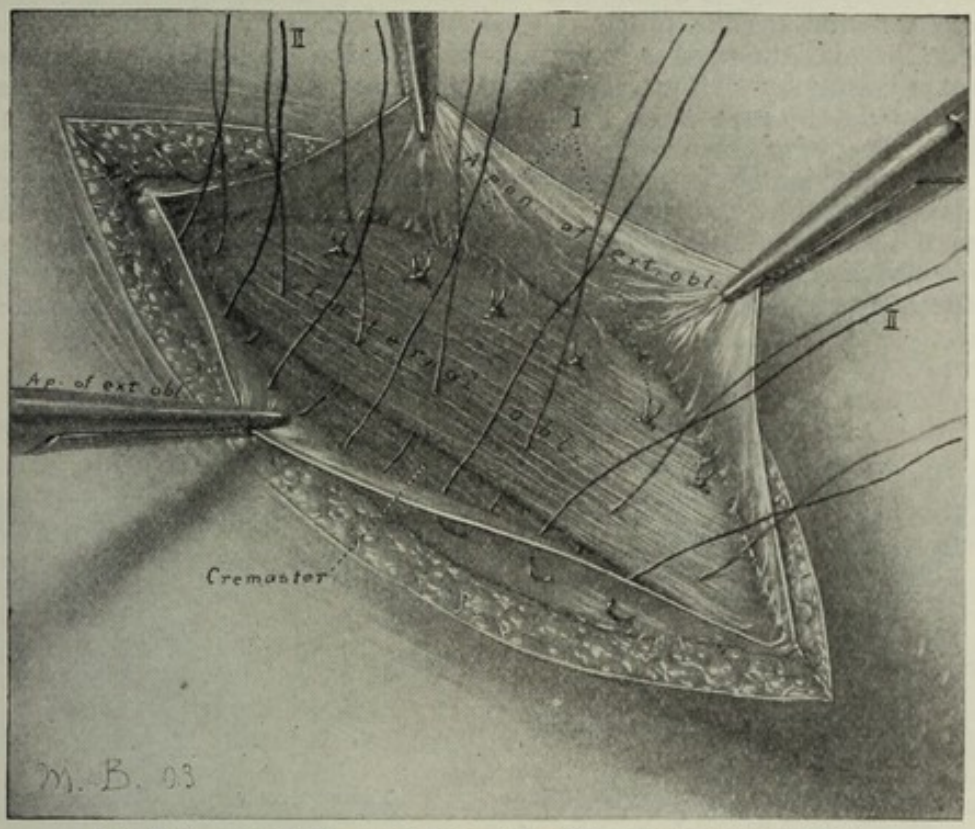


FIG. 916.—Halsted's operation. Mattress-sutures tied (Kelly).

early operation excised some of the veins of the cord. Whereas this step apparently decreased the percentage of recurrence, yet it increased the development of hydrocele as a sequel. Halsted emphasized the importance of using the cremaster muscle in

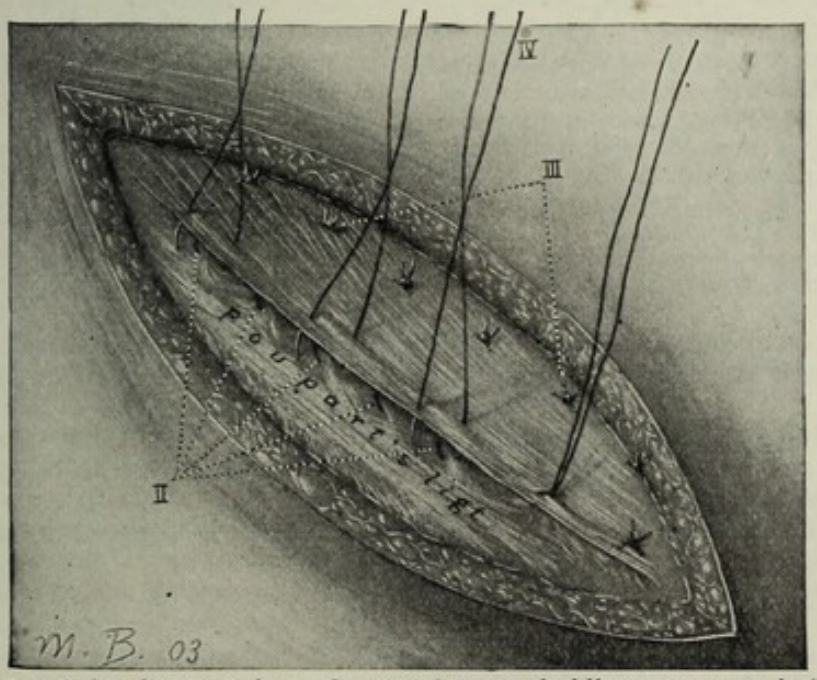


FIG. 917.—Halsted's operation. Suture of external oblique aponeurosis (Kelly).

the deep sutures to strengthen the suture line. Mattress-sutures are passed through the conjoined tendon, internal oblique, cremaster muscle and fascia, and then back through the conjoined tendon, internal oblique, and are tied. The cord is left undis-

turbed. The edge of the conjoined tendon and the edge of the internal oblique are then sutured to Poupart's ligament.

The flaps of the aponeurosis of the external oblique are overlapped. The edge of the upper flap is stitched to the outer surface of the conjoined tendon and the internal oblique. The lower flap is brought down and sewed to the upper flap. The superficial fascia and skin are closed.

In direct hernias the cord is sometimes transplanted, and if the conjoined tendon is deficient a triangular flap of fascia is transplanted from the anterior rectus sheath and used to cover the gap.

Halsted's Operation Plus Bloodgood's Method of Transplanting the Rectus Muscle (Jos. C. Bloodgood in "Johns Hopkins Hosp. Reports," vol. 7).—When the conjoined tendon is weak or obliterated, as in the case of direct hernias or recurrent hernias, a portion of the rectus muscle and its sheath may be transplanted. Halsted originally used the sheath of the rectus alone, but Bloodgood in 1898 described an operation which utilized the rectus muscle as well as the sheath. The anterior rectus sheath is incised

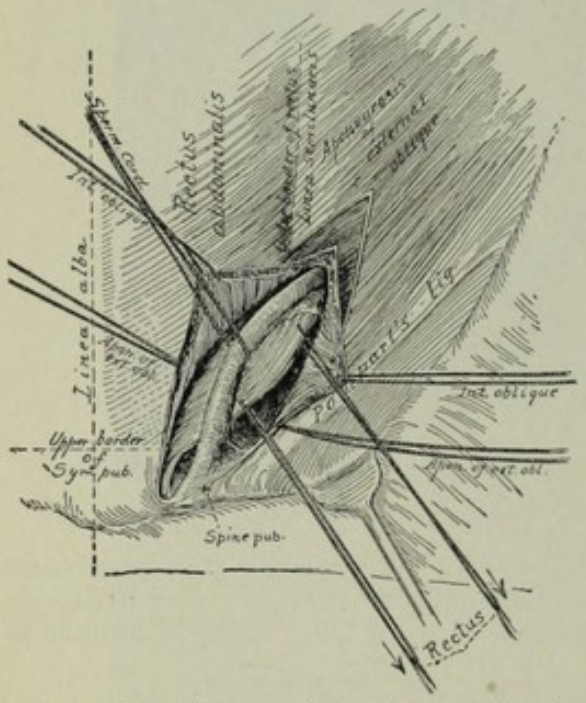


FIG. 918.—The method of transplanting the rectus muscle. The sac has been excised and the peritoneal cavity closed; the internal oblique muscle has been divided, the rectus exposed and transplanted; at this stage the wound is ready for the deep sutures. This illustration shows how perfectly the transplanted rectus muscle lines the lower half of the wound (Bloodgood).

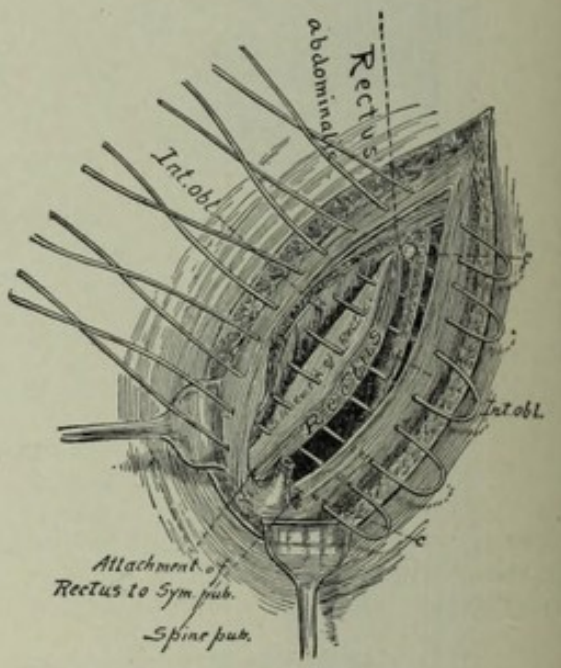


FIG. 919.—The transplanted rectus included by the deep sutures. In this illustration the cord has been excised in order to demonstrate the operation more clearly (Bloodgood).

for a distance of about 2 inches and the rectus muscle and sheath are drawn down and sutured with the conjoined tendon and internal oblique to Poupart's ligament (Figs. 918, 919).

We have used the Bloodgood operation with success in a number of cases of direct hernia, but do not believe that this method should be employed in operating on both sides for bilateral hernia.

Andrews ("Chicago Med. Record," 1895, vol. 9, p. 67) advocated the embrication of the aponeurosis of the internal oblique.

Kocher's Operation.—Kocher exposes the aponeurosis of the external oblique, makes a small incision through the aponeurosis above and external to the internal ring, and draws the sac through this incision and sutures it in place.

Ferguson's Operation.—In studying a number of recurrences after operation A. H. Ferguson observed that a hernial protrusion is apt to return at the upper and outer portion of the scar, above the cord and near Poupart's ligament. When he operated upon relapsed cases he discovered a slit of the aponeurosis of the external abdominal wall, through which the sac and some fat protruded. In order to determine the cause

of the failure of these operations, he thought it proper to make a semilunar incision and raise a flap of skin, fascia, and aponeurosis of the external oblique. On doing this, he was surprised to find an angle between the lower border of the internal oblique muscle and the inner aspect of Poupart's ligament absolutely unprotected by the internal oblique or the transversalis muscle. In some cases this angle extended upward and outward to the anterior superior iliac spine. He, therefore, concluded positively that the cause of a rupture returning in this angle after an operation for radical cure is deficient origin of the internal oblique muscle and of the transversalis muscle at Poupart's ligament. He is now persuaded that in all cases of hernia there is a deficient origin of these muscles, and he has demonstrated the same thing in a series of dissections in the inguinal region. Ferguson describes his operation as follows ("Jour. Amer. Med. Assoc.," July 1, 1899): He begins his incision over Poupart's ligament, 1½ inches below the anterior superior iliac spine, carries it inward and downward in a semilunar curve, and terminates it over the conjoined tendon, near the pubic bone. The incision goes down to the aponeurosis of the external oblique, and the flap, with its fat and fascia, is turned downward and outward. The next step is to incise the external abdominal ring to the intercolumnar fascia and separate the longitudinal fibers of the external oblique over the inguinal canal to beyond the internal ring, at a point nearly opposite the anterior superior spine of the ilium. Any transverse fibers that may be encountered are severed. The separated aponeurosis of the external oblique muscle is then retracted. One has then brought into view the contents of the inguinal canal, the hernial sac and its adhesions, the spermatic cord, the ilio-inguinal nerve, the internal abdominal ring, the subserous fat, the cremaster muscle, the conjoined tendon, the internal oblique and its deficient origin at Poupart's ligament, the transversalis fascia, and the internal surface of Poupart's ligament. The sac is now dissected from the cord and the internal ring. It is opened and its contents are inspected and properly dealt with. It is tied high up and cut off, and the stump is dropped into the abdomen. If the sac be congenital it is divided into two parts: the distal portion is used to make a tunic for the testicle and the proximal portion is treated as above directed. The cord is not disturbed, and it is beyond doubt that Ferguson is right in saying that the testicle frequently comes to harm after operations that disturb the cord. The veins in the cord should not be touched unless a varicocele also exists. Any excessive quantity of subserous adipose tissue should be removed. The next step in the operation is to restore the structures to their normal position; and one should remember that in the transversalis fascia is the internal ring. In hernia the internal ring is large and the transversalis fascia bulges outward; one must, therefore, take up the slack in this fascia and make a well-fitting ring for the cord by means of a catgut suture, either interrupted or continuous (Fig. 833). After this has been accomplished the internal oblique and transversalis muscles are sutured to the internal aspect of Poupart's ligament, after the lower borders of the muscles have been freshened and Poupart's ligament has been scarified. The sutures must be carried two-thirds of the way down Poupart's ligament, which is about the normal origin of this muscle in the female. The next step is to suture the edges of the divided aponeurosis of the external oblique; this restores the external abdominal ring. The skin-flap is then carefully sutured.

Radical Cure of Direct Inguinal Hernia.—If the hernia goes through the conjoined tendon or pushes that structure before it, the operation should consist in transplanting the rectus muscle as practised by Bloodgood (see page 1132) and suturing the arched fibers of the internal oblique and conjoined tendon to Poupart's ligament and beneath the cord, or the Stetten operation.

The Stetten Operation for Direct and Indirect Hernia ("Annals of Surgery," Phila., 1920, vol. 71, p. 744; vol. 78, p. 48—Figs. 920–923).—After the sac is ligated, excised, and the deep sutures placed the upper flap of the aponeurosis is sutured to Poupart's ligament. The lower flap of the aponeurosis is incised perpendicular to its fibers with double blunt-pointed scissors at a point opposite the internal ring as far as Poupart's ligament. The smaller upper portion of the lower flap is carried across the cord and overlapped on the upper flap and sewed. The larger lower portion of the flap is passed beneath the cord, lapped over the upper flap, and sutured. The incised lower flap should fit as snugly as possible around the cord without constricting it.

During the past three years Owen has used this method in practically all of his operations for direct and indirect oblique hernias in adults and in recurrent hernias, and the results have been most successful. It is at the present time the operation of choice for direct or indirect inguinal hernia in the adult male or for recurrence.

Downes in 1920 ("Arch. of Surg.," Chicago, vol. i, p. 53) described an operation for direct hernia utilizing the rectus muscle and fascia. The sac is ligated and excised. The internal oblique and transversalis are lifted up at the internal ring by a blunt retractor. The muscles are dissected free down to a point where they unite with the

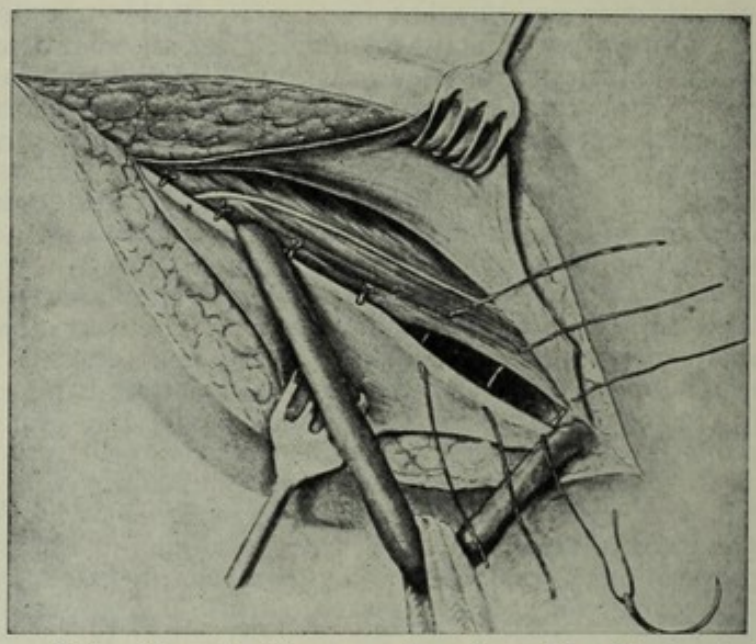


FIG. 920.—Suture of the internal oblique muscle and conjoined tendon to Poupart's ligament beneath the cord. The muscle is tucked under the ligament and two sutures are placed lateral to the exit of the cord. The inguinal branch of the ilio-inguinal nerve emerges between the sutures (Stetten).

transversalis fascia at the outer margin of the rectus. Here the sheath of the rectus is opened and the muscle exposed to the pubis. Three or four sutures of chromic catgut or kangaroo-tendon unite the muscle to Poupart's ligament, sutures being passed from below upward, ½ inch apart. The retractor is removed, and the internal oblique

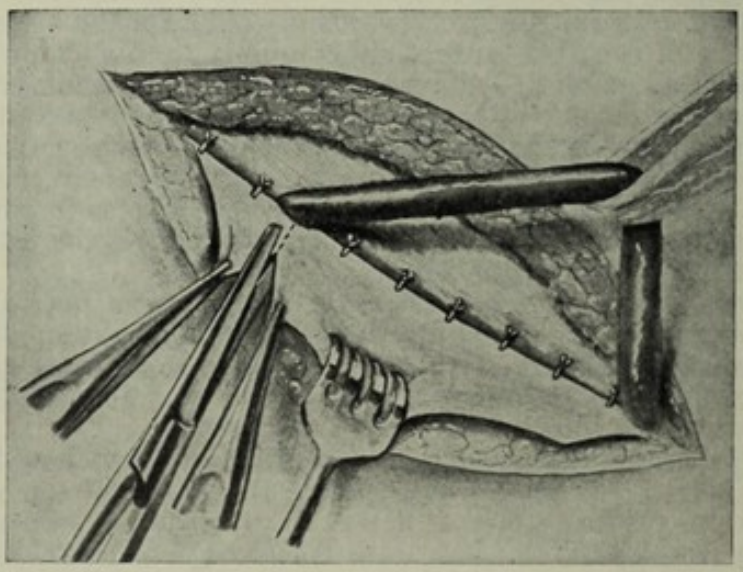


FIG. 921.—The suture of the upper flap of the aponeurosis of the external oblique to Poupart's ligament has been completed, medial and lateral, to the exit of the cord. Splitting of the lower flap of the aponeurosis of the external oblique, perpendiculurly to its fibers at a point opposite the ring. The lower flap is now divided into a smaller lateral and larger medial portion (Stetten).

is sewed to Poupart's ligament, under the cord, by interrupted sutures. The edges of the aponeurosis of the external oblique are overlapped, giving three separate layers instead of two, as in the Bassini operation. Watson ("Hernia," p. 247) strongly recommends this operation for direct hernia.

LaRoque Operation ("Surg., Gyn., and Obst.," Chicago, 1919, vol. 29, p. 507).—The Bassini incision is made. LaRoque opens the peritoneal cavity above the hernia. The peritoneum is opened above the sac. The hernial contents are examined and re-

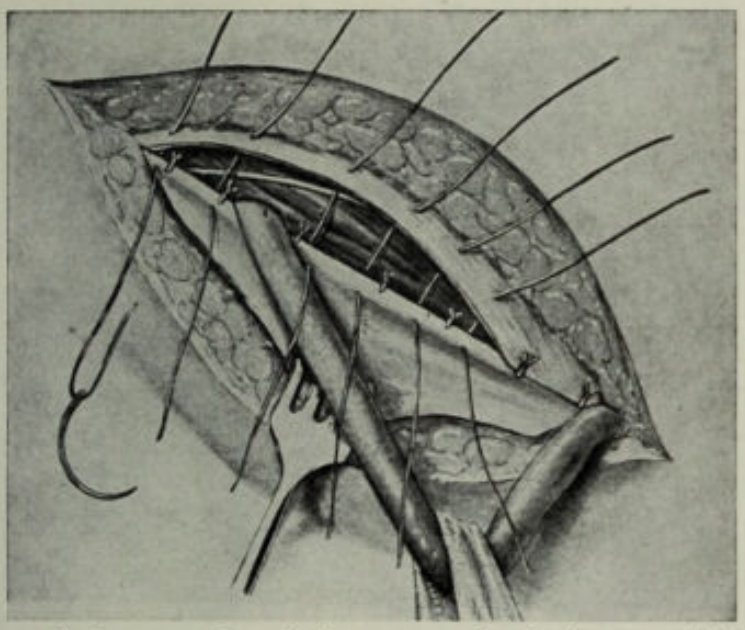


FIG. 922.—Suture of the upper flap of the aponeurosis of the external oblique to Poupart's ligament beneath the cord and over the previous suture line of the internal oblique muscle and conjoined tendon to Poupart's ligament, which has been completed (Stetten).

turned to the abdomen. The finger is then placed into the sac over the opening in the peritoneum above the ring. Forceps are then inserted into the sac and the lowest portion of the sac grasped, freed, and retracted to the abdominal cavity. The sac is

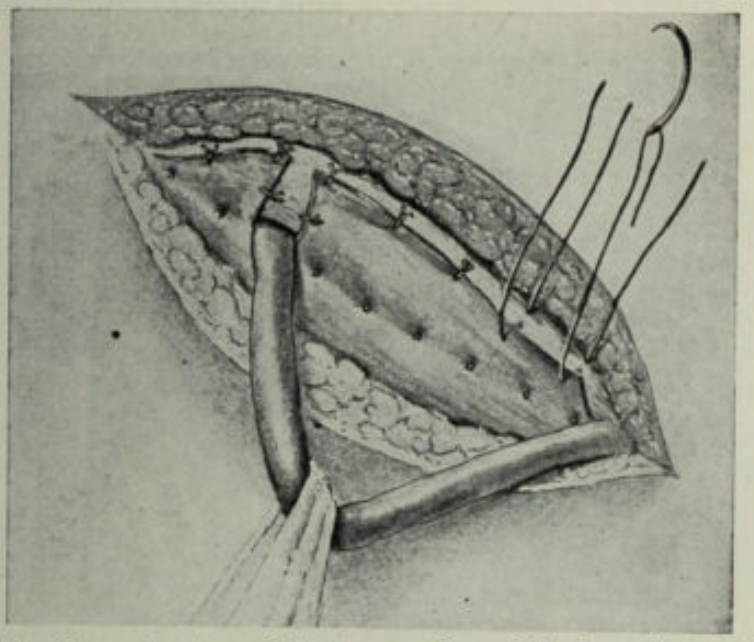


FIG. 923.—Overlapping and suture of the two portions of the lower flap on the already sutured upper flap of the aponeurosis of the external oblique. The larger, medial portion is passed beneath the cord, permitting the cord to emerge subcutaneously between the two divisions of the lower flap. A stitch is taken at each point where the lower flap has been divided and lies on the upper flap (Stetten).

then pulled upward and passed through the peritoneum 1 inch above the internal ring. The internal ring is completely obliterated. The sac is then excised. The inguinal canal is then reconstructed either with or without transplanting the cord (Figs. 926–928).

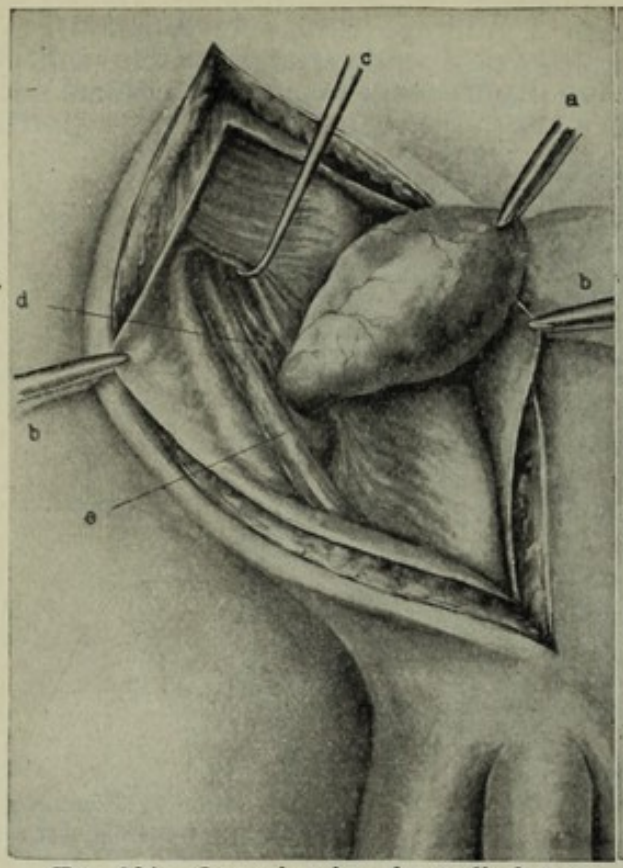


FIG. 924.—Operation for the radical cure of direct inguinal hernia: *a*, Hernial sac; *b*, *b*, retracted borders of the split external oblique; *c*, upwardly and inwardly retracted lower borders of the internal oblique and transversalis; *d*, deep epigastric vessels, seen through the transversalis fascia. (Bickham, "Operative Surgery," vol. iv.)

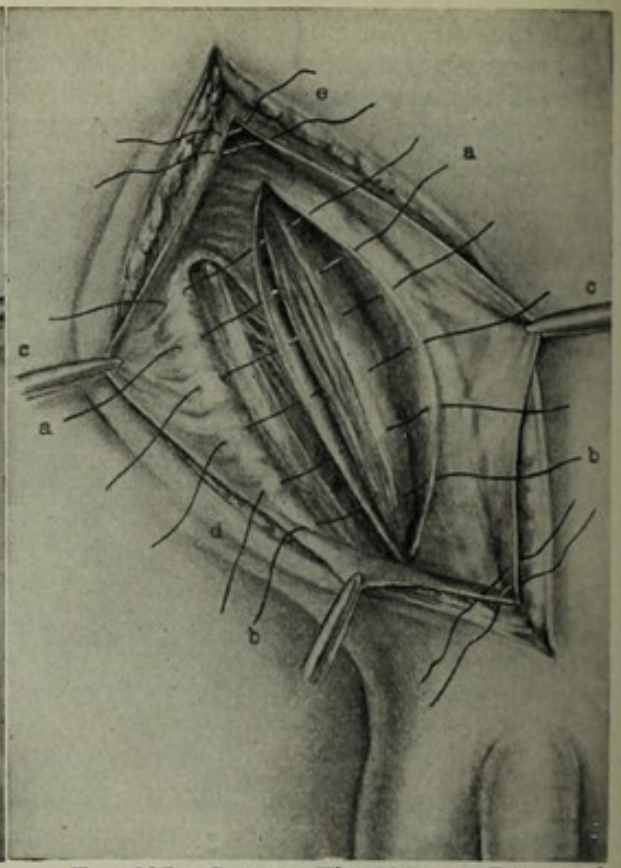


FIG. 925.—Same as Fig. 924: *c*, *c*, Retracted margins of the split external oblique; *a*, *a* and *b*, *b*, sutures approximating the margins of the freed rectal sheath and the split outer margin of the rectus, above and inward, to the shelving border of Poupart's ligament, below and outward, covering over the cord, which is seen beneath the sutures; *e*, sutures approximating the split margins of the external oblique. The hernial sac has been treated in the usual manner, and its stump returned to the abdominal cavity. (Bickham, "Operative Surgery," vol. iv.)

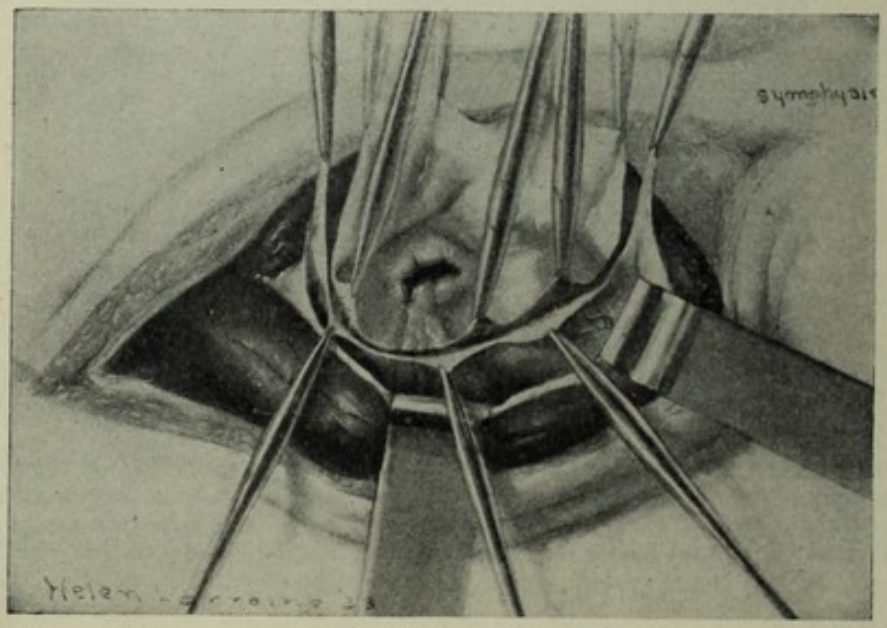


FIG. 926.—The peritoneum opened, the whole region of hernia exposed, and the redundant peritoneum of the area incised and about to be freed over a wide area preliminary to enucleation of the sac. Bladder at *B*, vessels and vas deferens plainly seen and felt through peritoneum (LaRoque).

Double Inguinal Hernia.—It has always been our custom to make a double incision for bilateral hernia. Judd ("Old Dominion Jour. Med. and Surg.," Richmond, 1913, p. 153) and Edmunds ("Med. Press and Circular," London, 1908) advocated a single incision. Edmunds' incision extends from a point midway between the two rings on one side, curves downward and passes across above the symphysis pubis, and upward

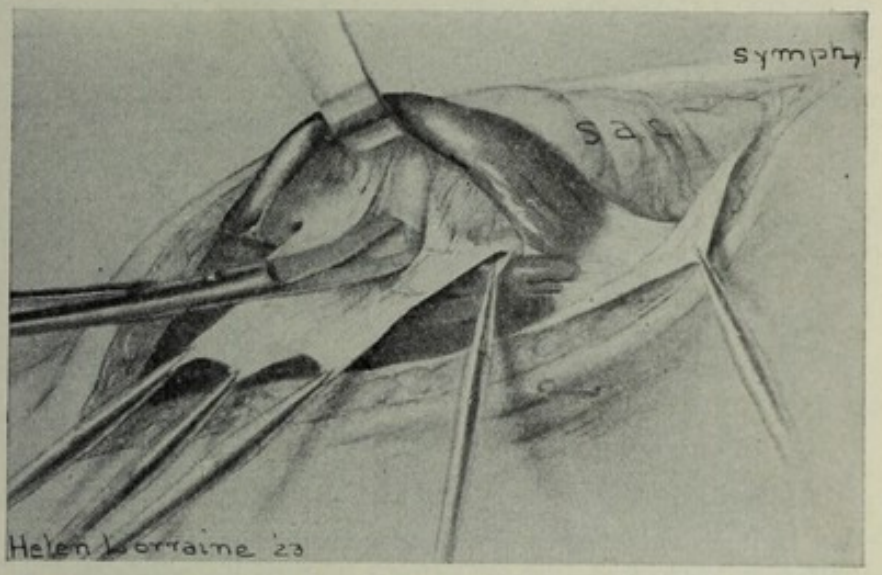


FIG. 927.—The lower edge of incised peritoneum, held flat and pulled upward, is easily separated by blunt blade scissors inserted into the space of easy cleavage between the peritoneum and infundibuliform fascia (LaRoque).

on the opposite side. Another incision is a straight transverse one, extending from a point half-way between the rings on one side to a similar point on the opposite side.

Winter ("Jour. Amer. Med. Assoc.," Newark, N. J., 1918, vol. 15, p. 340) describes a median incision 3 inches long just above the pubis. This incision is first retracted

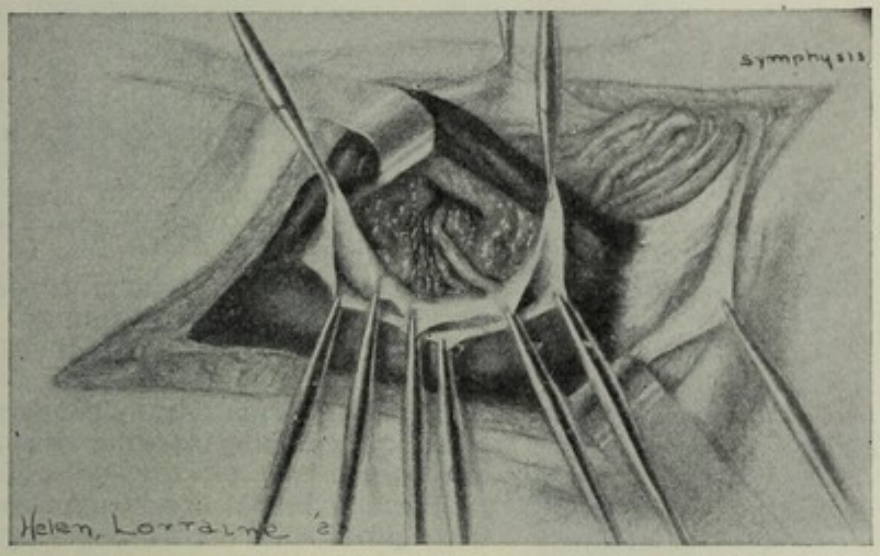


FIG. 928.—The sac now entirely removed, the edges of the incision in the peritoneum are held ready for suture. The peritoneum is easily freed from areolar tissue if necessary to do so, to suture without tension (La Roque).

for a hernia on one side and then retracted for the repair of the hernia on the opposite side.

Fascia Transplants in Large Hernias.—A strip of fascia lata 2 by 3 inches may be used to reinforce the inguinal canal in large hernias. The free transplant is fastened over the line of suture of the aponeurosis of the external oblique. Gallie ("Can. Med. Assoc. Jour.," Toronto, 1921, vol. 11, p. 504) uses six or seven strips of fascia lata each 6 inches long and $\frac{1}{4}$ inch wide. These strips are threaded upon a curved

needle and are woven into the edges of the surrounding muscles and aponeurosis. The use of periosteal bone-flaps and bone has been discontinued.

Hernia Associated with Undescended Testicle.—Hernia may be associated with undescended testicle. Every effort should be made to preserve an undescended tes-

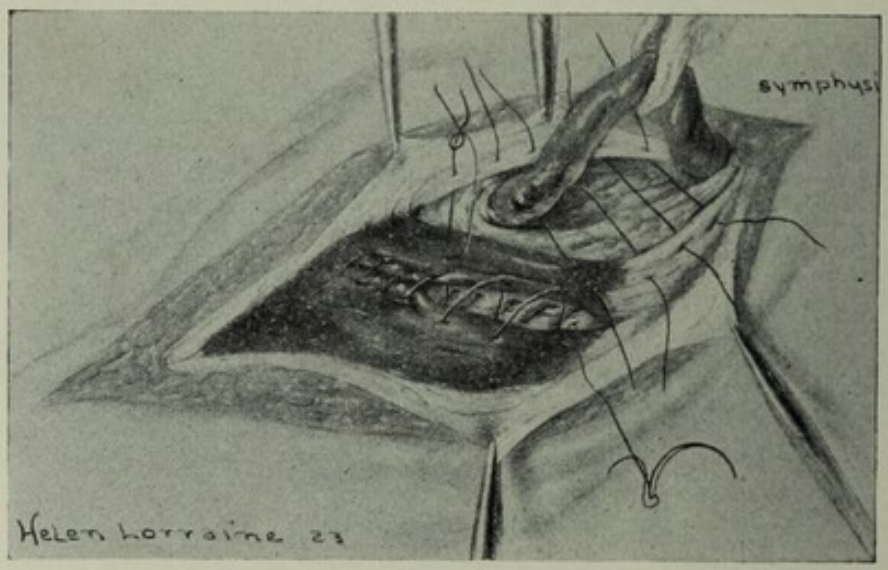


FIG. 929.—The peritoneum is sutured to a position much above the hernial orifice, each suture catching the transversalis muscle and its fascia when present; the separated bundles of internal oblique are sutured, and finally the canal may be closed in whatever method seems best in the individual case (LaRoque).

ticle. An attempt should be made to place and hold the testis in the scrotum. When this is impossible, some surgeons replace the testis in the abdomen because of its importance from an endocrine standpoint. Other surgeons recommend that the testis be removed when it is impossible to hold it in the scrotum because of danger of malignant degeneration. A truss should never be worn when hernia is associated with undescended testicle.

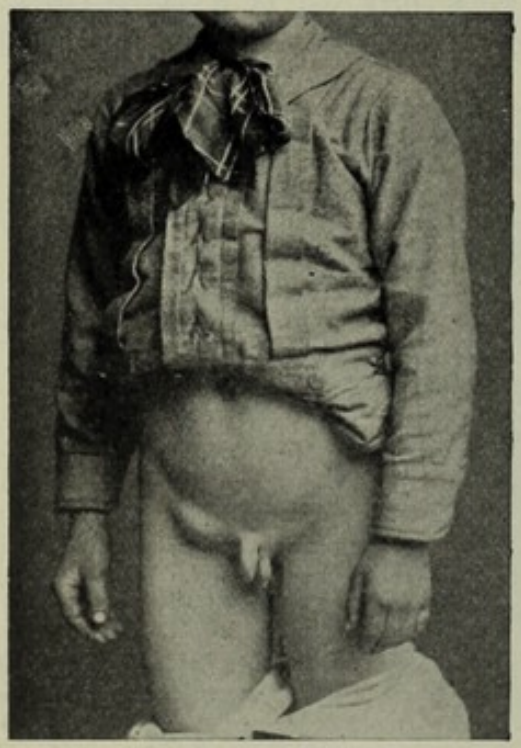


FIG. 930.—Femoral hernia in a child aged ten years of two years' duration ("Keen's Surgery").

The most favorable ages for operation for hernia associated with undescended testis is between six and twelve years of age (Watson, "Hernia").

Femoral hernia is also known as crural hernia (Figs. 930, 931). It rarely is seen before the twentieth year.

A femoral hernia is a protrusion of an abdominal or pelvic viscus through the femoral ring into the femoral canal or beyond it (Watson).

Femoral hernia usually contains omentum. It seldom contains intestine except in strangulated cases.

Femoral hernia occurs more frequently on the right side in both sexes. Inguinal hernia occurs with nearly equal frequency on both sides in woman, while femoral hernia is nearly twice as frequent on the right side in woman. In 8655 cases of inguinal and femoral hernias in Italian soldiers, reported by Perassi ("Gior. di med. mil., Roma," 1911, vol. 89, p. 41), 8563 were inguinal and 92 were femoral.

Femoral hernia may be combined with other hernias. It is most frequently associated with inguinal hernia. Femoral hernia is much more frequent in women than in men. It is less common than inguinal hernia in both sexes.

The femoral ring is bounded on the inner side by Gimbernat's ligament, on the

outer side by the femoral vein, in front by Poupart's ligament and the deep femoral arch, and behind by the horizontal ramus of the pubis. Behind it are the origin of the pectineus muscle and fascia. The hernia usually descends between the femoral vein and Gimbernat's ligament. The hernia rarely passes external to the femoral vessels (*Hesselbach's hernia*). It may pass through an opening in Gimbernat's ligament (*Laugier's hernia*). It may protrude alongside the femoral vein, but, instead of emerging from the saphenous opening, spread into the pectineus muscle (*Cloquet's hernia*). *Pectineal hernia* is a hernia beneath the pectineal fascia and in the pectineal muscle. The femoral canal contains a small amount of fatty tissue and a few lymph-vessels. The septum crurale of Cloquet closes the femoral ring and acts as a barrier against descent of hernia (Watson).

The coverings of a femoral hernia are the skin, superficial fascia, cribriform fascia, the femoral sheath, septum crurale, subserous tissue, and peritoneum.

The femoral hernia is usually congenital in origin. The contents of the sac consist of omentum, rarely intestine. Other abdominal viscera have occasionally been found as contents of the sac. In the usual variety of femoral hernia the femoral vein is to the outer side of the hernia, and the internal saphenous vein is in front of the hernia—also to the outer side.

Differential Diagnosis.—The presence of a lymph-gland in the region of the femoral hernia must be remembered. This gland is known as *Cloquet's ganglion* or *Rosenmüller's gland*. When enlarged it may simulate a femoral hernia.



FIG. 931.—Double femoral hernia. Man aged fifty (Dr. C. F. Nassau).

Femoral hernia must not be mistaken for saphenous varix, psoas abscess, adenitis, or lipoma. Occasionally a femoral hernia may, after passing under Poupart's ligament, take an upward course, which renders the diagnosis difficult. Inguinal hernia is always above a line drawn from the anterosuperior spine to the spine of the pubis, while the femoral hernia is always below this line. The neck of an inguinal hernia is internal and the neck of a femoral hernia is external to the pubic spine. The inguinal hernia is reduced by making pressure upward, outward, and backward, and pressure in the inguinal region will prevent the descent in inguinal hernia. Femoral hernia is reduced by pressure backward and upward.

In differentiating a femoral hernia from a saphenous varix it must be remembered that a saphenous varix disappears when the patient is in the recumbent posture and reappears when the patient stands. There are none of the characteristic signs of reduction in the case of saphenous varix which are found in a femoral hernia. Richardson ("Annals of Surgery," Phila., 1918, vol. 57, p. 471) reported 10 cases of saphenous varix, 7 of which were diagnosed before operation as femoral hernia.

A psoas abscess pointing in the femoral region is diagnosticated by its fluctuation and by *x*-ray pictures of the spine showing evidence of tuberculosis.

Lipoma and femoral adenitis may be confused with an irreducible femoral hernia. Lipoma gives no impulse on coughing, is not attached to the underlying structures, and is more movable than the hernia. Femoral adenitis gives no impulse on coughing,

and usually isolated glands can be palpated. Occasionally a femoral adenitis is associated with an inflamed or strangulated femoral hernia. Such a diagnosis is always extremely difficult to make before operation.

Treatment of Femoral Hernia.—It is difficult to properly adjust a truss to a femoral hernia. Strangulation is far more common in femoral hernia than in inguinal hernia because of the unyielding edge of Gimbernat's ligament, which forms the boundary of the small femoral ring, and because of the direction of descent of the hernia, which is downward, forward, and upward (Watson).

The radical operation is to be recommended.

The two modern operations for femoral hernia are the femoral operation and the inguinal operation. The femoral operation is usually preferable and suffices providing care is taken to close the femoral canal. Make the skin incision 1½ inches above Poupart's ligament, and extend it downward for a distance of 4 inches over the femoral canal parallel to the femoral vessels. Care must be taken not to injure the saphenous vein, which passes upward along the inner side of the thigh through the saphenous opening, about 1½ inches below Poupart's ligament. The femoral artery and veins are located and retracted. The sac should be freed as high as possible. It

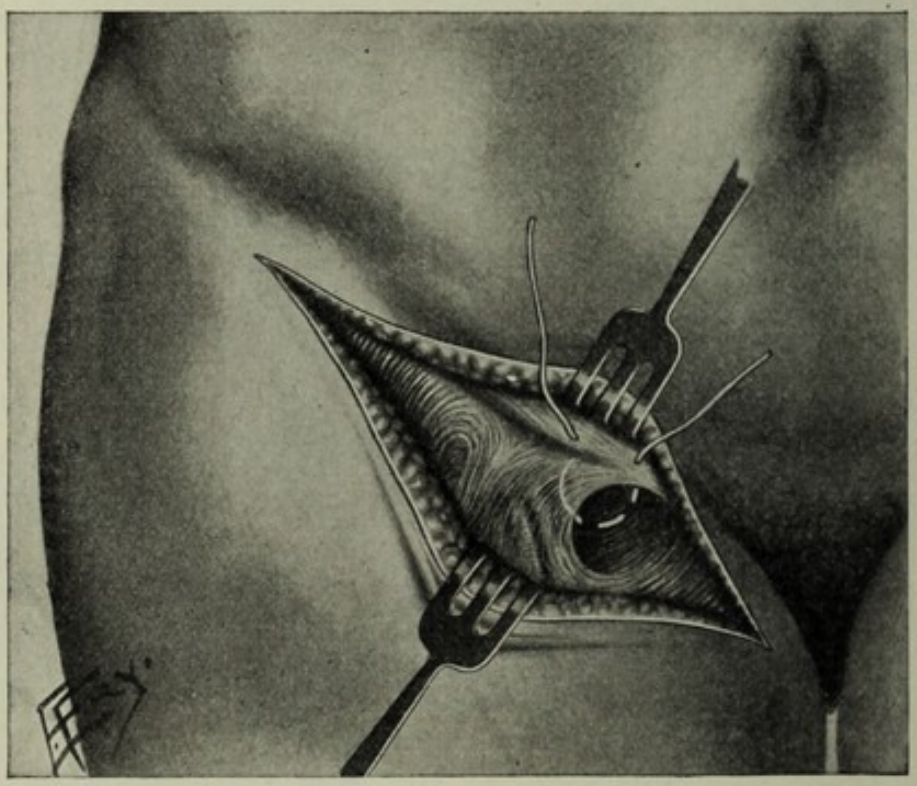


FIG. 932.—Obliteration of the femoral opening by purse-string suture ("Keen's Surgery").

is then opened and the contents of the sac replaced in the abdomen. The neck of the sac is exposed, transfixed, ligated, and excised. If the femoral ring is small, a purse-string suture suffices. This purse-string suture is passed through the inner portion of Poupart's ligament, the pectineal muscle and fascia, and then again through Poupart's ligament, emerging near the original point of entrance. If necessary more than one purse-string suture may be used (Figs. 932, 933).

Bassini's method consisted of passing three or four interrupted sutures between Poupart's ligament and the pectineal fascia, and two or three additional sutures through the fascia lata and the pectineal fascia.

When, however, the femoral ring is large, or when it has been necessary to divide the fibers of the ring to reduce the hernia, Andrews's operation may be performed (Andrews, "Ill. Med. Jour.," 1923, vol. 43, p. 29). It is described by Watson as follows: After the sac is removed the cord or the round ligament is raised or held out of the way by an assistant. By gauze dissection the triangle is cleared, exposing Poupart's ligament from below. A clamp is attached to the lower fragment of the aponeurosis; this clamp is grasped in the operator's left hand, held upward, and the middle finger of this hand inserted into the femoral canal. The needle is then brought from Scarpa's triangle under the ligament, being guided and guarded by the finger so

as to avoid the femoral vein, which lies in very close proximity. The needle is pulled through the canal. A large bite of the conjoined tendon is caught up and the stitch carried back and brought through the sharp edge of Poupart's ligament from within outward. It is then carried through the edge of the upper fragment of the aponeurosis and finally out into Scarpa's triangle by coming through the lower fragment of the aponeurosis very close to the ligament. It will be noted that when this stitch is tied it is no longer Y-shaped, but circular. The conjoined tendon is pulled under the sharp edge of the ligament and the aponeurosis above. Two or three sutures are generally sufficient. Kangaroo-tendon may be used. It will be observed that the stitches surround Poupart's ligament and that the knots all lie outside of the canal. Finally, the cord is replaced and the lower fragment of the external oblique is laid down over it to make a roof for the canal.

If the hernia is strangulated it is often advisable to open the abdomen by an incision at the outer border of the rectus muscle. The advantages are: the strangulation can be relieved without division of the femoral ring, circulation returns to the intestine more quickly when there is no traction on the mesentery (traction often necessary while trying to operate through the femoral incision), and resection of the intestine is more readily accomplished.

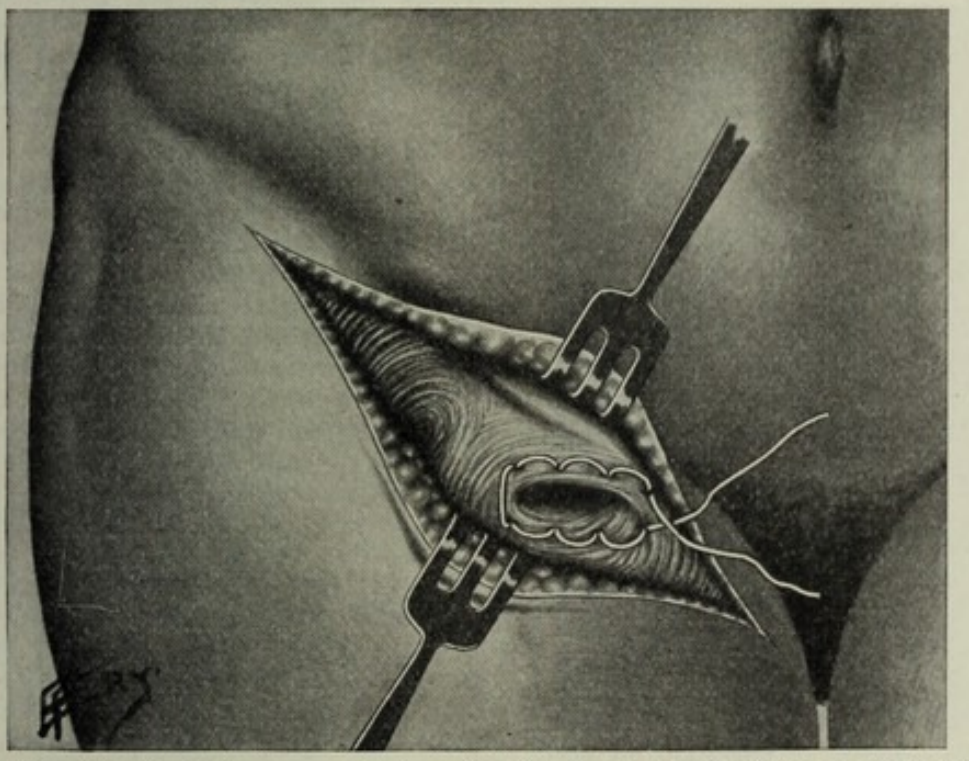


FIG. 933.—Cushing-Marcy purse-string suture for femoral hernia ("Keen's Surgery").

Some surgeons prefer operation by the inguinal route to correct femoral hernia. The patient should be placed in the Trendelenburg position. Incision is made over the inguinal canal, as for an inguinal hernia, with the exception that the lower end of the incision extends down over the pubic bone in the direction of the femoral ring. The aponeurosis of the external oblique is divided. The internal oblique and transversalis are retracted upward. The lower flap of the external oblique is retracted downward. The round ligament or cord is held aside. The transversalis fascia is divided and the peritoneum is exposed and opened just above the neck of the sac.

The inguinal operation is the better operation when the femoral hernia is strangulated. The inguinal operation, however, is more difficult and requires more time than the femoral, and has the further disadvantage that it opens Hesselbach's triangle. Consequently there is more danger of a postoperative direct hernia.

It must be remembered that a partial strangulation of a portion of the lumen of the intestines (Richter's hernia) is more frequent in the femoral variety than in any other. When there is a sliding hernia of the intestines care must be taken not to open into the intestine, mistaking the intestine for the sac. Care must also be taken not to injure the deep epigastric vessels and the femoral vein. The femoral artery has been injured while repairing the femoral ring.

Cruroscrotal Hernia (Fig. 934).—In very rare instances an inguinal hernia may descend into the femoral region instead of into the scrotum. It may follow the route of the testicle which has not descended into the scrotum, but has descended into the crural region. After emerging at the femoral ring the sac may divide into loculi that pass into one of three directions—either through the femoral canal, toward the obturator foramen, or, in rare cases, into the labium majus, or the upper part of the scrotum. These multilocular herniæ are known as *Cooper's hernias*. A femoral hernia may develop after an operation for inguinal hernia. This is probably due to the increased abdominal pressure which acted as a predisposing cause for the original inguinal hernia, or it may be due to the pulling upward of Poupart's ligament by the deep sutures in the operative procedure for correction of the inguinal hernia, thus increasing the size of the femoral opening.

Umbilical hernia is a protrusion of abdominal viscera through the umbilical ring. An umbilical hernia may be congenital (the ventral plates having failed to close to form the umbilicus as they normally should the third month of intra-uterine life, the cicatrix of the umbilicus having stretched), infantile, or acquired.

An acquired umbilical hernia may pass through the opening for the right or left umbilical artery, the opening for the urachus, the opening for the umbilical vein, or through the center of the umbilicus where Richet's fascia (the thickened layer of the transversalis fascia beneath the umbilicus) is thinned and destroyed. The most common form of hernia is through the opening for the umbilical vein. It appears at the margin of the ring. Its coverings are skin, subcutaneous fat (when in the upper part), thin superficial fascia, thin transversalis fascia, and peritoneum.

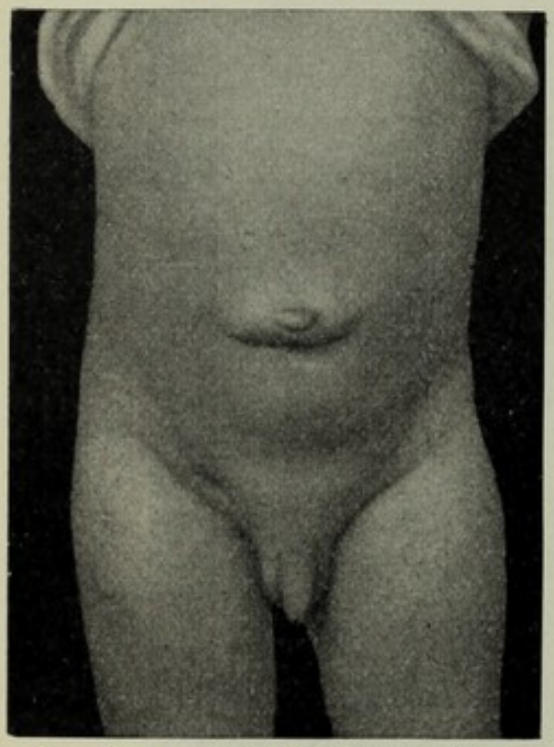


FIG. 934.—Result of operation for umbilical hernia with preservation of the navel (Children's Hospital; A. P. C. Ashhurst's "Surgery").

The congenital umbilical hernia occurs when the walls fail to close in the region of the navel, owing to a defect in development during intra-uterine life. The contents of such a hernia may include intestine or Meckel's diverticulum. Care should be used to return the contents of such a hernia to the abdominal cavity before tying off the cord. Congenital umbilical hernias are not infrequently associated with other malformations, such as imperforated anus, exstrophy of the bladder, spina bifida, hare-lip, cleft-palate, club-foot, etc. The structures passing through the umbilicus during fetal life are the urachus, umbilical arteries, umbilical vein, some of the fetal membranes, and a portion of the digestive tract. The umbilical ring should close after birth, and after two years of age the umbilical cicatrix should become sufficiently firm to prevent the formation of hernia as long as the muscles retain their normal strength and are not weakened by fat deposits.

Infantile umbilical hernia usually develops during the first six months of life, following a strain caused by constipation, phimosis, or a cough.

In congenital umbilical hernia the contents consist usually of one loop or more of small intestine. In umbilical hernia in adults the contents usually consist of omentum, commonly a loop of transverse colon, and sometimes small intestine. In 27 cases of umbilical hernia of Meckel's diverticulum collected by Watson only 1 was in an adult. Nearly all the patients were newborn infants. Congenital umbilical hernia of the cord is rare, occurring about once in every 10,000 births. Infantile umbilical hernia is common during the first year of life, less frequent in the second year, and seldom occurs after the third year. Umbilical hernia in adults may appear about the age of twenty. After this it increases in frequency, slowly in males and rapidly in females, owing to the beginning of the child-bearing period. Over 75 per cent. of all cases occur in females.

Umbilical hernia in an infant may be overlooked until the baby is several weeks old. Such a hernia may cause attacks of colic, and when the child stops crying the hernia is reduced.

Strangulation of umbilical hernia is rare in children, but not uncommon in adults. With a history of umbilical hernia, symptoms of intestinal obstruction, stercoraceous vomiting, etc., an operation is indicated. The fundus of the sac is frequently the site of ulceration which may involve the peritoneum. Occasionally the infection extends to the abdominal cavity. The diagnosis is often difficult, the condition simulating a superficial disease of the abdominal wall.

The differential diagnosis of umbilical hernia in infants and adults must be made from limpoma occurring in the neighborhood of the umbilicus, dermoid and other cysts in the umbilical region, and malignant tumors. Cysts and tumors do not give an impulse on coughing, nor do they disappear on manipulation.

Treatment.—Small congenital umbilical hernias can usually be satisfactorily treated by palliative measures. The mass is reduced and adhesive plaster is applied over the ring and two-thirds the way around the abdomen. The length of time required for a cure depends on the age of the child. If treatment is begun when the child is one month of age a cure should be effected in about two months. If the child is six months of age the treatment should be by binder worn for at least six to nine months. A pad or compress larger than the hernial opening should be placed directly over the umbilicus. A large button or a cork disk may be utilized as a pad. It should be covered by soft flannel or muslin to prevent chafing. Care should always be taken to see that this pad or compress is larger than the hernial opening, because if the pad is smaller it will tend to increase the size of the aperture of the hernia. After the application of adhesive plaster a binder should be applied. The adhesive plaster should be changed every week.

If the child is one or two years of age a truss with a water pad is usually more satisfactory than adhesive plaster. This truss can be worn in the daytime and a belt at night.

The radical operation on children with umbilical hernia is indicated when the hernia cannot be held satisfactorily by either a truss or a bandage, when the hernia is large and causes frequent attacks of intestinal symptoms, such as nausea, vomiting, colic, etc., and when there are symptoms of partial intestinal obstruction. The operation on children is usually made with an incision below the umbilicus. It is always well, if possible, to preserve the umbilicus (Fig. 934). The flap is turned up, the neck of the sac exposed, the sac is opened, the contents of the hernia reduced to the abdominal cavity, and the sac is ligated and cut off. The separated rectus muscles are sutured and the fascia overlapped transversely. This operation will suffice for the usual umbilical hernia in children. When, however, the hernia is large it may be necessary to use one of the operations for adult umbilical hernia.

A small umbilical hernia in an adult may be treated by a truss or belt if the hernia can be easily reduced.

If the hernia is large, or if it is irreducible, an operation should be recommended. Except in strangulation, which requires immediate treatment, a patient with an umbilical hernia should be given preliminary treatment for a period of at least two weeks; during this time rest in bed and a restricted diet will tend to reduce the amount of fat. This preliminary treatment lessens the danger of postoperative complications, such as acute dilatation of the heart, edema of the lungs, pneumonia, and renal insufficiency. These complications frequently follow a sudden increase in intra-abdominal tension on the return to the abdominal cavity of a viscus which perhaps has not been there for years and has lost its "right of domicile" (Watson).

Operative Procedure.—*Radical Cure of Umbilical Hernia.*—Because of the fact that the patient is in constant danger of strangulation, in large, irreducible umbilical hernias the radical operation should be performed unless contraindicated because of constitutional disease.

The patient is placed upon the operating table in the horizontal position. Watson calls attention to the fact that the Trendelenburg position is dangerous and suggests that if the patient's shoulders are slightly elevated and his hips raised the muscles of the abdomen are relaxed, are more easily repaired, and reduction of the contents of the hernia will be facilitated.

The Mayo operation is the accepted technic. Mayo believes that the defect of the old operation was that the recti muscles are naturally separated at the level of the umbilicus, and in bringing the recti together we have really performed muscle

transplanation, and these thin muscles are of no great value in preventing relapse, and in a large hernia it is not even possible to cover the gap by muscle.

Mayo's Operation (Figs. 935–938).—Transverse elliptic incisions are made around the umbilicus and the hernia. The base of the obtrusion is exposed. The surface of the aponeurosis is cleared for 1½ inches around the neck of the sac. The fibrous and peritoneal coverings of the hernia are divided by circular incision around the neck of the sac. The intestine is freed from adhesions and placed within the abdomen. The omentum is ligated and removed with

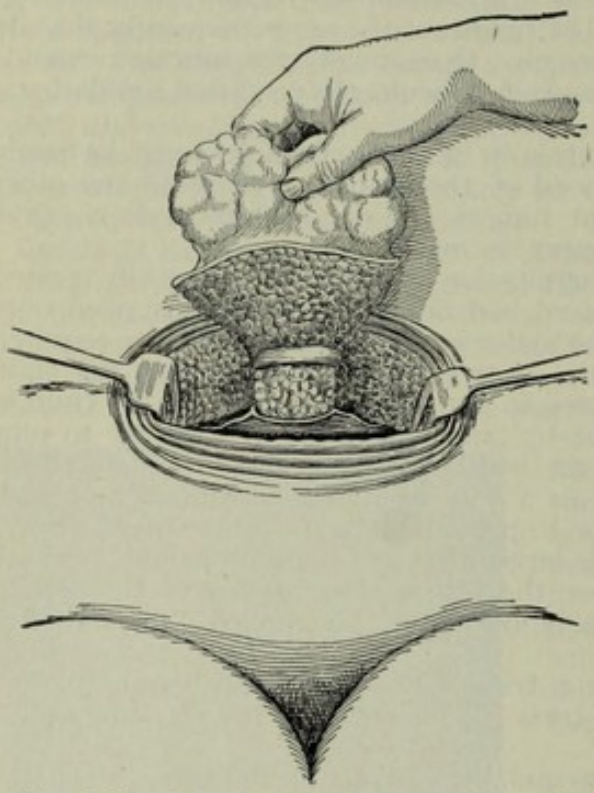


FIG. 935.—Mayo's operation for the radical cure of umbilical hernia: Exposure of hernia and lateral incision.

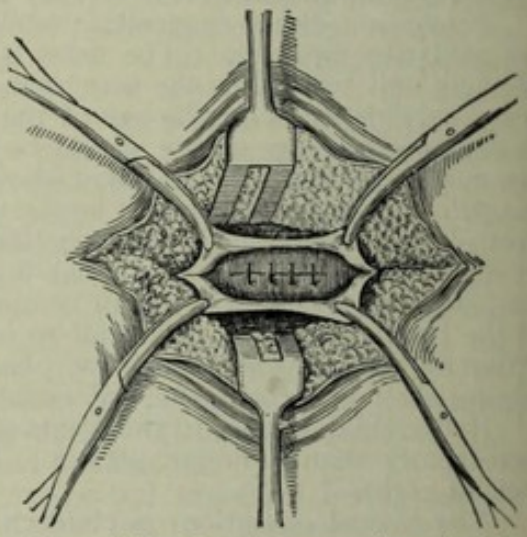


FIG. 936.—Mayo's operation for the radical cure of umbilical hernia: Peritoneum sutured.

the sac. The margins of the ring are grasped and overlapped in order to indicate in which direction closure can be most easily affected. An incision is made through the fibrous and peritoneal coverings of the ring 1 inch or more transversely on each side, and the peritoneum is stripped from the end surface of

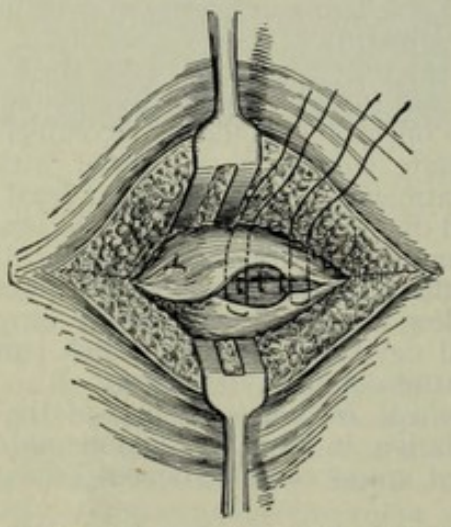


FIG. 937.—Mayo's operation for the radical cure of umbilical hernia: Aponeurosis sutured.

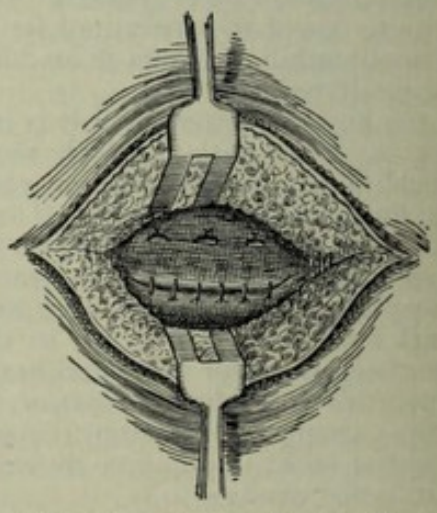


FIG. 938.—Mayo's operation for the radical cure of umbilical hernia: Aponeurosis sutured second time with gut sutures.

the upper flap. Several mattress-sutures of silver wire, kangaroo-tendon, or chromicized catgut are introduced 1 inch above the edge of the upper flap and are carried through the margin of the lower flap; sufficient traction is made to permit the closing of the peritoneum with a continuous catgut suture. When this

has been accomplished the first line of sutures of silver wire, chromicized catgut, or kangaroo-tendon is drawn so as to slide the lower flap into the pocket between the peritoneum and the end surface of the upper flap. The free margin of the upper flap is fixed by catgut sutures to the aponeurosis and the superficial incision is closed as usual (William J. Mayo, "Jour. Amer. Med. Assoc.," June 1, 1907).

Watson ("Hernia") finds that the flaps can be more accurately and firmly approximated if the lower flap is pulled through a narrow slit in the upper flap and sutured at intervals of 1 to 2 inches, instead of using the mattress-sutures. The edge of the upper flap is sewed to the anterior surface of the lower flap by a continuous suture of chromicized catgut. The skin and superficial fat are closed and the patient is kept in bed for twelve to twenty days.

The lateral flap operation, formerly used, has not proved as satisfactory as the Mayo operation or transverse flaps, because patients suffering with umbilical hernia usually have adipose abdomens which stretch the abdominal wall longitudinally. For this reason it is easier to overlap, as shown in Figs. 935–938, than by using the lateral flap. The double flap operation has been described by DuBois ("Surg., Gyn., and Obst.," vol. 21, p. 771) and a combined lateral and transverse overlapping operation is described by MacLean ("Surg., Gyn., and Obst.," Chicago, 1919, vol. 28).

In the series of 600 operations for non-strangulated hernia collected by Watson there were 9 deaths (1.5 per cent.).

When there is a considerable breach in the abdominal wall some surgeons use a filigree of silver wire introduced and stitched in place in the subperitoneal tissues. Should suppuration occur, removal of this wire filigree is often difficult. If there is a large opening in the abdominal wall a better procedure is to employ a flap of fascia lata stitched across the opening. There are few cases, however, that require this additional technic.

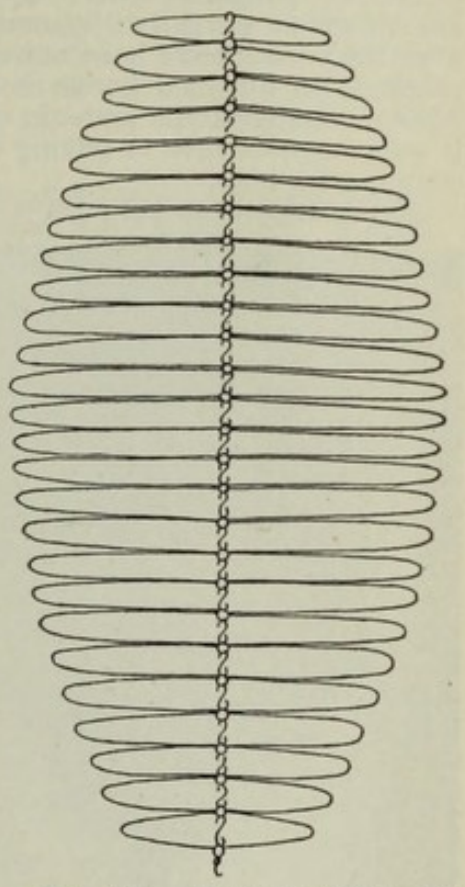


FIG. 939.—Bartlett's filigree for the cure of ventral hernia ("Mumford's Surgery").

Strangulated Umbilical Hernia in Adults.—Many umbilical hernias in adults are irreducible, and as the patient is probably accustomed to attacks of pain due to partial obstruction, it is often difficult to recognize when strangulation actually begins. Therefore strangulated umbilical hernia does not usually reach the surgeon as early as strangulated inguinal hernia. The strangulation is often intrasaccular and is frequently associated with gangrenous gut. Because of these facts, and because of the type of patients who usually suffer from umbilical hernia, discretion must be used in the extent of the operation. It is probably safer to relieve the strangulation under local anesthesia and to leave the radical cure for some future operation. The mortality of strangulated umbilical hernia is from 10 to 50 per cent., depending on the promptness with which operation is done.

Amniotic Hernia (*Congenital Hernia of the Cord*).—The coverings of such a hernia, according to Friend ("Surg., Gyn., and Obst.," September, 1920), are amnion, Wharton's jelly, and a sac prolonged from the peritoneum. The hernia may be small or large, and some of them are enormous. In some cases there is practical evisceration. The condition is probably the result of amniotic adhesions. If the mass can be reduced and the opening is not too large, prompt operation is imperative, and, if possible, the surgeon avoids opening the sac. A very small hernia does not require operation, as pressure by means of adhesive plaster will effect a cure.

Complications of Hernia.—A hernia may become inflamed, irreducible, obstructed, or strangulated.

Inflamed Hernia.—Inflammation of a hernia is local peritonitis, which involves the sac wall or the contents, and is due to frequent or rough manipulation, taxis, irritation from a truss, direct trauma, extension of inflammation from a loop of in-

testine, appendicitis, or tuberculosis. Inflamed hernia is most common in the femoral region, next in the umbilical, and finally the inguinal. It is more common in women than in men. The sac becomes tender and painful. Heat and tenderness may be noted. If the inflamed hernia is an enterocele, usually an accumulation of fluid is present. If the mass is an epiplocele, it becomes harder. The hernia cannot be reduced. There are gastro-intestinal symptoms, constipation, nausea, and vomiting. There is usually an elevation of temperature. The symptoms are more severe if the hernia is an enterocele than if it is an epiplocele. The mass still has an impulse on coughing. Some gas is usually passed through the bowels.

Treatment.—Rest in bed with abdominal relaxation. For children and adults an ice-bag to the tumor may be applied for a few hours, and a small amount of opium by mouth if the pain be severe. For the aged hot compresses should be used, as it is unwise to use an ice-bag for fear of producing gangrene. Give an enema. Do not give a purgative by mouth until after the bowels have been moved by an enema. An inflamed hernia is liable to become strangulated, and an operation is safer in preference to relying upon the conservative plan.



FIG. 941.—Hernia which has "forfeited the right of domicile."

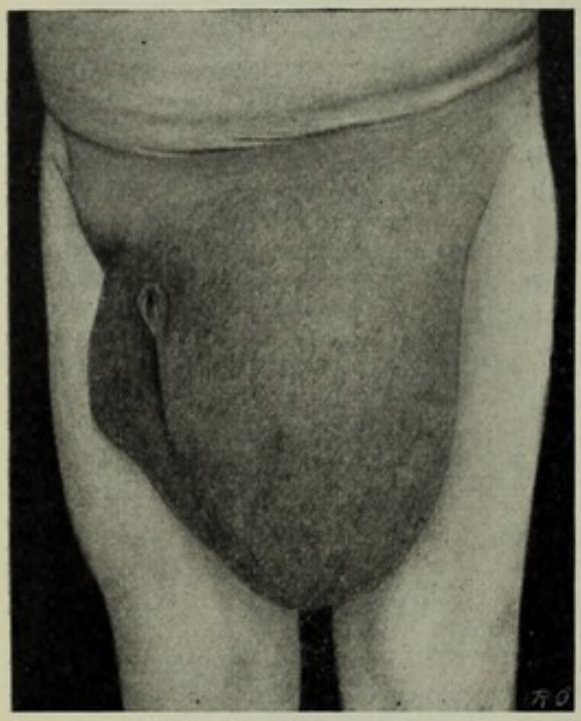


FIG. 940.—Irreducible hernia (de Garmo).

Irreducible Hernia.—The swelling of an irreducible hernia presents the usual evidences of hernia: imparts an impulse on coughing, but cannot be replaced in the abdomen. Sometimes a portion is reducible, but a portion left irreducible. A hernia may become irreducible because of the size of the mass, adhesions, excessive growth of omental fat, the accumulation of intestinal contents in the loops within the sac, or because of irritation and pressure of a truss upon the neck of the sac. Omentum is the most common content of the sac of an irreducible hernia. In order of frequency are omentum, large intestine, small intestine, ovary, tube, and bladder. An irreducible hernia is liable to be bruised. It may cause great distress and pain, and is always a menace to life because of the danger of inflammation, obstruction, and strangulation.

Treatment of an irreducible hernia is palliative or operative. An apparently irreducible hernia may be finally reduced by gentle taxis with the patient in the recumbent posture, the foot of the bed elevated, the thighs flexed on the abdomen, and a pillow beneath the shoulders so that the muscles of the abdominal walls are relaxed.

Taxis should not be employed for too long a time. Taxis should be gentle, never firm. If taxis causes severe pain, it should be discontinued. If taxis with the patient in the recumbent posture is not satisfactory, place the patient in a tub of warm water, first testing the temperature of the water with your own hand. With the patient submerged in the tub of water gentle taxis is again employed. If the contents of the sac is reduced to the abdominal cavity, a truss should be applied at once. Unless contraindicated, operation should be advised. The truss should be worn until the operation is performed. A large hernia (a hernia having lost its "right of domicile"—Fig. 941), if operation be refused, must be carried in a bag truss if the ordinary truss is not able to hold it in place. The patient must be warned against very active exercise, must keep the bowels regular, and live on an easily digested diet.

Operative procedure must depend upon the location of the hernia.

Obstructed, Incarcerated, or Choked Hernia.—Obstruction occurs as the result of the damming up of feces or of undigested food. The fecal current is arrested, but the blood-supply in the wall of the bowel is not cut off. Obstruction is most common in irreducible hernia, especially umbilical, and occurs during the existence of constipation. The passage of both gas and feces is obstructed. The hernia enlarges, becomes tender, painful, and dull on percussion. These symptoms usually develop slowly and may at first be indefinite. If an impaction of feces is present within the sac the hernia may feel like dough or putty. The abdomen is somewhat distended and painful. There is nausea, vomiting, and constipation. The vomiting is not as severe as in strangulation, and is not fecal. There may be attacks of colic.

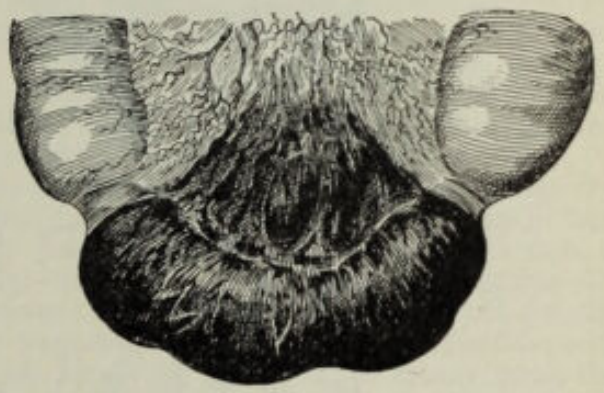


FIG. 942.—A strangulated coil of intestine after the strangulation has existed for a considerable period of time. The color has become almost black and the peritoneal surface is dull and covered with flakes of fibrin. The constriction rings are deeply sunken, their walls markedly thinned, relaxed, and dirty gray in color. Both constriction rings are gangrenous and hemorrhages are observed in the mesentery (Sultan).

The treatment is rest in bed in a position to relax the abdominal wall. An ice-bag is placed over the hernia in children and in adults, but should not be used in the aged for fear of the development of gangrene. A hot-water bag or hot compresses should be used in obstructed hernia in the aged. Do not employ taxis, as bruising the bowel may produce strangulation. Do not give a particle of food for twenty-four hours. A high enema should be used and, if satisfactory, a laxative may be given. Never give a laxative until the bowels have been moved by an enema. A small amount of opium may be administered to relieve acute pain. If improvement does not rapidly occur, advise operation. Prompt operation saves the patient from the danger of strangulation and cures the hernia.

Strangulated hernia is a condition in which, if the hernia contains bowel, not only is the fecal circulation arrested and gas prevented from passing, but the circulation of blood in the bowel wall is also arrested. The bowel is irreducible and obstructed, and the blood ceases to circulate (Fig. 942). If the hernia contains omentum the omental vessels are tightly constricted. Gangrene occurs in both bowel and omentum, but more quickly in bowel than in omentum. Strangulation is most common in old inguinal hernias in active middle-aged men, and is more frequent in enteroceles than in epiploceles. It is most common when the hernial orifice is small. It is seldom seen in large ruptures. It is more common in males than in females because a larger majority of hernias occur in men. The actual percentage of strangulation (14.06) is higher in females in proportion to the number afflicted. Strangulated hernia is rare in infants and infrequent in children. Strangulation is much more dangerous when bowel is present in the sac than when omentum is the only content. Femoral hernias strangulate most frequently—6.45 per cent. in men and 9.05 per cent. in women (Berger). This fact is due to the small fibrous ring and sharp cutting edge of Gimbernat's ligament (Watson). Umbilical hernia strangulates next in frequency to femoral hernia. Strangulation is due to the pressure of a constricton upon the sac contents, obstructing the blood-supply. Strangulation caused by the neck of the sac alone is infrequent.

Strangulation by the hernial ring, or extrasaccular constriction, is the condition which is usually found. The hernial ring is the primary cause. Elastic strangulation occurs when the intra-abdominal pressure of a subject of hernia is suddenly increased, as by violent cough or muscular effort. The hernial orifice is dilated for a moment. More intestine or omentum may enter the sac, become caught and squeezed by the now constricted hernial orifice, and strangulation occurs. A sudden increase of intra-abdominal pressure may force a quantity of fecal matter into the herniated intestine. The sudden entry of a quantity of fluid and gas into the hernial coil causes fecal strangulation, the mechanism of which is obscure. By retrograde strangulation (*Maydl's hernia*) we mean a condition in which the end of a loop of bowel or piece of omentum in a hernia re-enters the abdomen and then becomes strangulated, the balance of the hernia not being strangulated. In retrograde strangulation the sac contains two loops of intestine (Fig. 943). The portion of intestine between the two loops remains in the abdominal cavity (Watson, "Hernia"). Retrograde strangulation of the appendix, or Meckel's diverticulum, may occur. Strangulation due to volvulus or torsion of the

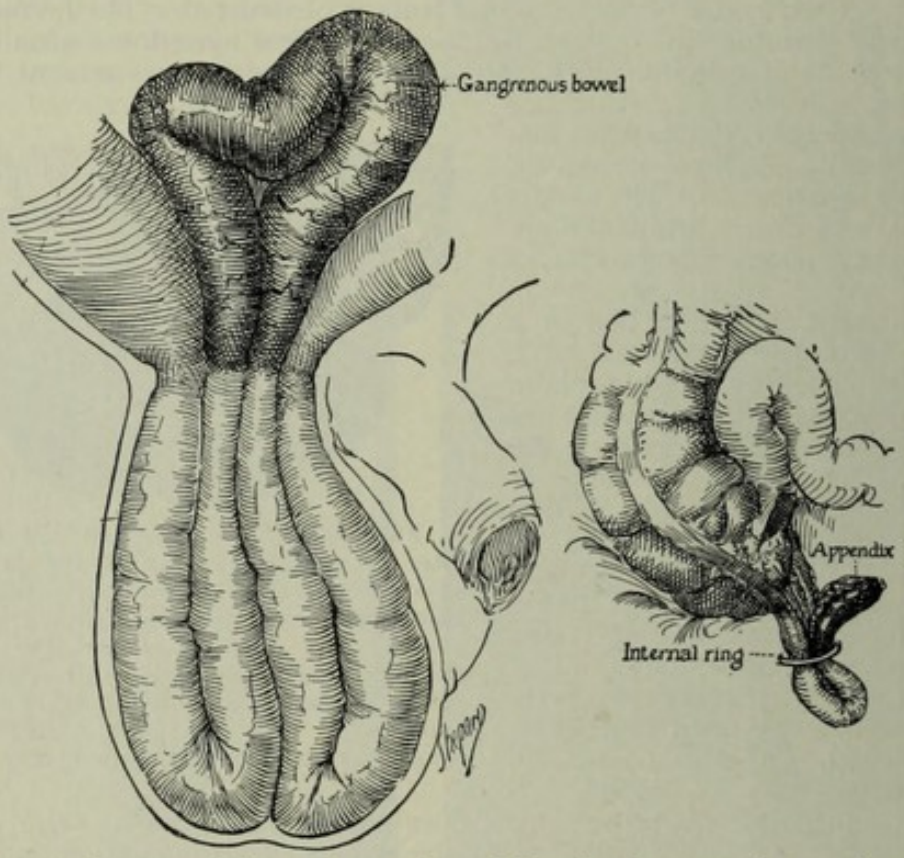


FIG. 943.—Retrograde strangulation: The portion of intestine between the two loops remains in the abdominal cavity (Watson, "Hernia").

sac contents is uncommon. Strangulation may be due to active peristalsis or congestion, or may arise from inflammation or from incarceration. The constriction may be at the neck of the sac, in the outside tissues, or even in the sac itself. In an hour-glass hernia the constriction may be in the body of the sac. In inguinal hernia a tight external ring is the common cause of strangulation, and is the commonest cause in children. Adhesions within the sac may cause strangulation. Spasmodic contraction of the tissues about the neck of the sac is an exploded hypothesis.

Strangulation is the most frequent complication of hernia. In 10,000 cases of hernia studied by Berger there were 43 irreducible hernias, 58 inflamed hernias, and 250 strangulated hernias (Watson, Ibid.).

Above the constriction the intestine is edematous and dark from venous congestion and is distended by gas. Peristaltic waves above the site of strangulation increase the tension. Here the intestine may be two or three times its normal size, and distention may cause a paralysis of the muscular wall of the intestine. That part of the intra-abdominal intestine which lies distal to the strangulation is of normal size and color, and is collapsed. In the beginning of the strangulation the intestine which is

caught is bright red in color, but, as the congestion increases, the obstructed veins dilate and the blood in them ceases to move. The bowel becomes deep bluish and finally black. The serosa remains shiny for a time. Effusions of blood occur beneath the peritoneum and the intestinal wall becomes edematous. As the venous stasis increases and the constriction gradually occludes the arterial supply the congested appearance is replaced by ecchymotic areas in the intestine, the edema increases, and the serosa, which was shiny, becomes rough and dull. Patches of serous exudate appear on the intestinal mucosa. Fluid transudes into the sac. Fluid is at first clear, then assumes a bloody hue, and finally becomes foul.

Strangulated omentum undergoes edema and hemorrhagic infarction and thrombosis occurs.

When strangulation once begins the hernia swells. A furrow forms on the bowel at the seat of constriction. Bowel and omentum below the constriction become deeply congested and edematous, and finally moist gangrene occurs. The gangrene may be in spots or the entire mass may be gangrenous (see Fig. 942). The mucous membrane may be gangrenous when the serous coat looks fairly sound. When gangrene is once established the bowel is in danger of rupturing. At the point of constriction there may be a line of ulceration or of gangrene, even though the remainder of the intestine may look fairly safe. A strangulated femoral hernia becomes gangrenous more rapidly than a strangulated inguinal hernia.

Perforation occurs most frequently at the convexity of the strangulated loop (Watson, "Hernia"). The changes in the strangulated mesentery are similar to those in the strangulated intestine. The mesentery becomes swollen and ecchymotic, and the mesenteric vessels are usually thrombosed. In Berger's series of 239 cases of strangulated hernia, 48 strangulated the first time the hernia appeared, 89 strangulated within ten years of onset, and 102 strangulated more than ten years after onset.

Symptoms.—Strangulation is sometimes preceded by diarrhea and pain about the hernial orifice. When strangulation begins the victim is seized with a pain in and about the hernia and with violent colicky pains about the umbilicus. This pain is due to the peristaltic waves from above the obstruction attempting to overcome the constriction. The paroxysms of colic become more and more frequent until, finally, the pain may become continuous. Pain does not subside until the peristaltic contractions have ceased. The cessation of pain is a grave symptom, as it may mean the cessation of peristaltic contraction and the development of gangrene. The hernia is found to be irreducible, larger than usual, tender, painful, dull on percussion, without impulse on coughing, and the skin above it may be reddened. On auscultation there are no gurgling sounds over the tumor. Eructations of gas are frequent and generally uncontrollable vomiting and prostration occur. Vomiting, as a rule, is an early symptom. In cases where a portion of the lumen of the intestine is obstructed, as in partial enterocele (Richter's hernia), there may be nausea without vomiting. Vomiting, as a rule, in complete obstruction is an early symptom. Vomiting occurs earlier when the constriction is in the upper portion of the intestine than when it is in the lower part of the ileum or large intestine. In the beginning vomiting is purely reflex and is projectile in character. Later the vomiting is due to reversed peristalsis and is stercoraceous. In rare cases vomiting does not begin for twenty-four or forty-eight hours. Vomiting is earlier and more violent when bowel is present in the sac than when the hernia is purely omental. Stercoraceous vomiting rarely arises until strangulation has lasted forty-eight hours, and may not appear until much later.

Prostration is a marked symptom of strangulated hernia, and it increases hour by hour until collapse occurs. Early in the case there may be an elevation of temperature, but later the temperature becomes normal or subnormal. The pulse is small, irregular, rapid, and very weak; the extremities cold; the face becomes Hippocratic. Prostration occurs early in infants, in young children, and in the aged.

Constipation is absolute, no gas even being passed, although in the very beginning there may be some diarrhea from below the constriction. The urine is scanty and high colored, and contains only a small amount of chlorids. The tongue becomes dry and brown. The eyes are sunken and dull. The skin is cold, clammy, and moist. When gangrene begins the symptoms apparently lessen in violence, hence there is a delusive calm, or false sense of security. Vomiting usually ceases, although regurgitation may take its place. Hiccough begins. The pain abates or disappears. The pulse becomes frequent, feeble, and intermittent. Breathing is labored, rapid, and shallow. The skin is cyanotic. Collapse deepens and delirium usually occurs. It is a safe clinical rule that in strangulated hernia sudden cessation of pain without relief of the con-

striction, the disappearance of the lump, or the use of opium means that gangrene has begun. In children convulsions are not unusual.

In a strangulated epiplocele the symptoms are identical, but are less decided.

Prognosis of a strangulated hernia is always serious. The gravity of the prognosis increases with age. The prognosis of strangulated massive hernias or those which have lost their "right of domicile" is very grave.

Treatment.—If a positive diagnosis of strangulation can be made, operation is the treatment of choice. The only exception to this rule is strangulated hernia occurring in children and infants, and those in whom, because of some associated constitutional disease, operation is contraindicated. For such cases taxis may be employed. When taxis is attempted it must be made with the gentlest manipulation. Always lower the shoulders and head and raise the pelvis. This can be accomplished by elevating the foot of the bed and placing pillows under the pelvis. In applying taxis to femoral or inguinal hernia flex and adduct the thigh of the affected side. In applying taxis to an umbilical hernia both thighs should be flexed upon the abdomen and the shoulders raised to relax the muscles of the abdomen. Grasp the neck of the sac with the fingers and thumb of one hand and employ the other to gently squeeze the hernia and reduce it toward the belly. In direct inguinal hernia the pressure should be backward and a little upward. In oblique inguinal hernia it should be upward, outward, and backward. In an umbilical hernia it should be backward. In a femoral hernia it should be downward until the hernia enters the saphenous opening, and then backward toward the pubic spine. If the bowel should be reduced it will pass in from the hand with a sudden slip and enter the belly with an audible gurgle. Omentum when reduced glides back slowly without gurgling.

If taxis fails with the patient in bed, gentle taxis may be attempted with the patient in a tub of warm water. If taxis is successful the patient should be put to bed and pads should be placed over the hernial orifice and a bandage applied. Allow no food until vomiting ceases, merely permit the patient to take a little hot water during the first twenty-four hours. Employ the Murphy drip and keep the patient on a liquid diet for several days. Do not disturb the bowels for forty-eight hours. Then give an enema. If the enema is effectual, follow it by a saline cathartic. There is usually a spontaneous movement within twenty-four hours after a reduction by taxis. Taxis must not be used if there is stercoraceous vomiting.

Taxis is contraindicated when the onset of the strangulation is acute and the symptoms are severe; when the coverings of the hernia are inflamed or edematous; when there are symptoms of prostration and shock; when there are signs of ulceration and gangrene (Watson, "Hernia"), and when it is known that the mass is irreducible.

Taxis possesses certain dangers. It may rupture the bowel; it may rupture the neck of the sac and force the bowel through the rent into the tissues of the abdominal wall; force infected sac contents into the peritoneal cavity; strip the perintoneum from around the hernial orifice and force the bowel between the detached peritoneum and the abdominal wall; reduce gangrenous intestine into the abdominal cavity; reduce ulcerated or perforated intestine to the abdominal cavity; produce intestinal hemorrhage; fail to relieve the strangulation when the constriction is intrasaccular; cause torsion of a loop of intestine which may persist after reduction; cause intestinal paralysis; or may reduce *en masse* or *en bloc*.

Reduction *en masse* or *en bloc* is reduction of a strangulated hernia without relieving the constriction of the contents of the hernial sac. By reduction *en bissac* is meant the forcing of a congenital hernia into a congenital pouch or diverticulum. Reduction *en masse* is a rare accident. It results from manipulation or taxis. The sac is freed from the subcutaneous tissues, the constricting ring is dilated, and the hernia displaced to a position beneath the peritoneum inside the internal abdominal rings. Reduction *en masse* may result when the patient tries to reduce his own hernia, or results in the aged when associated with an excessive amount of extraperitoneal fat and relaxation of peritoneum. It most frequently occurs between the ages of thirty and sixty. It is seldom seen except in males and is most common in the inguinal region. In a majority of the cases reported in the literature it was found at autopsy. The accident is a very dangerous one, and the prognosis is grave. The mortality is high (about 40 per cent. for inguinal reductions and 72 per cent. for femoral reductions). In acute cases the small bowel is the viscus which has been reduced. In subacute and chronic reductions *en masse* the omentum, large bowel, or bladder may have been reduced. Subacute and chronic cases may occur in non-strangulated hernia. In any of the above accidents obstruction may persist after the apparent reduction

by taxis. Persisting obstruction means strangulation or peritonitis, and calls for immediate laparotomy. When operating for a suspected hernia *en masse* a midline or lateral rectus incision should be used. By this incision each hernia ring should be examined in turn from within the abdomen. When the strangulated mass is found the constriction should be divided, the strangulated content of the sac should be withdrawn into the abdominal wound, inspected, and dealt with as the condition would indicate. A herniorrhaphy is performed if the general condition of the patient permits; otherwise the repair of the hernia is left for a secondary operation.

Operative Treatment for Strangulated Hernia.—If there has been stercoraceous vomiting the stomach must be washed out before beginning the operation. Local anesthesia is preferred. Patients with strangulated hernia are always poor risks because of shock. If a general anesthetic is given the combination of nitrous oxid and oxygen, with as little ether as possible, should be administed. If a general anesthetic is administered try gentle taxis for a very brief time, but never try taxis if stercoraceous vomiting has occurred. The term "kelotomy," or "herniotomy," was used by the older surgeons to describe a blind division of the constriction of the hernia. For this purpose Cooper's curved herniotome (Fig. 944), which is a curved, narrow-bladed bistoury with a sharp cutting edge and a blunt point, was the instrument of choice. It is still used by some surgeons to divide the constriction.

The old surgeons rarely opened the sac because of the fear of peritonitis.

The incision is made over the tumor. The incision is usually longer than for the radical cure of a non-strangulated hernia. The sac is exposed, isolated, and separated as far as possible from surrounding structures. The sac is opened carefully to avoid possible injury to the adherent underlying viscera. Note the character and amount of the fluid escaping from the sac and take a culture of the fluid. If the fluid is a clear serous exudate, it usually means that the changes in the intestine are not far advanced. If it is dark red or brown and has a fecal odor, gangrene has developed. The cause of strangulation is then searched for. The constriction is divided with a Cooper herni-

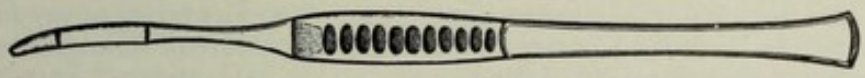


FIG. 944.—Cooper's curved herniotome.

otome. If the hernia is oblique inguinal and the constriction is at the internal ring, sever the constriction upward and outward or directly upward. In direct inguinal hernia and in oblique inguinal hernia constricted at the external ring the incision through the constriction is made upward and inward. This is to avoid injuring the deep epigastric artery. Doyen states that it is often easier to divulse or tear the constricting ring by means of a pair of long-bladed forceps than to cut it. (Doyen, "Surg. Ther. and Oper. Tech.," W. Wood & Co., 1920, vol. 3, p. 29.) If the serous coat of the intestine glistens, if the proper color returns to the bowel wall after application of towels rung out in sterile water or saline solution at a temperature of 115° F., and if there are no areas of gangrene, restore the bowel to the abdomen, and, if the patient's condition permits, do a radical operation. If the bowel is in a doubtful condition, fasten it to the incision, apply sterile vaselin dressing, and watch for the development of events. The abdomen is usually closed without drainage. If omentum is part of the contents of the sac, it should be returned to the abdominal cavity if in good condition. If the omentum is inflamed, strangulated, or irreducible, it should be ligated and excised. Watson emphasizes the importance of freeing the mesenteric vessels from all other tissue before ligating them to avoid leaving masses of necrotic mesentery, which are liable to become infected and suppurate. If the bowel is gangrenous our action must depend upon the condition of the patient. If the area of gangrene is small, it can be inverted with a purse-string suture. If the gangrene is extensive, the gangrenous portion is resected and an end-to-end intestinal anastomosis is performed. A Murphy button is occasionally used for this approximation. If the condition of the patient permits, the method of choice is to perform a lateral intestinal anastomosis. If the patient's condition is unsatisfactory, draw the gangrenous portion well out, anchor it to prevent leakage and retraction, make an artificial anus, and at a later period perform anastomosis. This procedure is most useful for strangulated hernias of the descending colon or sigmoid. Unfortunately, however, in some cases the artificial anus must be made in the small intestine. If the need of an artificial anus is uncertain, prepare the bowel for the opening, but do not open at once

because the bowel may recover in a day or two, when it can be restored to the abdomen, or it may slough and form the artificial anus. In such doubtful cases fasten the bowel to the belly wall with sutures, cover with sterile vaselin, dress it with hot antiseptic fomentations, and await developments. Strangulation of a femoral hernia may be operated upon by the femoral route or the inguinal route. If the femoral route is attempted and gut is found gangrenous or in a doubtful condition, it is then necessary to perform a combined operation.

The advantages of the inguinal operation for strangulated femoral hernia are that the sac and contents can be more thoroughly examined; a resection or an anastomosis, if necessary, can be more easily accomplished; the constriction can be located quickly and divided; and the remainder of the intestine can be inspected. The disadvantages of the inguinal operation are that Hesselbach's triangle must be incised, consequently there is more danger of a recurrence of a postoperative direct inguinal hernia, and it usually takes more time.

Strangulated umbilical hernia is often intrasaccular and due to the omental adhesions in the sac. Many who have umbilical hernia are of advanced age, obese, and have an associated myocarditis. For these reasons it is usually safer to relieve the strangulation under a local anesthetic and to leave the radical operation for a future time. For the radical cure of umbilical hernia see page 1144.

The postoperative treatment of strangulated hernia is to place the patient in the recumbent position; bend the knees over a pillow; give no food by mouth for twenty-four hours, only allowing sips of hot water by mouth; relieve thirst and aid shock by Murphy drip or an enema of salt solution every sixth hour. Hypodermoclysis may be used instead of the Murphy drip. No cathartic should be given for thirty-six hours. When it has been necessary to do an intestinal resection rectal feeding should be used for several days.

Mortality.—Cases of strangulated hernia irreducible by taxis will practically all die without operation. The mortality following operation is large. It is not due to the operation, but due to the condition, and is due particularly to delay in operating or to the use of forcible antecedent taxis. The mortality of operation for non-strangulated hernia is under 1 per cent. The mortality rate of strangulated hernia is in direct proportion to the duration of the strangulation. Alexander ("Annals of Surgery," Phila., 1923, vol. 48, p. 639) reported 105 cases of strangulated hernia. Mortality of those operated within one to twelve hours was 5 per cent.; twelve to twenty-four hours, 28 per cent.; twenty-four to forty-eight hours, 41 per cent.; three to four days, 76 per cent. The mortality rate is higher for femoral hernia than for inguinal, and the mortality rate of strangulated umbilical and ventral hernias is nearly twice as great as of inguinal hernia. "The mortality rate for strangulated hernia is still much too high. It can be lowered only by early diagnosis, prompt treatment, a more general adoption of the two-stage operation in gangrenous hernia in the seriously ill patient, and the routine use of local anesthesia" (Watson).

Recurrence of Hernia.—Without an elaborate follow-up system it is impossible to give correct and accurate statistics on the recurrence of hernia after operation for radical cure. Statistics as given in many text-books are misleading. One text-book states that "recurrence of hernia takes place in very few cases—3 per cent. or less"—whereas another text-book states that "recurrence occurs in 10 per cent. of the cases." Masson's statistics as to recurrences in the Mayo Clinic ("Minnesota Medicine," Oct., 1919, p. 373) shows that in 7016 cases there was "less than 1 per cent. following the anatomic operation." This article fails to record the number of recurrences which followed operation for direct hernia or indirect hernia.

The statistics of Seward Erdman ("Annals of Surgery," Feb., 1923) give the late results of 978 cases operated upon at the New York Hospital on the service of Dr. E. H. Pool. These statistics were compiled as the result of a most efficient follow-up system. Of the 978 cases, 908 returned to the hospital for examination; 70 other cases were examined by physicians other than the staff of the hospital and letters were forwarded noting their conditions; 92.84 per cent. of the 978 cases operated upon returned for examination at the hospital, and 7.16 per cent. were traced by letter. The percentage of recurrence in the 978 cases was 7.46. Of the 665 operations for oblique hernia, there was a recurrence in 3.15 per cent., while of the 313 operations for direct hernia, there was a recurrence in 16.61 per cent. This, in my opinion, gives the most accurate information on recurrence of hernia at present in our literature. We are too apt to belittle the possibility of recurrence. Erdman classifies the direct-indirect, or saddle-bag, hernia under the recurrences of direct hernia.

No statistics are accurate unless the patient has been examined by a surgeon for recurrence, because the patient may have a recurrence and not be aware of the condition.

Erdman points out that 47.9 per cent. of all recurrences were observed within six months after operation, 73.9 per cent., within the first year; 90.4 per cent., within eighteen months; 98.6 per cent., within two years.

Bull and Coley report 65 per cent. of the cases recurring within the first six months after operation and 80 per cent. within the first year.

The age of the patient as a contraindication for operation for hernia has been mentioned on page 1126. Erdman does not recommend operation for hernia after the age of fifty-five, unless the patient is unable to wear a truss, or there is obstruction, strangulation, etc. Coley ("Progressive Medicine," June, 1923, p. 19), on the other hand, does not regard age alone as a serious contraindication to operation, "but many conditions associated with advanced age make it unwise to operate; namely, the presence of nephritis, diabetes, valvular lesions of the heart, or advanced arteriosclerosis."

Coley ("Annals of Surgery," 1918, p. 225) reports a total of 8589 cases, 6090 of which were operated on at the Hospital for the Ruptured and Crippled, at New York. Most of them were under fourteen years of age; 1966 were operated on at hospitals other than for the ruptured and crippled. Of 4220 cases of oblique hernia in the male, all ages, there were 25 recurrences, or 0.57 per cent. Of 33 direct hernias, male, there were no recurrences. Of 369 indirect hernias in women there were 13 recurrences, or 3.5 per cent. Of 13 direct hernias in women one recurred, 7.7 per cent. It must be noted in the excellent results of Coley that a large percentage were operations on children under fourteen years of age. Coley states in the same article, "if the final results of patients who have been operated upon for direct hernia are carefully followed up for at least a period of two years after operation, we believe that fully 10 to 15 per cent. would show a distinct recurrence."

Druner ("Deutsch. Ztschr. f. Chir.," Liepzig, June, 1919, vol. 150, p. 7) reports 21.4 per cent. of recurrences following the Bassini operation. Moschcowitz ("Annals of Surgery," 1917, p. 733), at New York Hospital, reports 6.86 per cent. recurrences. Stetten ("Annals of Surgery," 1920, p. 744) reports 200 cases operated on by his method, in which there was no recurrence.

Cases for herniorrhaphy should be properly selected. The older the patient, the greater the chance of recurrence. Masson (Ibid.) reports that in 330 cases of recurrence 25 per cent. were fifty years of age or over, and more than 50 per cent. of the recurrences were over forty years of age. The younger the patient, the more readily the tissues heal, and, as a rule, the younger the patient, the less dilated are the rings. Taylor's statistics ("Arch. of Surg.," 1920. p. 382) emphasize an interesting point—that of 356 patients examined at Johns Hopkins Hospital for recurrence following operation for inguinal hernia 8.4 per cent. recurred, and of 460 patients heard from by letter, but not examined, only 3.4 per cent. were reported as having recurred. This proves that a patient's opinion concerning recurrence is not accurate.

In the compilation of statistics for the determination of the percentage of recurrence it is of paramount importance to divide the direct hernia from the indirect. No table of statistics is of any value, in fact, it is misleading unless this division is made (Owen, "Penna. Med. Jour.," vol. 25, 1921–22).

In Erdman's statistics of 849 males, 220 were operated upon on both sides. The tendency to bilateral hernia is much more marked in the direct than in the indirect. Erdman believes that the *Pool bulge* (a marked bulging of the fatty abdominal muscles of the inguinal region) not only predisposes to hernia but also predisposes to recurrence.

Patients suffering with hernia should be studied very thoroughly before operation. It should be noted in the history whether the hernia is direct, indirect, or whether saddle-bag (a direct-indirect hernia); also the condition of the muscles and, especially, the strength of the conjoined tendon. Bloodgood emphasizes the fact that recurrence of hernia is in a large part due to the failure of surgeons to grasp the importance of the conjoined tendon in solid repair. He finds that in 5 per cent. of inguinal hernias the conjoined tendon is missing.

The rôle of the anesthetic in recurrence of hernia is questionable. There are many advocates of local anesthesia for practically all herniorrhaphies, except in children. Stetten operated on 200 cases under local anesthesia, without any recurrence. Taylor (Ibid.) reports 50 cases of indirect hernia under local anesthesia, with 6 recurrences, only 1 case was infected. Taylor states that "the use of local anesthesia slightly in-

creased the rate of recurrence, but did not seem definitely to have affected the healing of the wound." For routine herniorrhaphies I still use the combination of nitrous oxid gas and oxygen anesthesia. For hernias with strangulation, pulmonary complication, etc., I employ local anesthesia or spinal anesthesia.

There can be no one operation for hernia—direct, indirect, or recurrent. The operation should conform to the varying conditions presented by each individual case.

The operation should be performed by cutting with scalpel or scissors and not by tearing or stripping with gauze. The same gentleness in handling tissues should be used if the patient is under a general anesthetic as must be used when operating under local anesthesia. The ilio-inguinal and iliohypogastric nerves must never be cut or caught in sutures. When possible the sac of the hernia should be tied high up and completely removed. In the indirect hernia the sac should be invaginated under the transversalis and internal oblique. Erdman, however, points out that "in bilateral hernia when the neck of the first hernial sac has been transfixed high up and doubly ligated, in operating on the other side it is quite possible in the effort to close the sac high up undue traction is exerted across the midline or upon the recently ligated first sac and slipping of the ligature may take place." He adds, "this is no mere conjecture of the writer, but is based upon actual experience and inspection during the simultaneous operation on bilateral hernia by the operator, and an assistant, when it is very easy, especially in direct hernia, for the operator, by tugging on the sac, to exert too much traction on the opposite sac."

For what length of time should a patient who has been operated on for hernia remain in bed? It is believed that many recurrences are due to the fact that the patient was allowed to get out of bed too soon after operation. It is my practice to keep all adults in bed at least eighteen days and, if the operation was bilateral or for large and direct hernia, to keep the patient in bed twenty-one days. Children may be allowed out of bed in ten to twelve days. Some surgeons, notably Masson, allow patients out of bed in eight days. I am not convinced that remaining in bed fifteen to twenty-one days causes muscle weakness or atrophy from disuse.

Recurrence may occur if a man is allowed to resume laborious work too soon after operation, especially if he is compelled to use the same group of muscles continuously. This point is emphasized impressively by Owen's operations upon the police and firemen of Philadelphia. He never allows a policeman or fireman to resume active duty until three months have elapsed since the operation for hernia. He is allowed to do light duty or house duty four to six weeks after being discharged from the hospital. Physicians in large industrial plants have demonstrated that a man is more likely to have a recurrence if returned to the same character of work after operation as was assigned to him before operation.

Should a bandage or belt be ordered for a patient following herniorrhaphy? I do not make it a rule to order a belt if the patient is young and muscular, but recommend a belt for one who has a large, adipose, or pendulous abdomen, or after operation for bilateral hernia. A truss should never be worn following herniorrhaphy.

Moschcowitz tabulates the causes of recurrence as follows:

1. Proper operation improperly done.
2. Improper operation properly done.
3. Improper operation improperly done.

Mortality Following Non-strangulated Hernia.—In 8000 operations for non-strangulated inguinal hernia in adults collected by Watson (Ibid.) there were 30 deaths (0.38 per cent.).

Ventral hernia is a protrusion in any part of the anterior abdominal wall, except at the umbilicus, inguinal, or femoral regions (Fig. 945). A ventral hernia may be median (hernia of the linea alba) or lateral. Ventral hernias are of two groups—spontaneous or acquired and traumatic or incisional.

There are several types of the spontaneous variety—hernia in the linea alba, hernia in the linea semilunaris, hernia in a transverse line, and hernia in the sheath of the rectus muscle.

Traumatic or incisional hernias may appear anywhere in the median or lateral abdominal wall.

The term "*epigastric hernia*" is restricted to those appearing in the epigastric region. In the condition known as epigastric hernia there is a protrusion of the peritoneum in the space bounded by the ensiform cartilage, the ribs, and the umbilicus. The sac of the peritoneum may be empty, may contain omentum, or omentum and

bowel. The stomach very rarely passes into the sac. The protrusion is usually, but not invariably, through the linea alba. The condition may be due to a congenital gap in the transversalis fascia, or to the growth of a fatty hernia. This condition may cause abdominal pain, chronic diarrhea, epigastric pain, nausea and vomiting after eating or effort. It is very seldom strangulated. In some cases the omentum becomes strangulated. In young children the linea alba is very thin and abnormally wide. Bulging is often noticed when the child cries. If the protrusion is above the umbilicus, it is known as supra-umbilical eventration. In adults diastasis of the recti muscle may occur anywhere along the linea alba, but usually appears below the umbilicus.

Mechanical treatment in epigastric hernia is usually unsatisfactory, and operation is the treatment of choice. Operation should be performed early, before atrophy of the muscles occurs.

Hernia in the linea alba includes about 1 per cent. of all cases of hernia. Ventral hernia occurs four to five times more commonly in men than in women. It is usually caused by congenital weakness of the linea alba, by laborious occupations, and traumatic injuries. In woman pregnancy is the principal exciting cause. Obesity and rapid emaciation also play an important part.

Litten's Sign.—With the patient in the erect position, if the examiner place his hand over the suspected hernia and the patient coughs, the examiner will feel a vibration or tremor as would be experienced if liquid or a handful of peas were thrown against his hand. It is believed that this is due to the presence in the sac of intestine containing fluid, and to small lobules of fat in the omentum forced outward by the impulse of coughing.

Treatment.—The mechanical treatment of hernia in the linea alba is unsatisfactory because of pain and discomfort caused by wearing a truss or belt.

Operative Treatment.—A small vertical or transverse incision is made over the center of the mass, and the skin and subcutaneous tissue are divided down to the hernia. After returning the contents of the hernia to the abdominal cavity, and all adhesions are separated, the fascia is closed, preferably by overlapping. If the hernia is large, flaps can be reinforced on each side by additional flaps from the anterior sheath of the rectus muscle or from free fascial transplant from the fascia lata.

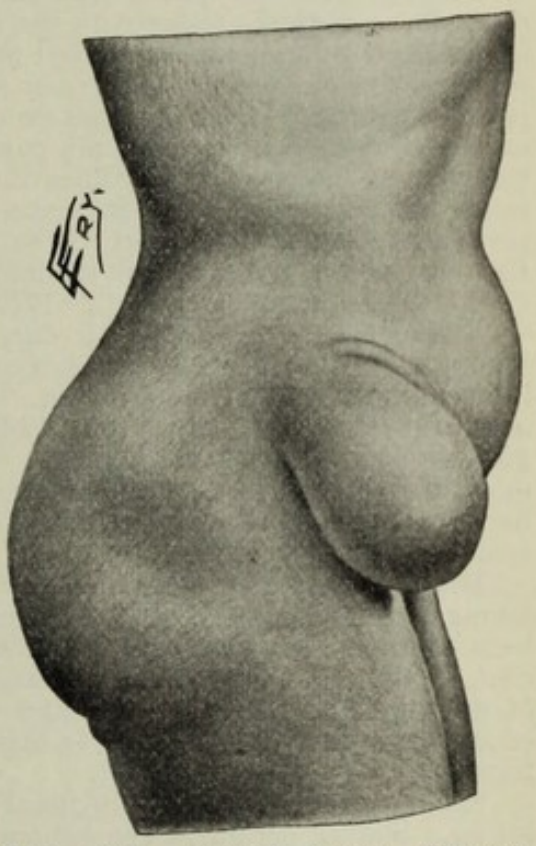


FIG. 945.—Ventral hernia ("Keen's Surgery").

Hernia in the linea semilunaris is usually situated at the semilunar fold of Douglas, where the posterior rectus sheath is deficient. It is nearly always found at the inner third of a line passing from the anterosuperior spine of the ileum to the umbilicus. The hernia may have more than one opening and may be subcutaneous or interstitial. Macready has termed it the "masked hernia." There is usually a sac, which contains omentum and small intestine.

The spontaneous type of lateral ventral hernia is usually due to multiple pregnancies, obestity, marked emaciation after obesity, ascites, maldevelopment of the abdominal wall, and muscular paralysis (Watson).

These hernias usually occur in middle life and both sexes are equally affected.

Traumatic lateral ventral hernia is usually due to accident or is incisional. When due to injury it is usually caused by a crushing blow or a fall from a height. The incisional type usually follows postoperative suppuration and the use of drains, large size, or of packs, or to faulty closure of the muscles and fascia and the division of nerves supplying the muscles.

Incisional hernias may occur anywhere in the abdominal wall.

The prevention of incisional hernia depends largely upon the incision employed,

the method of closing the wound, and asepsis. The incision should be as small as is consistent with the proper management of the case, and great care should be exercised to avoid motor nerves and to protect, as far as possible, muscles, fascia, and blood-vessels. Muscle-splitting incision should be used when possible. Two short incisions will heal more solidly than one long incision and strong traction is always to be avoided. Fascia unites more slowly than muscle, and, for this reason, the edges of fascia should be overlapped. Tension should be avoided. This can best be accomplished by placing a pillow under the knees. The patient should be kept in bed for at least three weeks after an abdominal operation requiring large incision. All hemorrhage should be carefully checked to avoid hematomas. The deep epigastric arteries should be preserved in an abdominal operation. Rapid gain in weight is not uncommon after abdominal operation and tends to increase the liability to postoperative hernia. The use of an elastic belt after operation checks the tendency to rapid accumulation of fat.

The mechanical treatment of incisional hernia consists of the wearing of a proper truss or belt. When secondary operation is contraindicated such an apparatus may be worn permanently.

The operative procedure must be adapted to each case. The scar is excised, sac opened, sac contents restored to the abdominal cavity, and all adhesions freed. Adherent omentum should be ligated and excised. The flaps should be overlapped in the direction of least tension, either side to side, above downward, or obliquely. The peritoneal surface of one flap lies on the aponeurosis of the other, and small mattress-sutures of chromicized catgut are passed through the outer flap and then through the free edge of the inner flap. When the sutures are tied the inner flap is drawn up beneath the outer one. The free edge of the outer flap is now turned back and the peritoneal surface is stitched to the aponeurotic surface of the inner flap. Finally the edge of the outer flap is sutured to the aponeurosis overlapping the deep flap (Judd, "Surg., Gyn., and Obst.," 1912, vol. 14, p. 175).

Sliding Hernia (*Hernia of the Large Intestine; Hernia Par Glissement*—Fig. 946).—Sliding hernia is a protrusion of large intestine through a normal or abnormal opening in the abdomen or pelvis (Watson, "Hernia"). This condition was first thoroughly described by Scarpa. In Watson's collection of 800 cases, 765 were inguinal or femoral; 20 were of miscellaneous varieties. He found that hernia of the large intestine is most frequent in infants under two years of age and next frequent in subjects between the ages of forty-one and sixty. It is far more common in men than in women.

Brenner ("Arch. f. klin. Chir.," Berlin, 1906, vol. 79, p. 1080), in 3000 cases of hernia, found sliding hernia of the sigmoid 20 times and of the cecum 39 times. It has been estimated that 40 per cent. of strangulated hernias in the newborn and 27 per cent. of those in children contain large intestine, usually the cecum; while 3 per cent. of the simple hernias in children and 6 per cent. of those in adults contain a portion of the large intestine (Lardennois and Okinczyc, "Studies of Hernia of the Large Intestine," Paris, Masson, 1910).

Sliding hernia in the right inguinal region is twice as frequent as in the left inguinal region. Sliding hernia in the femoral canal is ten times more common on the left side than on the right.

A sliding hernia on the right side usually contains ascending colon, cecum, and appendix, while on the left side it usually contains descending colon.

Causes of sliding hernia, as given by Watson (Ibid.), are abnormal position of the bowel; unusual length of peritoneal attachement of the intestine; descent of the ileum into a hernia may draw the cecum, appendix, and ascending colon after it; distention of the intestine and appendix adherent in the inguinal sac may drag down the cecum and ascending colon; and congenital causes, such as adhesions of the sigmoid or cecum to the descending testis.

The question of the parasaccular and extrasaccular types has caused considerable discussion. Carnett ("Annals of Surgery," 1909, vol. 49, p. 491) believes that the terms "extraperitoneal" or "retroperitoneal" should be applied to those viscera lying in contact with the peritoneum, but which are at no time surrounded by it, as the bladder and kidneys; and that the terms "retroserous" or "extraserous" should designate those viscera which have been intraperitoneal, but have lost their serous layer as the result of fusion in one or more aspects.

Congenital hernias of the large intestine include all those with complete sacs. They resemble ordinary hernias in that the cecum has a mesocolon and descends into a preformed sac. The cecum is entirely covered with peritoneum; it is movable and

can easily be drawn into the sac. Besides the cecum, the sac may contain appendix, ascending colon, sigmoid, descending colon, transverse colon, omentum, small intestine, or other viscera (Watson, "Hernia").

The acquired hernias include those in which the sac is partially or completely attached. Sliding hernia of the cecum is most common. Sliding hernias are due to a sliding of the posterior parietal peritoneum on the underlying cellular tissue. The peritoneum slides into the hernial ring, carrying with it the attached loop of large intestine.

By the term "*hernie par bascule*" we mean a hernia of the large gut in which the ascending colon is first to descend and draws the cecum with it.

In making a diagnosis of a hernia of the large intestine in an infant one may be guided by the fact that usually the mass is extremely large. In the adult the size of the hernia is usually excessive and the neck of the sac is large. A skiagram taken after an opaque meal may show evidence of large intestine in the hernial sac. Because of the fact that the hernial opening is large, strangulation is rare, occurring much less frequently than obstruction. Peritonitis in the hernial sac may follow strangulation, or may follow an inflammation of an appendix contained within the sac.

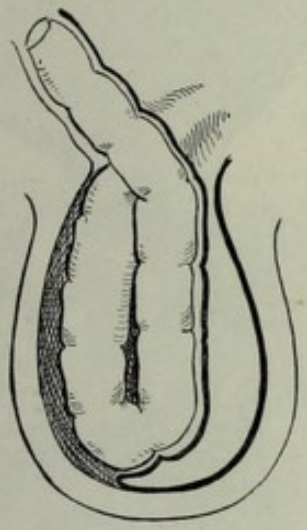


FIG. 946.—The large intestine behind the peritoneum (Weir).

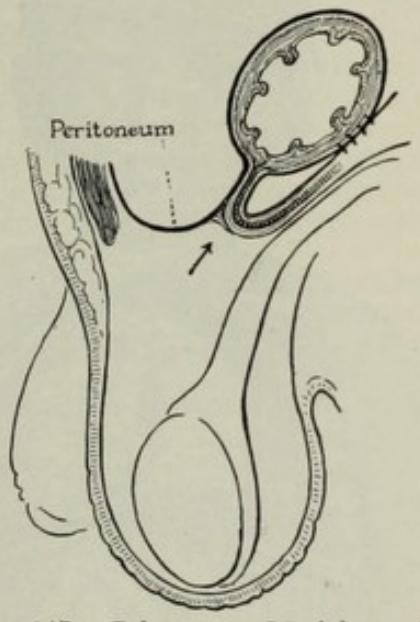


FIG. 947.—Colopexy. Mesial section to show the colon anchored in the iliac fossa (Watson's "Hernia").

Treatment.—The prognosis of hernia of the large intestine is not as favorable as in hernia of the small intestine. Because of the size of the hernia and because of the enlarged ring a truss is usually unsatisfactory. Operative treatment for hernia of the large intestine depends somewhat upon the conditions found at operation. The intrasaccular variety can usually be repaired by one of the usual operations for repair of inguinal or femoral hernia. When, however, there is a considerable loop of ascending or descending colon in the sac some surgeons make a lateral rectus incision and fix the colon to the posterior abdominal wall (colopexy) to prevent recurrence (Fig. 947). In the parasaccular or extrasaccular type it is often difficult to find the sac and there is danger of incising the intestine in mistake for the sac. In a left-sided inguinal hernia the sac is usually found behind and to the outer side of the mass, and in right-sided hernias the sac is usually found in front and to the inner side.

In sacless hernias the peritoneal covering is entirely absent.

When the sac is located it should be incised along its anterior surface because the nutrient vessels usually lie behind the intestine. The sac must not be separated from the colon, because to do so will obstruct the blood-supply. After the contents of the sac have been freed of adhesions and returned to the abdominal cavity some surgeons fix the mobile intestine in the iliac fossa by cecopexy or colopexy (Fig. 947). The final closure of the hernial orifice may be performed by one of the usual operations for inguinal or femoral hernia. Because of the usual massive size of the hernia and enlarged hernial rings recurrence after operation is very common.

Diaphragmatic Hernia (*Phrenic Hernia, Thoracic Hernia*).—A diaphragmatic hernia is a protrusion of abdominal viscera through a normal or abnormal opening in the diaphragm into the thorax.

Diaphragmatic hernia may be congenital or acquired.

The congenital type is usually on the left side and due to an absence or weakness of muscle tissue. The early development of the liver prevents congenital hernia from appearing more frequently on the right side. Congenital hernia rarely occurs through the normal openings of the diaphragm (esophageal, aortic, or caval). Of the three, the hernia occurs most frequently through the esophageal opening.

The acquired type of diaphragmatic hernia is often traumatic, and usually enters the thorax through the diaphragm. It may enter the thorax through the parasternal orifice (*foramen of Morgagni*), which is the interval between the tendinous fibers from the ensiform cartilage and the cartilages of the adjoining ribs. This is a normally weak point in the diaphragm (Watson).

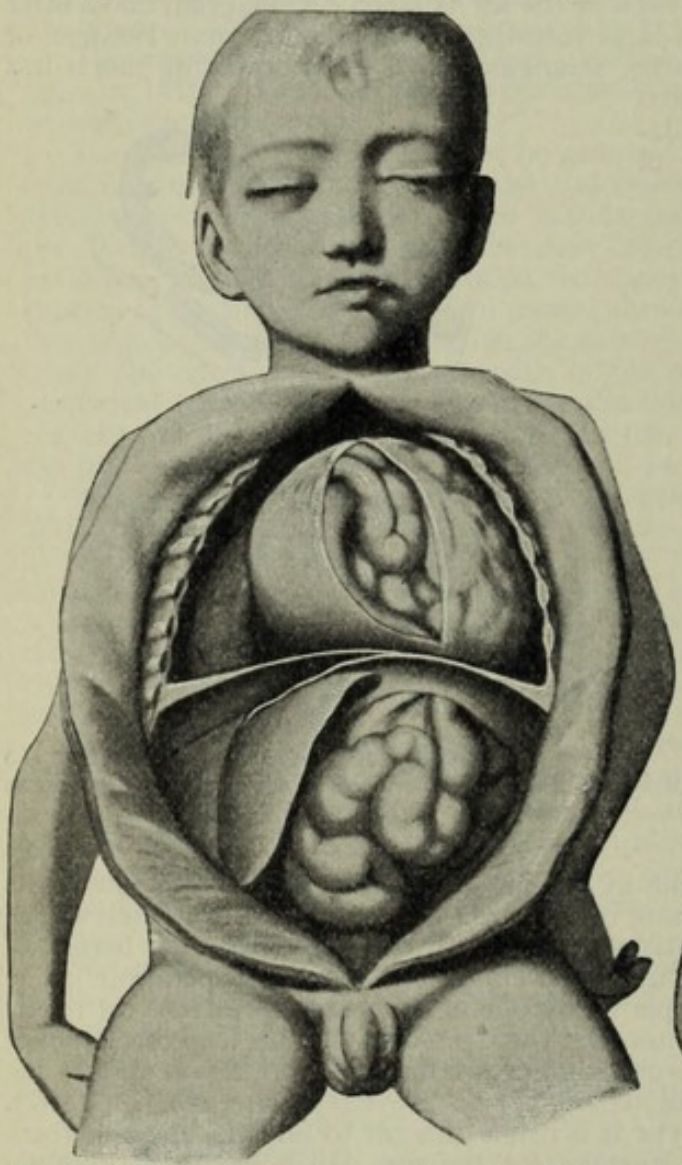


FIG. 948—A newborn child with a true left-sided congenital diaphragmatic hernia (Sultan).

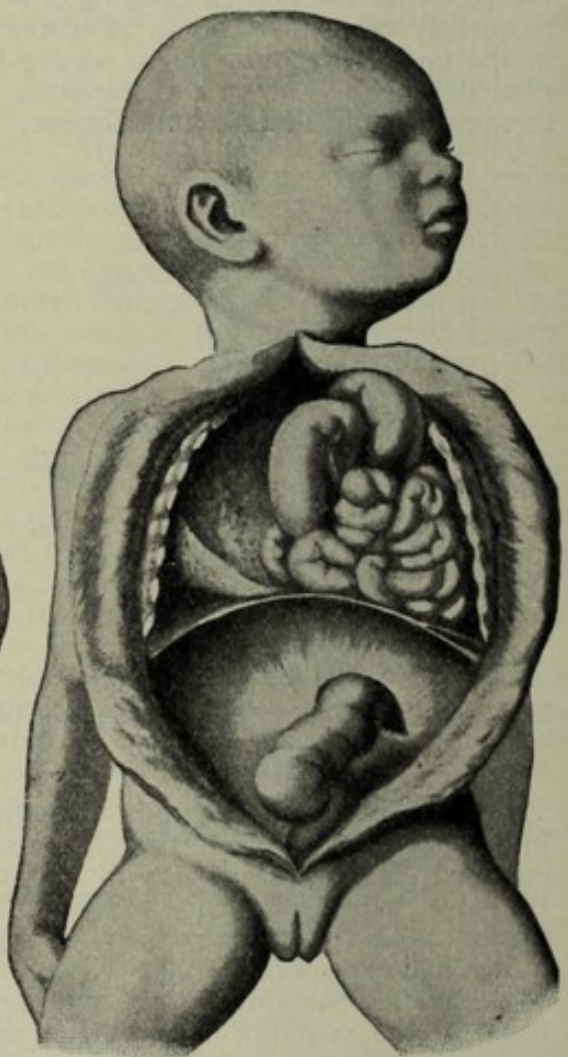


FIG. 949.—A newborn child with a false left-sided congenital diaphragmatic hernia (Sultan).

Traumatic hernia may occur anywhere in the diaphragm. Of 433 cases collected by Murray and Morgan ("Lancet," 1917, vol. 2, p. 857), 233 were congenital and 181 acquired. In the remaining number the cause was not stated.

Congenital diaphragmatic hernia is eight times more frequent on the left side than on the right.

Some authors term true diaphragmatic hernias those in which there is a sac and term false diaphragmatic hernias those without a sac. Either the congenital or acquired may be of the true or false type, but the traumatic hernia is without a sac at all times (Figs. 948, 949).

Contents of the Sac.—The stomach may be wholly or partially within the hernia. The transverse colon is most frequently found in the hernia, the descending colon next

in frequency, and the ascending colon is most seldom found. The small intestine may enter the sac if the hernia is large. The liver is rarely found within the hernial mass. Diaphragmatic hernia of the spleen and the kidney are rare.

Traumatic diaphragmatic hernia usually occurs in adults, and is more often found in man than in woman. It may be indirect, due to a crushing injury, or in trauma which increases intra-abdominal pressure sufficiently to rupture the diaphragm; or it may be due to a weakening of the diaphragm due to disease, such as false pregnancy, empyema, or subphrenic abscess. The diagnosis of diaphragmatic hernia is usually made by *x*-ray study.

The subjective symptoms are dyspnea, which may be slight or may be so severe as to cause orthopnea; there may be irregular attacks of cyanosis and syncope, due to pressure on the heart. A change of position while lying on the unaffected side will often give relief. Digestive disturbance and epigastric pain are frequent symptoms. Hiccough is not uncommon. Physical signs are often vague. Auscultation over the lung of the affected side may elicit a feeble vesicular murmur. When the stomach or intestine has entered the left side of the thorax there is a tympanitic note on percussion over that area of the thorax, the heart is displaced to the right, and the affected side of the chest is usually unduly prominent. The upper border of the tympanitic area does not move with respiration. There are no breath sounds audible over the tympanic area, but gurgling may be heard. Respiratory sounds will be normal at the apex of the lung, but are usually lessened when the patient is in the knee-chest position. There are no characteristic symptoms of congenital diaphragmatic hernia in infants. There are apt to be marked cyanosis and dyspnea, and death usually occurs in a few hours.

The *x*-ray is the best means of diagnosis in non-strangulated diaphragmatic hernia. It is usually possible to recognize diaphragmatic hernia by a fluoroscopic examination, but it is always advisable to examine the patient after a preliminary barium sulphate meal.

Strangulated Diaphragmatic Hernia.—The transverse colon is most often strangulated, the stomach is next in frequency, and the small intestine is rarely strangulated. Strangulation may follow a sudden strain or trauma which forces one or more of the viscera through the opening into the thorax. The symptoms of strangulation are severe, sudden pain, localized in the epigastric region, violent vomiting, dyspnea, a boat-shaped abdomen, great thirst, constipation, and excretion of a very small amount of urea. Respiration is of the superior costal type. There are a number of recorded cases of operations performed for supposed stomach trouble, gall-stones, and appendicitis, in which the diaphragmatic hernia was undiscovered until there was subsequent operation for unrelieved symptoms or until an autopsy.

Routine examination of the diaphragm, as well as other regions, should be the rule in every laparotomy for obscure abdominal symptoms.

Diaphragmatic hernia must be differentiated from pneumothorax, fluid in the thoracic cavity, elevation or eventration of the diaphragm, and diverticulum of the esophagus. In pneumothorax there are no subjective symptoms of hernia, and no intestinal or stomach sounds can be heard by auscultation over the thorax. Differential diagnosis can usually be made by the *x*-ray.

If a hernia is mistaken for a pneumothorax and aspirated, the result may be fatal.

Pleural effusions, either pus or blood, are usually diagnosed by the physical signs showing the presence of such fluid in the thoracic cavity. *x*-Ray study will usually exclude the possibility of diaphragmatic hernia.

Elevation or eventration of the diaphragm and unnaturally high position of the left half of the abdomen, with advent of the viscera of the abdomen, and especially the stomach, may be mistaken for diaphragmatic hernia.

D. Y. Keith ("Amer. Jour. Roentgenology," New York, 1920, vol. 7, page 288) gives the differential *x*-ray diagnosis as follows:

Eventration.	*Hernia.*
High dome of diaphragm with no loss of contour.	High diaphragm with loss of contour, a portion being regular and a portion being blurred.
No gas shadows above liver shadow.	Gas or barium shadow seen above liver shadow, gastric deformity.
More likely to be congenital.	Obstruction.
Paradoxic movement of the diaphragm.	The presence of gas or fluid, or both, in the hernial sac.

The *treatment* is operative.

There are three methods of operative procedure—by the abdominal route, by the thoracic route, and the combined thoracico-abdominal route. Some surgeons prefer the abdominal route, while others prefer the thoracic route. The abdominal route is usually indicated following injury to the abdominal cavity or with symptoms of intestinal obstruction.

Internal Hernia (*Retroperitoneal Hernia or Intra-abdominal Hernia*).—(See page 967.)

Obturator Hernia.—An obturator hernia presses through the obturator membrane into the obturator canal and is felt below the horizontal ramus of the pubis and internal to the femoral vessels. The obturator nerve is pressed upon and causes referred pain along its course (Figs. 950, 951).

Watson ("Hernia") has collected 396 cases of obturator hernia, of whom 228 were operated upon. The diagnosis previous to operation or autopsy was made in only 53. This type of hernia is more common in the female than in the male. Final results given in 228 cases: Operation followed by recovery, 77; operation followed by death, 72; death, no operation, 79.

Pregnancy is an important factor as an etiologic cause because of the fact it leaves the parietoperitoneum relaxed. Another reason assigned for the frequency in women more than in men is the fact that in women the pelvis is larger and inclines more

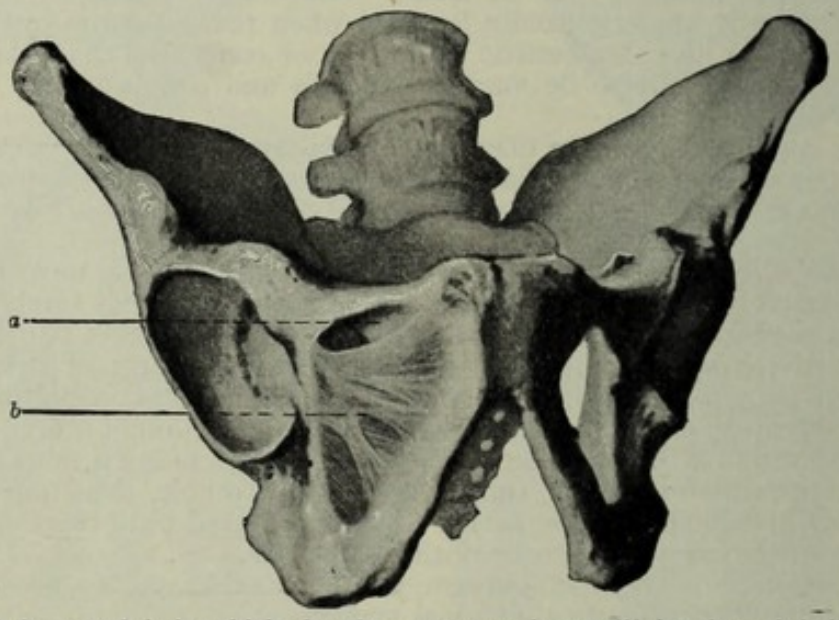


FIG. 950.—A bony pelvis in which the obturator membrane (*b*) has been left in the right obturator foramen. The membrane entirely fills the foramen, with the exception of an opening (*a*) which is designated as the obturator canal. It is through this opening that the obturator hernia escapes, the obturator vessels and nerve being pushed to one side (Sultan)

obliquely than in men, and the obturator foramen is relatively larger. Other predisposing causes are chronic cough and laborious occupations associated with heavy lifting and straining.

A reducible obturator hernia is seldom diagnosed. It usually gives rise to gastro-intestinal symptoms and pain along the course of the obturator nerve. The hernia must be large to be palpable.

Small intestine is usually present in the sac.

A Richter hernia into the obturator foramen is not uncommon.

An obturator hernia must be diagnosed from a femoral hernia, adenitis, psoas abscess, varicose veins, and internal hernia.

The Howship-Romberg sign of obturator hernia is pain along the course of the obturator nerve. This pain is present in over 50 per cent. of all cases.

Lumbar Hernia (*Petit's Hernia*).—This is a very rare condition. It may be congenital, traumatic, or spontaneous, and may follow a lumbar abscess. It occurs usually through the *triangle of Petit*. The triangle of Petit is bounded in front by the external oblique, behind by the latissimus dorsi, below by the iliac crest, and its floor is formed by the internal oblique. The superior lumbar triangle is bounded anteriorly by the external oblique, posteriorly by the iliocostal muscle, above by the serratus posticus inferior and the end of the twelfth rib, and below by the internal oblique.

The latissimus dorsi overlies it. A lumbar hernia may appear through the superior lumbar triangle (*Grynfelt-Lesshaft space*). Lumbar hernia is three times more common in males than in females. It usually contains omentum, sometimes large or small intestine. Lumbar hernias are frequently epiploceles or fatty hernias. A traumatic lumbar hernia may follow a severe crushing blow or a fall from a height. Pott's disease is the most frequent cause of an acquired lumbar hernia. The tumor is usually easily seen, is soft, and reduces easily. The chief symptom is that of pain in the back, with occasional attacks of colic and vomiting.

Mechanical treatment is unsatisfactory. An operation should be recommended.

Sciatic or Gluteal Hernia (Fig. 952).—A sciatic hernia makes its exit through the greater or lesser sacrosciatic foramen. It is rarest of all hernias. It occurs with equal frequency in the two sexes. Diagnosis is seldom made until strangulation occurs. There may be a small tumor in the gluteal region, with tenderness over the sac or sciatic foramen. There may be referred pain down the sciatic nerve. If the hernia is reducible, an impulse can be felt when the patient coughs. An *x*-ray study may make the diagnosis. Strangulated sciatic hernia is sometimes found during the course of a laparotomy for symptoms of intestinal obstruction. Even when a diagnosis of sciatic hernia can be made operative procedure through the abdomen is preferable to sciatic operation.

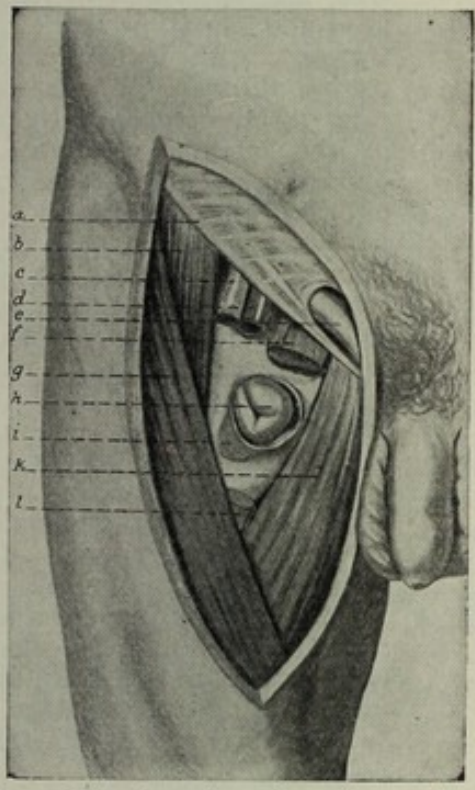


FIG. 951.—Anterior view of an obturator hernia. A part of the pectineus and the entire obturator externus muscle have been removed, exposing the bony pelvis and a portion of the obturator membrane. The iliopsoas and pectineus muscles have been drawn apart, and between them lie the stumps of the femoral vessels. The sac of the obturator hernia has been opened and an intestinal coil is seen within: *a*, Poupart's ligament; *b*, iliopsoas muscle; *c*, femoral artery; *d*, femoral vein; *e*, spermatic cord; *f*, upper stump of the pectineus muscle; *g*, sartorius muscle; *h*, obturator hernia; *i*, obturator membrane; *k*, adductor longus; *l*, lower stump of the pectineus muscle. (Sultan.)

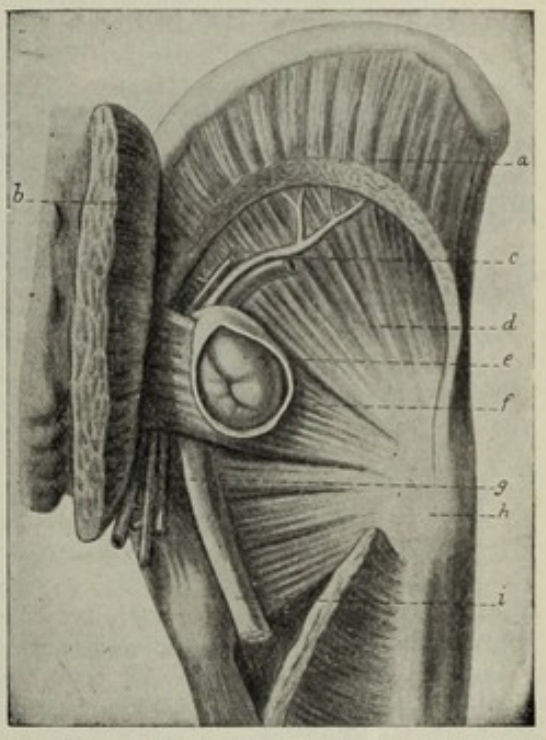


FIG. 952.—A lateral view of a sciatic hernia (superior gluteal hernia) (Sultan).

Pudendal Hernia (*Vaginal Hernia; Perineal Hernia*).—A pudendal hernia is an inguinal hernia which descends into the labium majus. A perineal hernia protrudes through the muscles and fascia of the outlet of the pelvis. Perineal hernias are divided into anterior, which escape through a rent in the levator ani, which may be congenital, or the result of trauma; and posterior, which in man descend between the bladder and rectum, usually appearing in the ischiorectal space or in the perineum. The posterior perineal hernia in woman, or retro-uterine hernia, descends between the rectum and vagina, and makes its exit through a defect in the levator ani. It may occupy the ischiorectal space and protrude below the lower border of the gluteus maximus muscle, thus resembling a sciatic hernia. This hernia may be congenital or may be traumatic.

Mechanical treatment is unsatisfactory. Operation should be recommended. The abdominal approach is the operation of choice. The abdomen is opened, the hernia is reduced, and the sac invaginated, folded upon itself, and sutured over the muscles to obliterate the hernial orifice. The perineal route presents more difficulties in closing the internal opening.

Partial Enterocele or Richter's Hernia (*Masked Hernia, Lateral Pinching of the Intestine, Lateral Enterocele, or Nipped Hernia*—Fig. 953, *A*).—A description of this hernia was published by Richter in 1785, but Lavater had observed it in 1672. Littre's supposed cases, seen in 1700, have been shown to have been instances of hernia of Meckel's diverticulum. It is a catching of a portion of the circumference of the bowel, usually a portion of the lower part of the ilium. It is usually due to the intestine becoming adherent to the sac wall, and a sudden increase in intra-abdominal pressure forces the sac, with its attached intestine, through the constricting ring. It is most frequently found in the inguinal, femoral, and obturator regions—more rarely in other regions. It may be due to truss pressure or to incomplete reduction of a hernia. Gangrene occurs earlier in a Richter hernia than in ordinary strangulation. Strangulation of a partial enterocele may not completely close the lumen of the gut. There may not be vomiting or absolute constipation; when vomiting is present it is seldom stercoraceous. In about 50 per cent. of the cases no lump can be felt.

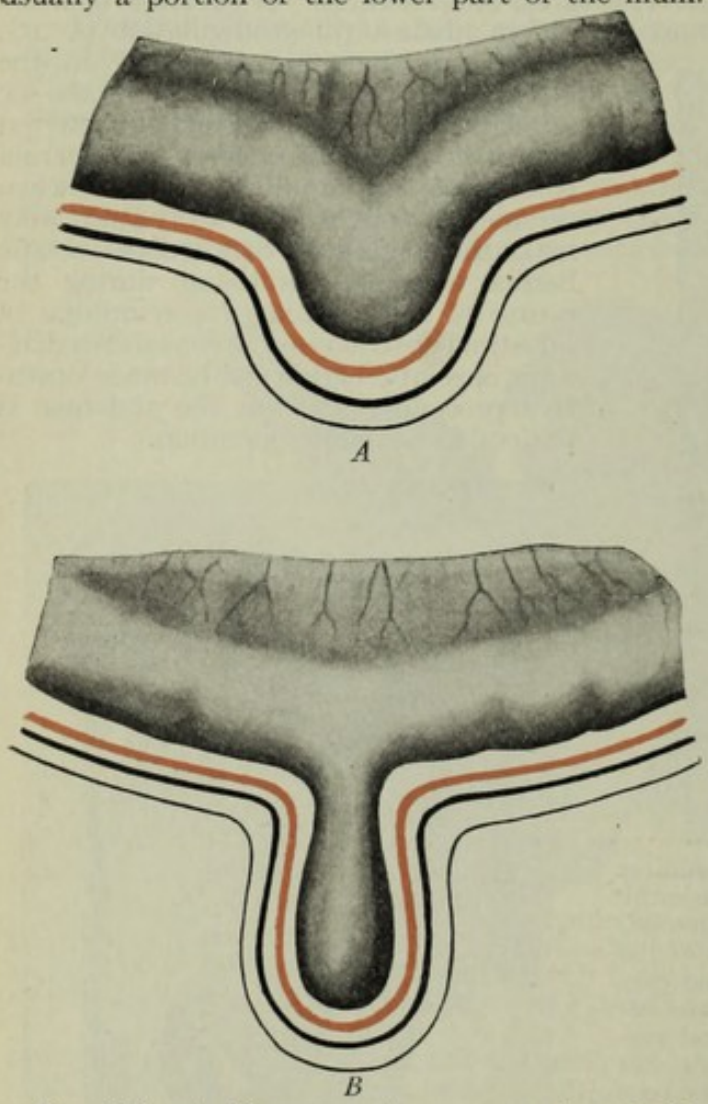


FIG. 953.—*A*, Diagrammatic representation of Richter's hernia of intestinal wall. *B*, Diagrammatic representation of Littre's hernia, which is a hernia of Meckel's diverticulum. (Sultan.)

Prognosis is unfavorable because of the early development of gangrene and because operation is usually undertaken late on account of the uncertainty of diagnosis.

Treatment is immediate operation. If the intestine is not gangrenous it can be returned to the abdominal cavity. If the gangrenous area is small, it may be inverted with Lembert's sutures. If the gangrenous area is large, it is necessary to resect the intestine. If the patient's condition will not permit an extensive resection, it is best to do a two-stage operation, limiting the first operation to forming a fecal fistula and the second operation to closing the fistula and repairing the hernia.

Rokitansky's diverticular herniæ are due to separation of the muscular fibers of the bowel, permitting the sacculation of mucous membrane and peritoneum. These false diverticula may be no larger than peas or may be larger than walnuts, and there may be scores of them in one patient. They may produce no symptoms or may lead to peritonitis, abscess about the bowel, perforation, or to symptoms of intestinal obstruction.

Littre's hernia is a hernia of Meckel's diverticulum (Fig. 953, *B*). Two cases were seen by Littre in 1700, but he regarded them as cases of partial enterocele. Ruysch, in 1698, was the first to observe the condition (see Macready's "Treatise on Ruptures"). The diverticulum is a persistent vitelline duct and comes off from

the ilium from 12 to 36 inches above the iliocecal valve. It arises from the convex side of the gut and rarely has a mesentery. The hernia of the diverticulum may be accompanied by small intestine, which sometimes becomes strangulated, or by omentum. Littre's hernia is rare. It is more common in middle-aged adults, and is found more frequently in men, in the proportion of 2 to 1. It usually occurs in the right inguinal region. Littre's hernia is seldom diagnosed before operation. The symptoms of strangulated Littre's hernia are similar to those of a partial enterocele or hernia of the appendix, in that the symptoms are not usually severe; at first, if vomiting occurs, it is not stercoraceous and obstruction is not complete.

When the sac of a hernia is opened and there is absence of mesentery the surgeon should at once think of the possibility of Littre's hernia.

Prognosis is more favorable than that of Richter's hernia because the lumen of the intestine is not involved.

Treatment.—Operation is indicated. The diverticulum should be resected at its junction with the small intestine. It is inadvisable to return the diverticulum unresected, as there is always danger of subsequent attacks of diverticulitis.

Hernia of the Bladder.—This is a protrusion of a portion of the bladder wall through a hernial opening. It constitutes about 1 per cent. of all hernias in adults, but is less frequent in children. Watson has collected 406 cases of hernia of the bladder. In 305 cases in which the sex was given, 204 were males and 101 females; 130 were right inguinal, 103 left inguinal, 5 bilateral, and in 42 cases the side was not stated, 43 were right femoral, 21 left femoral, 2 bilateral, and 13 side not given. Of other varieties 2 were sciatic, 5 ventral, and 1 obturator; 204 were paraperitoneal, 85 were extraperitoneal, and 17 were intraperitoneal. In the 406 cases collected by him the bladder was wounded in 194. From the above statistics it may be seen that hernia of the bladder occurs more frequently in men and more frequently on the right side.

Hernia of the bladder may be extraperitoneal or it may be partially or wholly covered by peritoneum. Hernia of the bladder has, therefore, been divided into extraperitoneal, paraperitoneal, and intraperitoneal. The sac may contain bladder alone or small intestine and omentum may also be occupants of the sac. A small portion of the anterior wall of the bladder may occupy the sac or the whole of the bladder. The portion of the bladder in the hernia may be a diverticulum. Prehernial lipoma is not rare. It is usually covered by a blue, vascular network of vessels, and when seen during an operation one should realize that the bladder is in close proximity.

The *symptoms* of hernia of the bladder are chiefly frequent urination and urination in two stages; that is, the patient will first empty the pelvic portion of the bladder and then, by pressure on the tumor, the contents of the hernia of the bladder is voided. Pressure on the tumor may cause a desire to urinate. Occasionally the hernia may vary in size, being larger when the patient has not urinated for some time and smaller after emptying the bladder. There will be a difference in percussion note. If the hernia contents is bladder, percussion note will be dull. If intestine occupies the hernial sac, there will be a tympanitic sound. Sometimes, if a sound is passed into the bladder, it can be felt in the hernial sac, or if the bladder is distended with air or fluid, the lump will increase in size. Cystoscopic examination may assist in the diagnosis. Watson suggests that when the presence of a hernia of the bladder is suspected methylene-blue should be administered the day before operation, so that if the bladder is wounded the accident will be promptly recognized, or if a wound of the bladder is suspected during operation, test with litmus-paper to tell if urine is present.

Prognosis is good unless strangulation occurs, and this is rare. The chief cause of death is peritonitis due to a leakage of urine from an injury to the bladder. This injury may be recognized at time of operation, or may not be recognized until the development of peritonitis.

Treatment by the use of a truss is unsatisfactory. Operation is the method of choice. The bladder should be loosened gently from its surroundings and returned to the abdomen, and the radical operation be performed as for inguinal or femoral hernia. If the bladder is incised during operation, the walls of the bladder should be immediately caught with hemostats and the tear should be closed with interrupted sutures of chromicized catgut. No suture should go through the mucosa. A drain should be inserted for two or three days. A retained catheter is usually unnecessary. If the injury to the bladder is not recognized and repaired at the time of operation there is danger of peritonitis. If ominous symptoms arise, the wound must be opened at once and the injury to the bladder found and repaired.

Hernia of the Ureter.—This type of hernia is very rare. Watson has collected 46 cases; 21 were females and 25 males. It usually occurs in the inguinal region. The inguinal variety nearly always occurs in men and the femoral variety in women. Hernia of the ureter may accompany a hernia of the bladder. There are no characteristic symptoms. The condition is seldom diagnosed before operation. Cystoscopic examination and *x*-ray study with the catheter in the ureter are practically the only ways to make a preoperative diagnosis.

Treatment.—If during an operation for hernia the ureter is part of the contents of the hernial sac and is wounded, the wound should be repaired by longitudinal or transverse interrupted sutures. If it has been completely divided, the ends should be united by end-to-end anastomosis.

Hernia of the Ovary, Tube, and Uterus.—In Watson's collection of 175 cases 156 were hernia of the ovary alone, 58 hernia of the non-pregnant uterus, and 30 of the pregnant uterus; 90 per cent. of the hernias of the ovary and tube are of the inguinal variety. The hernia is more frequent on the left side. Hernia of the tube alone is very rare. Hernia of the non-pregnant uterus is almost always inguinal. Hernia of the pregnant uterus may be inguinal, femoral, umbilical, or ventral. Hernia of the ovary and tube is the most frequent variety, most of the cases occurring in children under two years of age. Of 68 cases of hernia of the tube and ovary there was tubal pregnancy in 11. Hernia of the uterus hardly ever occurs alone and is usually associated with hernia of the ovary and tube. Hernia of the ovary and tube is probably due to the proximity of the ovary to the hernial orifice and by the mobility of the ovary and tube. It may have an abnormally long broad ligament. This may be associated with a patent canal of Nuck, which may remain open for some time after birth.

The exciting causes may be a fall from a height, a strain, or intra-abdominal pressure caused by chronic cough.

Hernia of the uterus is most frequently found in multipara.

The hernia may be congenital or acquired. The acquired type is by far more common. The uterus may enter a pre-existing hernial sac or pressure of a nearby tumor may force the uterus into a hernial sac. A pre-existing hernia of the ovary and tube may become adherent in the sac and draw the uterus into the sac. Impregnation may occur while the uterus is herniated. If the herniated uterus becomes impregnated or if an impregnated uterus becomes herniated, pregnancy may go on to term. In many cases congenital abnormalities have been found to exist, viz., the bicornate uterus, rudimentary uterus, shortness of round liagment, imperforate vagina, etc.

The symptoms of a hernia of the ovary and tube are usually confined to the ovary alone. The ovary may be palpable in the canal. While the normal ovary is insensitive, the herniated ovary is often hypersensitive. The most useful means of diagnosis is vaginal or rectal examination. Hernia of the non-pregnant uterus is most frequent after the menopause. Diagnosis is usually determined by vaginal examination or by the passage of a uterine sound.

Treatment.—Operation offers the best method of treatment. The ovary and tube are returned to the abdominal cavity unless diseased, in which case they are removed. Hernia of the pregnant or non-pregnant uterus is treated by reduction and operative closure of the hernial opening. If, however, the herniated uterus is near term and it is impossible to reduce the uterus to the abdominal cavity it may be necessary to perform hysterectomy.

Hernia in Childhood.—Umbilical and inguinal hernias are extremely common in infants and young children. Inguinal hernia is almost always of the oblique variety. Direct hernia is very rare. Femoral hernia is seldom seen in infants because of the small size of the ring. Coley and Hoguet ("Annals of Surgery," Phila., 1918, vol. 68, p. 255) found 21 direct hernias in 4114 operations on patients under fourteen years of age. It is estimated that during the first year of life 1 child in every 21 has hernia, and this proportion is maintained until the age of six. It then decreases rapidly until the age of thirteen, at which age there is 1 hernia in every 77 children. It is therefore obvious that 75 per cent. of herniæ in children of six years will heal spontaneously before the age of thirteen. Ochsner states 95 per cent. of hernias in children will be cured without operation. He points out that between the ages of thirteen and twenty hernia is very common among boys, but very rare among girls. The reason for this tendency to cure is somewhat uncertain. A view advocated by Thomas C. Martin is that the pelvis broadens and the parietal peritoneum enlarges. It does this at the expense of the mesentery, which is shortened, and the internal abdominal

ring is displaced. In a very instructive analysis of this condition Ochsner shows that in 25 per cent. of cases of hernia in children hereditary weakness exists, and that the condition is commoner among the poorer classes than among the rich; that in many cases there is an undescended testicle; and that the chief cause is an excess of intra-abdominal pressure. Premature infants are liable to inguinal hernia. The inguinal canal is much shorter in children than in adults, and the internal and external rings are practically on the same plane. Excess of intra-abdominal pressure may result from flatulent distention of the stomach and intestines, the product of bad feeding; constipation and straining at stool; straining on urinating, due to the existence of phimosis; vomiting; coughing, and straining during colic.

The sac usually contains small intestine, but may contain omentum, cecum, appendix, bladder, ovary, tubes, or uterus. A hernia in a child may be overlooked. In childhood a hernia may make a large bulge today and tomorrow it may have withdrawn entirely. We cannot always get a young child to cough, a lump may fail to appear even when the child strains or cries, and hence the surgeon may deny the existence of a hernia which actually exists. A hernia in a child when once reduced may not again "come out" for weeks or even months.

When it is impossible to make the child cough or cry, press over the abdomen with the palm of the hand, and the hernia will occasionally descend. It is sometimes difficult to differentiate oblique hernia from direct hernia because the inguinal canal is short and because of the fact that the two rings are practically on the same plane. An infant suffering with a hernia is likely to be more irritable than usual, takes food poorly, and is therefore not properly nourished. There may be frequent attacks of colic.

Strangulation is rare in childhood. When it occurs the usual symptoms of strangulation are present; acute abdominal pain; vomiting, which may be stercoraceous in character; persistent crying; and a rapid, weak pulse. There is constipation and occasionally retention of urine; the child may have convulsions. Watson points out when an infant or child complains of pain in a hernia an undescended testicle or appendicitis may be the causative factor of the pain. He quotes Veau's report ("Bull. Med.," Paris, 1917, vol. 28, p. 492) of 53 cases of appendicitis in hernia operated on in infants and children. Because of the small size of the canal and sac Veau found it very difficult to remove the appendix through the hernial incision in children under four years of age, and suggested the advisability of a double operation.

Treatment.—Conservative treatment for hernia is strongly advocated in children under four years of age. This is the opinion of Watson (Ibid.), Coley (Ibid.), and Beuford ("Surg., Gyn., and Obst.," Chicago, 1913, vol. 17, p. 632). The processus vaginalis, which is patent at birth in about 50 per cent. of infants, usually closes at the end of the first year, so that a hernia occurring during the first year of life may disappear spontaneously. Ochsner ("St. Paul Med. Jour.," St. Paul, Minn., 1917, vol. 19, p. 151) claims that 95 per cent. of all hernias in infants and young children can be cured by keeping the child recumbent, on a restricted diet, and the foot of the bed raised from four to six weeks. If phimosis exists, it should be operated on and any other causative factor should be treated—cough, vomiting, constipation, indigestion, etc.

It is unwise to operate for non-strangulated hernia on any infant for fear of pneumonia, wound infection from urine and feces, and complications such as the acute infectious fevers—measles, whooping-cough, etc. Most cases are curable without operation, the ring being guarded by a bandage, a truss of rubber, a pad of lamb's wool, or a worsted truss. Watson gives the following method for making a worsted truss: Select 8 to 12 strands from a skein of any strong, white, knitting wool; form a loop and fit to the child's body below the navel; tighten the loop and place the end in the external ring, cut the free end and draw it down along the inside of the thigh and back up across the gluteal fold, and tie it up to the loop that passes around the pelvis. The worsted truss is only indicated in very young infants. Care must be taken not to irritate or cut the skin by pulling the worsted truss too tightly.

A spica bandage or a framed truss is the better method of treatment in all cases except very young infants. Coley (Ibid.) states that 50 per cent. can be cured by means of a truss. Ochsner believes that 95 per cent. are cured by a truss associated with accessory methods.

Operative Treatment.—Operation is indicated if the hernia is painful, irreducible, strangulated, complicated by hydrocele, when a truss does not properly hold the hernia in place, when there is deformity so that a truss cannot be used when the circumstances

of the patient are such that the parents will not properly care for the child by conservative treatment, or when the hernia is associated with undescended testicle. Operative treatment is indicated in case of undescended testicle because the wearing of a truss over a hernia associated with an undescended testicle is always painful and may cause atrophy of the testicle.

The majority of surgeons believe that high ligation of the sac suffices and that transplanation of the cord is unnecessary. Watson advocates the Bassini operation in childhood. If the cord is transplanted, dissection must be made with great care for fear of injuring the vas deferens and the wound should be dressed with collodion dressing or protected by gutta-percha, rubber-dam, or oiled silk to prevent contamination by urine or feces. It may be necessary to give a sedative, such as paregoric, in order to reduce pain and prevent crying.

XXVII. DISEASES AND INJURIES OF THE RECTUM AND ANUS

Teratoids and Dermoids in the Sacrococcygeal Region.—In the sacrococcygeal region there are many opportunities for developmental error. In this region the caudal end of the primitive streak must undergo evolution and involution, the neurenteric canal must form and disappear, the anus must be formed, the posterior fissure must close, the sacrum and coccyx must develop, and various other processes must go on correctly and uniformly if complete development is to be obtained. As Coplin puts it: "Perfect evolution of the tissues embraced in this part of the body is beset by many narrow escapes" ("Publications from the Laboratories of Jefferson Med. College Hospital," 1906, vol. iii). Fissures and clefts may fail to close, fragments from one blastodermic layer may be lodged in another layer, groups of cells may be sequestered, closing clefts may include tissue elements, and parts that should normally atrophy may do so late or not at all.

In order to understand teratomata and dermoids arising in the rectal region we must recall some facts of development.

Early in embryonic life the central canal of the spinal cord and the alimentary canal are continuous around the caudal end of the notochord by a communicating path called the neurenteric canal.

When the anal pit undergoes invagination it meets the gut considerably in front of the region where the neurenteric canal joins the gut. The portion of intestine between the anus and the opening of the neurenteric canal is called the *postanal* gut. The postanal gut disappears during normal development. If it persists it causes tumor formation.

The congenital tumors of the sacrococcygeal region are: (1) Tumors of the postanal gut; (2) dermoids back of the rectum; (3) rectal dermoids.

According to Bland-Sutton, tumors of the postanal gut "are composed of closed vesicles lined with glandular epithelium and contain glue-like fluid" ("Tumors, Innocent and Malignant," by Sir J. Bland-Sutton). These tumors grow to a large size.

Dermoids back of the rectum often contain teeth, may attain large size, are apt to mount up behind the peritoneum, and may rupture and form a fistula. I helped Prof. Keen operate on such a case. The skin over the mass showed a growth of hair, there was a gap or cleft in the sacrum, and through this there was a clear passage from the rectum to the skin. This sinus closely resembled the trachea in structure.

Dermoids occasionally grow from the mucous membrane of the rectum and are apt to contain an abundant growth of hair.

Examination of the Anus and Rectum.—There are four positions in which we may place the patient for rectal examination, the one to be selected depending upon the probable local difficulty. These positions are the left lateral prone, the knee-chest, the exaggerated lithotomy, and the squatting position. The knee-chest position is desirable if the sigmoidoscope is to be used. A commonly employed position is the *left lateral prone position of Sims*, in which the patient lies on the left side, the chest on the table, the left arm behind the back, the knees drawn up, and the pelvis elevated on a hard pillow.

Very stout people should be placed in either the *knee-chest position* or the *exaggerated lithotomy position*, as the rectum cannot be seen when they lie on the side.

A *squatting position*, when the patient is placed as though on a commode, is best adapted to cases of prolapse and hemorrhoids. It is also used to bring within the range of the finger strictures or new growths that in the other attitudes would be beyond digital reach.

Sometimes the surgeon is able to pass a sigmoidoscope upon a patient in the exaggerated lithotomy position when it has been found impossible to carry the instrument high enough with the patient in any other position.

While making a rectal examination the patient should have no constriction about the abdomen, such as corsets, bandages, or tight clothing.

It is important that the first examination be made when no cathartic or enema has been administered, so that the condition of the excretions and secretions may be noted. By such first examination pus, blood, mucus, or inspissated fecal matter if present may be seen, and from their varying characteristics, quantities, and locations inferences as to causation may be drawn. After these observations have been made an enema should be given and the anus and rectum be well cleansed. When the parts have been cleaned and the bowel washed out the anus is carefully inspected, the anal folds being opened during the process. By inspection the surgeon can notice the external opening of a fistula, external piles, protruding internal piles, mixed piles, pruritus, discharge from the rectum, eczema, fissure, tumor, ulcer, condylomata, abscess, whether or not the anus is retracted and funnel-shaped or protruding, or if there be parasites on the anal hairs.

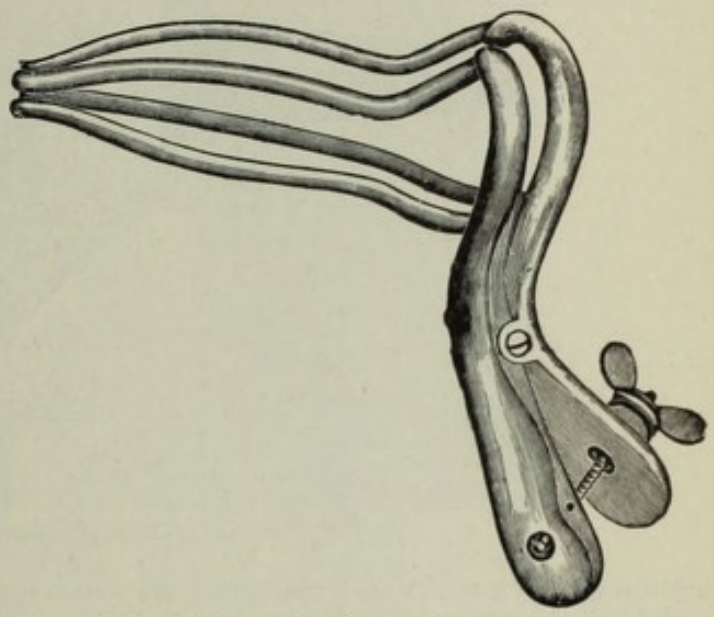


FIG. 954.—Mathews's self-retaining rectal speculum.

Next the thumbs should be placed on either side of the anus and gently separated; this maneuver, aided by a bearing down effort on the part of the patient, will often cause piles to protrude, exhibit fissures and polypi, and reveal the condition of the mucocutaneous border.

Next, a digital examination of the rectum is made. The nail of the index-finger is filled with soap and the finger is oiled or, better, is covered with a rubber finger-tip which is oiled. The digit is gently inserted through the sphincter, the patient being asked to strain lightly during its insertion. The finger is inserted with a gentle boring

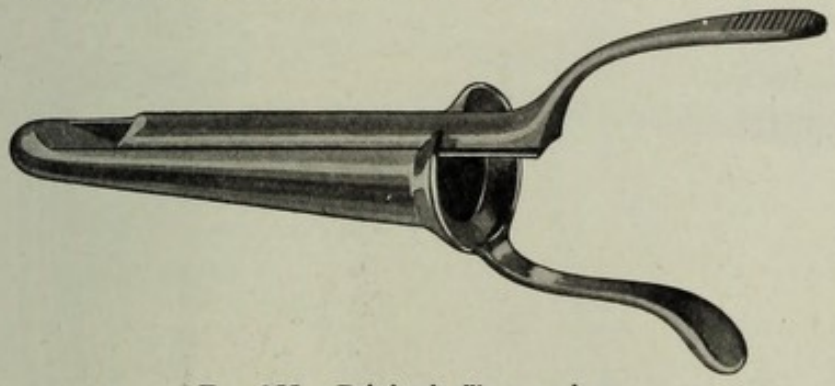


FIG. 955.—Brinkerhoff's speculum.

motion and is pointed toward the umbilicus until the sphincter is passed. A digital examination enables the surgeon to detect an ulcer, a polypus, a tumor, a stricture, and to determine certain points regarding the condition of the prostate in the male and the uterus in the female. Non-indurated piles cannot be detected by the finger. A speculum will be needed to discover them if they are not protruding.

Next, in some cases, the rectum must be examined by means of a speculum. It is not often necessary to give ether. Mathews's speculum (Fig. 954) is very serviceable. Sims's duck-bill speculum is a valuable instrument for certain cases. The speculum is warmed, oiled, and slowly introduced. It is first directed toward the umbilicus, and when it passes the sphincter its direction is gradually altered until it is toward the

promontory of the sacrum. Illumination is obtained by direct sunlight or by a forehead mirror and an electric light. This examination will extend, confirm, or disprove the findings of the digital examination; ulcers, hemorrhoids, and malignant growths can be carefully examined, and the condition of the rectal mucous membrane can be thoroughly investigated.

Marion Sims in 1845 demonstrated the ballooning of the vagina by atmospheric pressure, and in 1870 Van Buren applied this method to the rectum. Kelly in 1895 put forth his straight tubes and described in detail the methods and advantages of

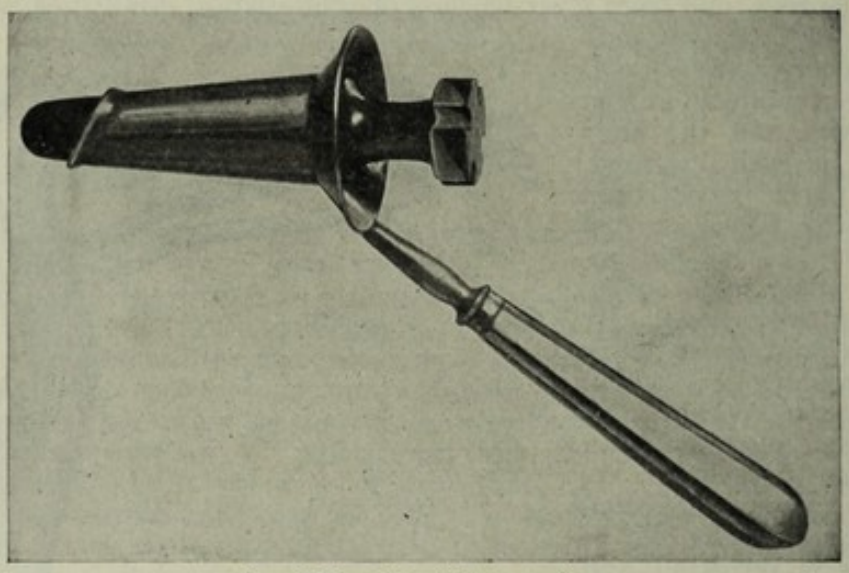


FIG. 956.—Martin's speculum.

examination by them, and the great diagnostic value of ballooning the rectum. Kelly's method of examination is shown in Fig. 958. The tubes are shown in Fig. 959. It is not necessary to give ether. The patient is placed in the knee-chest position. A tube containing an obturator is well greased with vaselin. "The buttocks are drawn apart, and the blunt end of the obturator is laid on the anus, which is also coated with vaselin. The direction of the instrument should be first downward and forward, and, when the sphincter is well passed, up under the sacral promontory. The moment the speculum clears the sphincter ani and the obturator is withdrawn, air rushes in audibly and distends the bowel." When the entering instrument is pressed gently against the

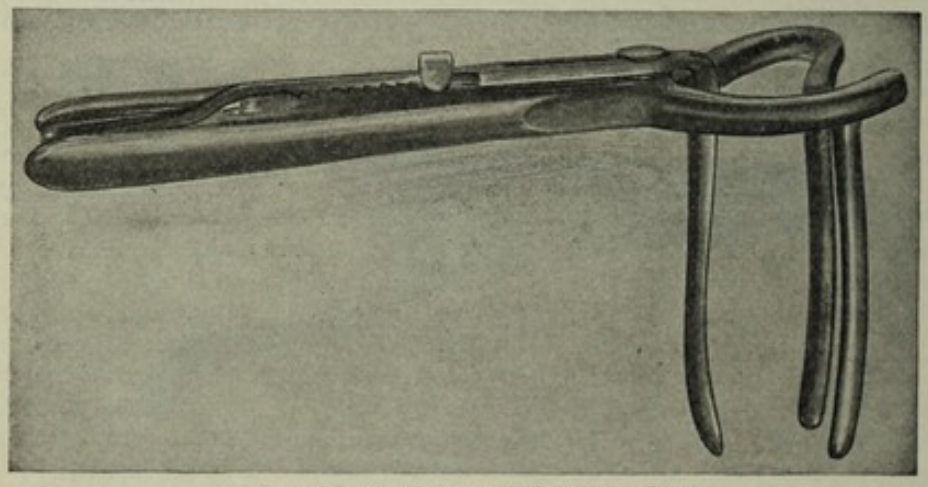


FIG. 957.—Cook's operating speculum.

sphincter a sharp muscular contraction ensues. If the instrument is gently and slightly withdrawn, relaxation occurs, and the moment of relaxation may be seized to make an entry. An entry so made is rapid and unresisted. The bowel being distended with air, the mucous membrane is plainly seen as the tube is slowly withdrawn and the electric light is reflected into the speculum by a forehead mirror. The normal mucous membrane is dull red, like the nasal mucosa, and the blood-vessels are plainly distinguishable. The Kelly tube must be used with great care, as harm may be done by it, and the longest tube should be used in exceptional cases only.

I use with the greatest satisfaction James P. Tuttle's pneumatic proctoscope (Fig. 960). Dr. Tuttle describes it as follows ("Diseases of the Anus, Rectum, and Colon"):

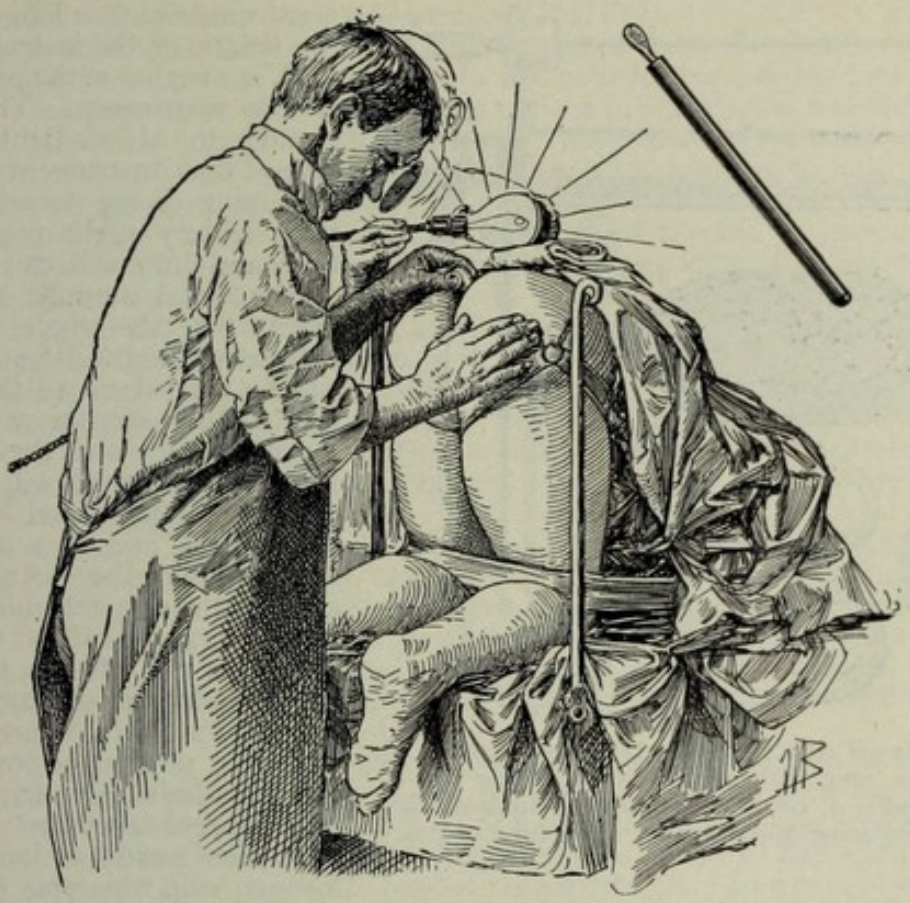


FIG. 958.—Examination of the rectum by reflected light (Kelly).

"This instrument is composed of a large cylinder (*f*), into one part of the circumference of which is fitted a small metallic tube closed by a flint-glass bulb at its distal end.

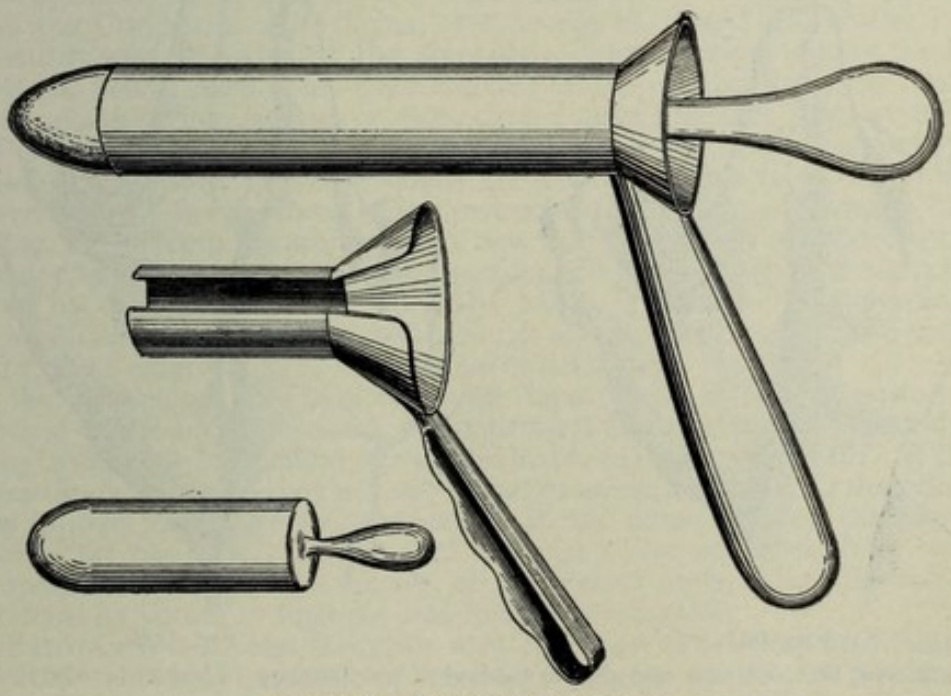


FIG. 959.—Kelly's rectal specula.

The electric lamp (*d*) is fitted upon a long metallic stem, and carried through the small cylinder to the end of the instrument, as shown in the illustration. The proctoscope

is introduced through the anus with the obturator (*a*) in position. As soon as the internal sphincter is passed this obturator is withdrawn and the bayonet-fitting plug (*b*), which contains either a plain glass window or a lens focused to the length of the instrument to be used, is inserted in the proximal end of the instrument. This plug is ground to fit air-tight and thus closes the instrument perfectly. The plug being inserted in the tube, a very slight pressure upon the hand-bulb will cause inflation of the rectal ampulla to such an extent that the whole rectum can be observed and the instrument can be carried up to the promontory of the sacrum without coming in contact with the rectal wall. Further dilatation will show the direction of the canal leading into the sigmoid, and, by a little care in manipulating the instrument and keeping the gut well dilated in advance, it can be carried up into this portion of the intestine without the least traumatism of the parts. If any fecal matter obscures the light by being massed or smeared over the glass bulb, the plug can be removed, and a pledget of cotton, introduced with a long dressing forceps, will wipe this off, so that the plug can be reintrodued and the examination continued with very slight delay or inconvenience. The adjustable handle (*c*) fits on the rim of the instrument and thus converts it into a Kelly tube. This instrument is operated with an ordinary

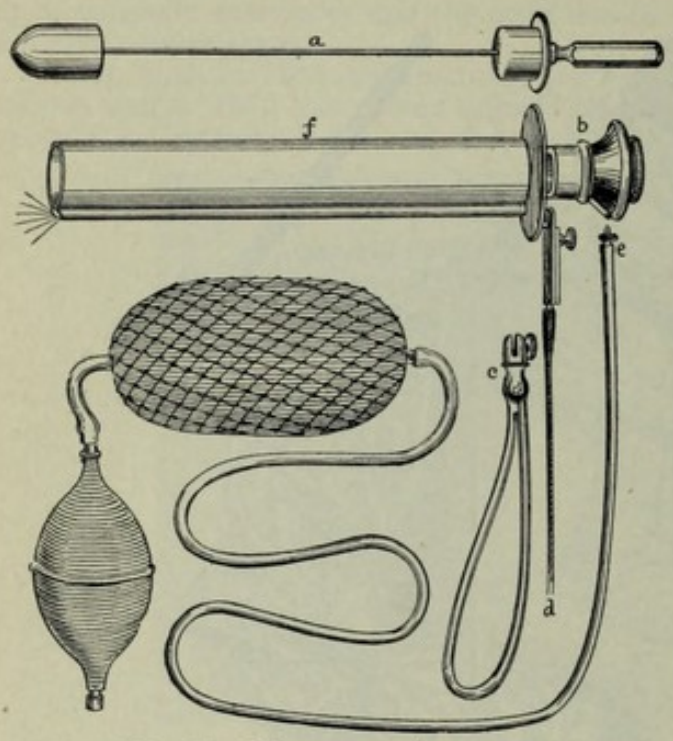


FIG. 960.—Tuttle's pneumatic proctoscope: *a*, Obturator; *b*, plug with glass window closing end of tube; *c*, handle; *d*, cords connecting instrument with battery; *e*, inflating apparatus; *f*, main tube of proctoscope.

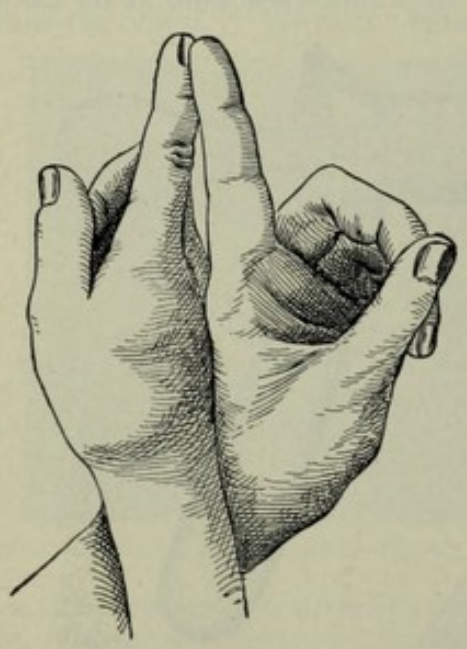


FIG. 961.

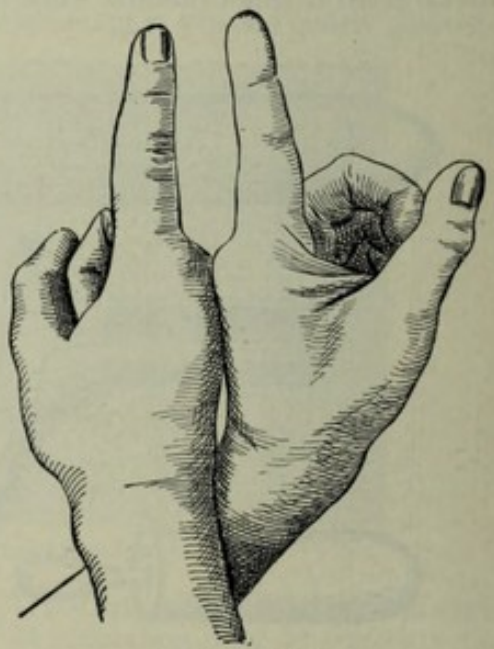


FIG. 962.

FIGS. 961, 962.—A new and simple method of proctoscopy (Thomas C Martin).

dry battery of four cells. It is better, however, to have a battery with six cells, as it will not require to be recharged so frequently." All the air must be allowed to escape before the instrument is withdrawn, otherwise colic may develop.

If an anesthetized patient is placed in the knee-chest position, the sphincter can be stretched by the fingers, and the rectum will distend with air and can be easily examined. The fingers are introduced as suggested by Martin (Fig. 961) and the rectum becomes visible when they are separated (Fig. 962).

Passage of Rectal Tubes.—Some have asserted that soft tubes can be passed from the anus through the sigmoid. I do not believe this can be done in a normal rectum, it matters not in what position the patient is placed, and whether or not fluid flows from the tube during its introduction. A soft tube always coils up after it has ascended 6 or 7 inches. In a number of laparotomies, desiring to locate the rectum, I have had an assistant pass a rubber tube. It would never ascend above the rectal dome unless I aided it with a hand in the belly, when it could be passed through the sigmoid. Fortunately it is not necessary to give high enemas, as fluid introduced into the rectum is carried back to the sigmoid. If we wish fluid retained, attempts to pass the tube high up will cause irritation, and irritation will lead to expulsion.

Foreign Bodies in the Rectum.—It is not at all unusual for hard, undigested articles taken with the food to lodge in the rectum. They can usually be removed through a speculum by means of forceps. In some cases ether must be given and the sphincter stretched; in others, the sphincter must be divided. Sometimes large bodies are voluntarily inserted and the individual is unable to remove them. Lewis H. Adler ("Amer. Med.," July 20, 1901) removed the valve of a steam radiator pipe from the rectum. The small end was $1\frac{1}{2}$ inches in diameter; the large end was $2\frac{1}{2}$ inches in diameter. The patient had been in the habit of introducing it frequently and removing it with a hook of galvanized iron wire. A. Marmaduke Sheild ("Lancet," Oct. 12, 1901) reports the case of a man sixty years of age who forced a gallipot into the rectum. The pot was $2\frac{1}{2}$ inches in diameter and $2\frac{3}{4}$ inches in height. The patient broke it trying to get it out. Sheild incised the sphincter from behind and removed the article by means of obstetric forceps.

If the foreign body be soft, as an apple or a potato, a hole should be bored through to allow the air to pass and thus relieve the suction. It can then be lifted out. If the body be of wood, screw in a gimlet; if of metal, cut with strong forceps; if of glass, remove as Sheild did the gallipot. If the article be rough or has sharp edges, pack gauze all around it as a first step to protect the rectal wall. In a case in which a boar's tail had been introduced, large end first, the holding back of the bristles was overcome by sliding over it a large-sized rubber catheter.

Foreign bodies may escape into the sigmoid and necessitate a laparotomy. They may also cause periproctic inflammation.

A remarkable series of cases of foreign bodies in the rectum may be found in "Anomalies and Curiosities of Medicine," by George M. Gould and Walter L. Pyle.

Wounds and Injuries of the Rectum.—These accidents may result from fractures of the pelvis, most often from fracture of the sacrum; from the improper use of bougies, enema syringe nozzles or tips; from gunshot wounds, stab wounds, or foreign bodies introduced by the patient; and, rarely, from digital examinations. The important points to consider in these wounds are whether or not there is perforation of the entire rectal wall, involvement of the perirectal tissues, or peritoneum. Slight wounds involving the mucous membrane only are frequently very grave from the fact that the hemorrhage is constant into the rectum, filling back into the sigmoid, and often followed by collapse before or when the blood is voided. The investigations into these conditions should always be thorough and by both digital and visual examination, for exact diagnosis is of the utmost importance.

If the peritoneum has been lacerated, laparotomy should be performed at once, the wound in the bowel repaired, the peritoneal cavity cleansed and drained, and the Murphy treatment for general peritonitis instituted (see page 1010). If the laceration involves the perirectal tissues but not the peritoneum, cut down on the side of the bowel that is injured and make free drainage. In the event of very extensive injuries to the perirectal tissues the question of inguinal colostomy should be considered. If the wound involves only the mucous or submucous coats, dilate the sphincter, arrest hemorrhage by suture or ligature, and follow by irrigation.

Inflammation of the Rectum and Sigmoid (Proctitis and Sigmoiditis).—These conditions may be acute or chronic, simple or specific. The simple forms are acute catarrhal, atrophic catarrhal, and hypertrophic catarrhal. The specific forms are gonorrheal catarrhal, diphtheritic catarrhal, erysipelatous catarrhal, dysenteric catarrhal, and syphilitic catarrhal (Tuttle, "Diseases of the Anus, Rectum, and Colon").

Acute Inflammation.—Acute catarrhal inflammation may be caused by that class of incidents which are apt to be followed by ordinary catarrh of the respiratory passages and, in addition, errors of diet or sudden change of temperature, as sitting on a cold seat when overheated. The onset is sudden, with chill, general malaise, pain and discomfort locally, and slight fever. There is a sense of fulness and weight, with often a burning sensation referred to the rectum, and at times tenesmus with frequent desire to go to stool. Pain radiates to adjacent parts and there is bladder irritability. Patients usually prefer to be in the recumbent posture.

There will be at first a thin fecal discharge followed by mucus tinged with blood. Ulceration soon supervenes. The parts are hot, dry, and swollen in the first stages and digital examination is very painful. Later the parts are slimy and the mucous membrane is covered with tenacious mucus and pus.

Treatment.—First remove irritating intestinal contents and reduce engorgement by lavage and saline cathartics, followed, if early in the case, by irrigations of cold water; if later, by hot water. A useful medicated irrigation is a 5 to 10 per cent. solution of the aqueous extract of krameria.

Chronic Inflammation.—In chronic proctitis and sigmoiditis the symptoms are similar to those present in the acute forms of the inflammation, but less severe in character. In addition, there is increased secretion of mucus, flatulence, and marked general intestinal disturbance.

The mucous membrane is soft, doughy, and thickened, and this condition of the mucous membrane palpably reduces the caliber of the gut. Through the speculum the membrane is seen to be edematous, pale, and covered with secretion. It bulges into the aperture of the speculum and does not bleed easily.

Treatment is hygienic and dietetic, with antiseptic and astringent irrigations.

Atrophic Inflammation.—The atrophic variety of inflammation is characterized by long-continued constipation, the dry stools being covered with blood and mucus. There is such pain on expulsion of feces as to simulate in many cases fissure of the anus. The mucous membrane of the anus ruptures easily when stretched during examination. It is bright red and shiny, does not fill the aperture of the speculum, and bleeds readily. Ulceration is common and hemorrhoids are a frequent complication.

Treatment is local and general. Locally, use a dilute solution of nitrate of silver (1 : 2000), hydrastis (2 per cent. solution), or ichthyol, applied after the rectum is emptied. General treatment is hygienic and dietetic.

Peri-anal and Perirectal Suppurations (Peri-anal Abscess and Ischiorectal Abscess).—These are of two classes—circumscribed inflammations or abscesses and diffuse inflammations that always develop pus. The circumscribed variety may be either superficial or deep. The superficial variety again may be tegmentary, subtegmentary, or *ischiorectal.* The deep variety may be of two forms—retrorectal or superior pelvirectal. It is important to note that right-sided superior pelvirectal abscess may be confounded with appendicitis.

The diffuse perirectal inflammations are variously classified, but the particular names refer only to the degree of the inflammatory process, which may vary from ordinary suppuration to gangrene.

These inflammations travel in the line of least resistance, which is upward, and burst into the bowel far more often than externally. They may follow chilling of the region or external traumatisms, may be caused by perforation of the rectum by hard fecal masses, but usually result from the direct passage of bacteria into the lymphatics of the fossa through a fissure, an abrasion, or an ulcerated pile. Ulcer seldom precedes. Perirectal suppuration is the great cause of fistula and blind internal fistula is the most common result. It may be either acute or tuberculous. In some cases the process is at first tuberculous, and secondary infection with pyogenic bacteria takes place.

The **symptoms** are nearly identical with those of abscess elsewhere, the swelling, however, being brawny, and it being difficult or impossible to detect fluctuation. Pain in the groins is often complained of, and there may be enlarged glands in these regions. Abscesses commonly result in fistula, and a patient should be warned of this tendency before operation is performed. Superior pelvirectal abscesses generally follow inflammation of some pelvic organ, viz.: tubes, urethra, prostate, and the symptoms are mainly those of such an inflammatory condition. The usual tendency of the pus is to burrow upward. The presence of pus is indicated by the symptoms of suppurative toxemia, which sometimes simulate typhoid fever.

The **treatment** is instant incision. The patient, after having been anesthetized, is placed in the lithotomy position. The cut should be parallel to the fibers of the

external sphincter and well outside of the muscle and longer than the inflamed area. When this incision is made, the finger should be introduced to break down the necrotic septa of cellular tissue. Then an incision should be made from the middle of the first cut radiating outward and opening any pockets external to the original focus. Search for a fistula into the rectum. Then the free edges of the cuts are pared away, sacrificing all involved tissue (cut away the cutaneous and fascial floor). The wound is irrigated, the sphincter dilated, and the cavity packed with iodoform gauze. If a fistula is found opening into the rectum, it is not to be operated on until after the wound is nearly healed, only a small fistulous tract remaining.

In cases of superior pelvirectal abscess the incision should be made at right angles to the fibers of the levator ani muscle to facilitate drainage. In these cases tubal drainage is used.

Imperforate Anus.—There are two forms of this condition. In one form the rectum empties into the bladder, vagina, or urethra. In the other form there is no rectal opening either upon the surface of the body or in the genito-urinary organs. The diagnosis is usually at once apparent, except in cases in which the anus looks normal, when the diagnosis will often not be made until symptoms of obstruction arise.

Treatment.—If the rectum bulges when the child cries, open into it with a knife and keep the opening patent by inserting a plug of iododorm gauze. In cases in which the rectum is more deeply seated, a catheter is introduced into the bladder, an incision is made from the anus to the coccyx, the rectum is sought for, and when found is sewed to the anus and is incised. Keen, the author, and others have performed Kraske's sacral resection, pulling down the rectum to the anal margin, sewing it there, and incising the occluded anus. If the rectum cannot be found or cannot be pulled down, an artificial anus must be made.

Fistula in ano (anorectal fistula) is a persistent, burrowing, and often tortuous sinus, the result of an unhealed abscess. Nearly one-third of all rectal cases are

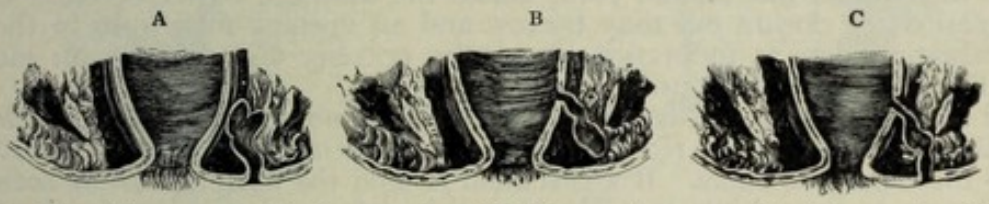


FIG. 963.—Fistula in ano: A, Blind external; B, blind internal; C, complete (Esmarch and Kowalzig).

fistulas (Tuttle). We designate a fistula as *incomplete* or *complete*. An incomplete fistula opens upon one surface only. There are two forms, viz., 1, *Blind external fistula*. It opens outside of the anorectal line (Fig. 963 A). 2, *Blind internal fistula*. Opens in rectum, that is, above the anorectal line (Fig. 963, B).

Complete Fistula (Fig. 963, C).—There is an external opening outside of the anus, an internal opening, and a patent tract joining them. Another classification depends on the tissues which are involved. We have *subcutaneous* (under the peri-anal skin), *submucocutaneous* (beneath the mucocutaneous lining of the anal canal), *submucous* (under the mucous membrane of rectum), *submuscular* or *subaponeurotic* (entirely outside of the muscle of the anus and rectum). There may be one or more openings through the skin or into the rectum. Pathologically fistulas are *specific* (cancer, syphilis, or tuberculosis) and *non-specific* (inflammatory).

Causes.—It is true that fistulas occasionally result from wounds, injuries, cancer, stricture, etc., but in a huge majority of cases abscess is the cause. Rectal ulcer as a cause is extremely unusual. The abscess nearly always precedes any opening in the bowel. The abscess may be opened externally or may break into the rectum. Why should an abscess refuse to heal? It is evident that a complete fistula or a blind internal fistula must be irritated by feces and gas. Such irritation is not present in blind external fistula. There must be a cause common to all. We find that cause in the constant movements of the muscles of the anus and rectum. Movement of the parts occurs in defecation and passing of wind and is caused by every cough, laugh, deep breath, muscular effort, etc. The parts are never at rest for any considerable length of time. Even when there is free drainage open healing may fail because the sinus has developed rigid and fibrous walls, because the abscess has burrowed, because the drainage tract is very tortuous, or because there are unfavorable constitutional conditions. Among these conditions are impairment of the general health, Bright's disease, diabetes, cirrhosis of the liver, typhoid infection, dysenteric infection, cancer

of the rectum, syphilis, and tuberculosis. In cases of syphilitic ulcer and stricture the rectal wall may be perforated and perirectal inflammation arise. Such a condition is not truly specific, as it is not due to breaking down of gummatous material. And yet there is some element existing in syphilitis which retards healing. This is shown by the fact that not unusually cases which have refused obstinately to heal improve rapidly under specific treatment. What is the influence of tuberculosis? We all see tuberculous cases. Some claim that many of them are primary (inoculation of rectal abrasions with tubercle bacilli). It seems proved that primary infection can occur, but such conditions are usually secondary to some tuberculous focus near or distant.

It is important to remember than even a victim of pulmonary phthisis can suffer from non-tuberculous abscess or fistula. Tuttle ("Diseases of the Rectum and Pelvic Colon") speaks of *tuberculosis in the fistulous*, and says that in his experience nearly 50 per cent. of fistulas occur in those who have or who develop tuberculosis. This estimate is so large as to suggest a very common connection between tuberculosis and fistula. Other observers are more conservative (Allingham, 14 per cent., Hartmann, 30 per cent., Meyer, less than 10 per cent.). In many cases the connection must be more than casual. How many tuberculous cases develop fistula (*fistula in the tuberculous*)? The estimates vary from less than 1 to 5 per cent.

Blind External Fistula.—An abscess has shrunk to a sinus, but, although it may close temporarily from time to time, refuses to heal. The opening may be near to or far from the anus. It may be at the summit of an elevation, at the bottom of a cicatricial depression, may be an ulcer, or a fissure in between anal folds. The probe finds no internal opening, neither does injection of colored fluids, but nevertheless an internal opening might not be found when it existed if the tract were constricted or tortuous, or if it ran up outside of the bowel and above the internal opening. A finger in the rectum and a probe in the sinus can usually demonstrate an internal opening. Certain knowledge is obtained by aid of the speculum. The discharge is thin and scanty. There is discomfort, but seldom pain, unless the drainage outlet becomes blocked. During periods of closure pus may burrow and an opening may form in the rectal wall. Palpation detects induration about the opening and perhaps an indurated sinus. The general health is usually good.

Blind Internal Fistula.—Pus is mixed with bowel movements and defecation may cause pain. A finger in the rectum may feel the opening in an area of induration, and also the indurated sinus. If a speculum is used the opening can be seen and a bent probe can be passed into it. The general health may be impaired.

Complete Fistula.—The discharge varies in amount, but is usually fairly profuse, at times contains fecal matter, gas emerges from the external opening, and there is a foul odor on examination of the parts. There is pain on defecation and the feces may contain pus. The fibrous sinus may be palpated. A finger in the rectum, the speculum, and the probe find the internal opening. There may be one or more external openings.

Subcutaneous Fistula.—The external opening is usually within 1 inch of the anus, and the internal opening is usually external to Hilton's white line. The channel joining the openings is usually straight, but may encircle the anus (Tuttle, Ibid.).

Submuscular Fistula.—The internal opening is usually between the sphincters, but may be higher, and the sinus branches and winds around the rectum (Tuttle, Ibid.). The external opening is an inch or more from the anus. The tract may pass through muscles. Urinary fistula or fistula from pelvic abscess is sometimes confused with submuscular fistula.

Tuberculous Fistula.—If it arises from a tuberculous abscess the opening is large and irregular, the edges are undermined, the granulations are edematous, and the skin is apt to exhibit tuberculous nodules (Tuttle, Ibid.). In all probability another focus can be found (pulmonary, osseous, or glandular). Always examine for clubbed finger-nails and evidences of near or distant tuberculosis. Some tuberculous fistulas have small external openings. The discharge may contain bacilli of tuberculosis. They can probably be obtained from scrapings of granulation tissue.

Horseshoe Fistula.—Tracks around the anus. There is usually but one internal opening. That is most commonly in the posterior commissure (in abscess of the posterior quadrant) and in the anterior commissure (in abscess of the anterior quadrant). There may be one, two, or several external openings.

Treatment.—In blind external fistula dilate the sphincter, incise through the skin outside of the external sphincter, curet or cauterize, incise all branching sinuses, and drain.

Blind Internal Fistula.—Insert a speculum, pass a blunt probe from within into the fossa, incise from without; cut down layer by layer from the skin surface on to the probe, and then act as in complete fistula.

Complete Fistula.—The old plan was to pass a probe from the skin opening into the rectum, substitute a grooved director, and bring the end of it out the anus (Fig. 966). If the opening was not found, the director was forced through the rectal wall. The intervening tissue was then divided. Such an operation will often succeed if there are no branching sinuses, if the tract is straight, if the internal opening is reached, and if no burrowing has taken place outside of the rectal wall and above the internal opening. If the tract is not straight the sphincter will be divided obliquely, incontinence may result, and the wound may refuse to heal (Fig. 964). Such operations commonly fail. A radical operation means a large and straight incision outside of the external sphincter, division of tissues layer by layer down to the bowel, division of all tissue between the internal opening and the surface, opening of all pockets, incision of all sinuses, dissection of all indurated sinuses and areas, and free drainage.

The sphincter must be cut transversely across (Fig. 965). If there are two internal openings the sphincter is to be cut but once at the first operative séance. The surgeon waits for several weeks to permit of muscle repair and then completes the operation. To cut the sphincter in two places at one séance will result in fecal incontinence.

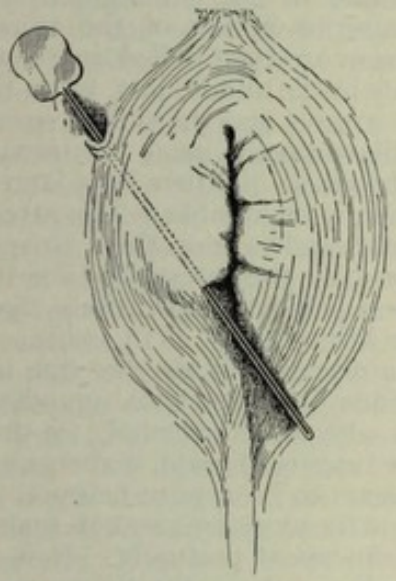


FIG. 964.—The wrong way according to Tuttle. Grooved director passed through fistulous tract and showing how passing a bistoury along the groove and cutting outward will divide the sphincter obliquely.

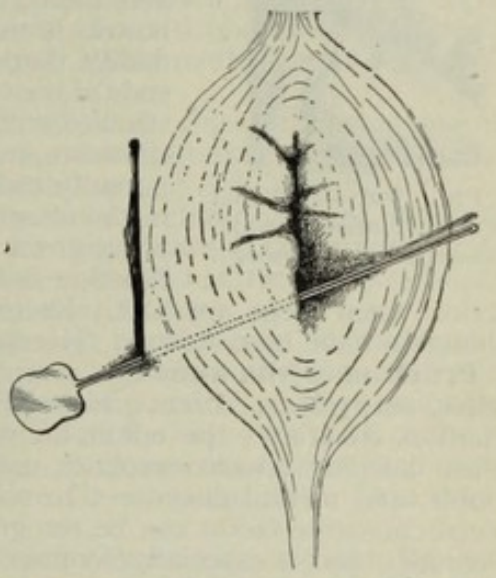


FIG. 965.—The correct way according to Tuttle. Fistula laid open outside of sphincter so that the latter can be cut squarely across.

If the victim of fistula has advanced, pulmonary tuberculosis drainage alone is justifiable.

In one with non-progressive or incipient phthisis operate radically, but use the cautery knife.

A fistula primarily tuberculous should be operated upon with the cautery knife.

An operation for fistula requires a general anesthetic. If anything more than drainage is indicated in a tuberculous fistula or in a fistula in a tuberculous person, give gas and oxygen. Ether might awaken into activity a latent pulmonary area. After an operation for fistula keep the patient in bed for at least two weeks and do not let him sit up straight in a chair for a much longer time.

In horseshoe fistula more than one operation may be necessary in order to avoid cutting the sphincter muscle twice in one operation, a proceeding which would probably lead to fecal incontinence. One side alone is operated on at one séance. Sinuses are opened and scraped, the sphincter is divided, the angles and edges of skin are trimmed away, and the wound is packed. When the wound is healed, or nearly healed, the other side should be operated upon.

Any operation for fistula will fail if it is not done thoroughly. Operative failure is common after fistula operations. The operation usually gives excellent results in simple fistula. It gives reasonably good results even when the internal opening is between

the sphincters, although in that case it may leave distinct impairment of fecal control. If the internal opening is above the internal sphincter, the operation just outlined leaves as a legacy definite loss of sphincter control and great consequent discomfort (Mackenzie, "Treatment of Fistula in Ano"). For such cases, and particularly for horseshoe fistulæ, Mackenzie (Ibid.) performs an operation which does not mutilate the sphincter. He dilates the sphincter; finds and dilates the internal orifice of the fistula; cuts the mucous membrane around it; pares it in the direction of the long axis of the bowel; trims the muscle in the direction of the circumference of the sphincter; sutures the muscle with catgut, the stitches passing at right angles to the fibers; sutures the mucous membrane with chromic gut; makes a flap on the side involved, the flap including the fistulous tract and all of its branches (in a horseshoe fistula he makes a flap on each side); removes all scar tissue from the rectal wall and enfolds the wall by catgut over the stitches within; removes all of the fistulous tracts from the flap, sutures the fat with buried sutures of catgut, inserts a small drain, and closes the skin.



FIG. 966.—The old operation for fistula in ano (Esmarch and Kowalzig).

If fecal incontinence results from an operation for fistula, remove the scar tissue and endeavor to suture the separated muscular fibers. A. W. Mayo-Robson ("The Practitioner" Feb., 1903) performs the following operation for incontinence: A crescentic incision, from ½ to ¾ inch in depth and taking in about one-half of the circumference of the bowel, is made at the anterior border of the anus. The middle borders of the incision are then pulled apart until the ends of the cut approximate in the middle line, when they are stitched with deep catgut sutures and the skin is sewed with silkworm-gut, the immediate result being an incision apparently radiating from the anus. If there be a large defect in the muscles simple suture is impossible. The attempt to bring down adjacent muscles and to train them to sphincter function is futile. To constrict the intestinal tube is of no service when feces are soft. Rectopexy is useless. Plastic operations upon the sphincters have been devised (Koerble, "Arch. für klin. Chir.," 1916, cviii).

Pruritus of the anus is a symptom and not a disease. It may be due to piles, fissure, seat-worms, eczema, nerve disturbance, kidney disease, gout, jaundice, constipation, inebriety, the opium-habit, torpid liver, dyspepsia, alcohol, tea-drinking, vesical calculus, tobacco-smoking, urethral stricture, uterine disease, diabetes, ovarian trouble, and mental disorder. In some cases it seems to be a pure neurosis and no special causative factor can be recognized. It is vastly more frequent in males than in females, and is especially common in fat men who sweat profusely. It is seldom seen before the age of thirty, except in children suffering from thread worms. The itching comes on gradually and usually intermittently, but grows progressively worse and worse until it becomes torturing. In many cases it is at first noticed only when warm in bed; in other cases it exists day and night. A violent exacerbation may be excited by worry, anxiety, overwork, dietary indiscretion, a sudden change of temperature, and many other things. The itching finally becomes an unbearable agony, sleep, except in snatches, is impossible, the appetite disappears, the strength fails, and the sufferer may become a nervous wreck. In some cases of pruritus the anal folds are edematous, there are abrasions here and there from scratching, the area is white and moist, and gives origin to a fine secretion; in other cases the mucous membrane is dry and fissured.

Treatment.—In every case first of all make a careful examination to find a probable or a possible cause, local, reflex, or constitutional, and endeavor to remove this supposed cause. Then undertake treatment for the pruritus. It is very important to prevent constipation. Kelsey directs that the parts be cleansed twice a day, and after each cleansing the following ointment be applied: Menthol, 1 dr.; cerat. simp., 2 oz.; oil of sweet almonds, 1 fl. oz.; acid carbolic, 1 dr.; pulvis zinc oxid, 2 oz. Mathews commends the following mixture: Chloral, 1 dr.; gum-camphor, ½ dr.; glycerin and water, each, 1 oz.[1] In this disease a "scarf skin" forms, which may be made to peel off by the application of iodin, pure carbolic acid, corrosive sublimate (4 gr. to 1 oz. of cosmolin), or calomel (2 dr. to 1 oz. of cosmolin). In obstinate cases paint the parts, night and morning, with a mixture of 60 gr. of alum, 30 gr. of calomel, and 300 gr. of glycerin; or smear with an ointment composed of ½ part of oleate of cocain, 3 parts of lanolin, 2 parts of vaselin, and 2 parts of olive oil (Morain). In very severe cases, in

[1] "Diseases of the Rectum."

which the skin is dry and cracked, apply a 5 per cent. solution of eucain to the abraded portions and paint the entire surface with a concentrated solution of silver nitrate It may be necessary to repeat this treatment several times at intervals of four or five days. Adler advised us to apply to the parts the day after the silver has been used unguentum hydrargyri nitratis in full strength, only discontinuing on the day a fresh application of silver is made, and the next day resuming the applications of ointment. If during treatment the skin becomes sore, use calomel ointment until soreness disappears. Violent attacks of itching are met by applying hot water and black wash or calomel ointment. This plan of treatment must be pursued for some months (Lewis H. Adler, Jr., "New York and Phila. Med. Jour.," July 29, 1905). I have used this plan with some satisfaction. In severe and protracted cases we may employ the *x*-rays twice a week (J. R. Pennington). I have seen their application productive of great benefit in the worst cases. In some cases we employ the Paquelin cautery, in others we resect the mucous membrane, as in Whitehead's operation for hemorrhoids. Ball divides the sensory nerves going to the implicated skin and has obtained excellent results. H. B. Stone ("Bull. Johns Hopkins Hospital," 1916, xxvii) has had success with injections of alcohol. He anesthetizes the parts by injecting a 1 per cent. solution of novocain or a 1 per cent. solution of urea hydrochlorid and quinin. A general anesthetic may be given instead of local anesthesia. The needle for the alcohol is carried through the skin vertically and is then placed horizontally under the skin. It must be found to be freely movable from side to side. Alcohol is injected beneath the area involved. The anal canal is not injected. This method is as beneficial as operation.

Fissure of the anus is an irritable ulcer at the anal orifice producing spasm of the sphincter. Pain exists because twigs of nerves are exposed upon the floor of the ulcer. Fissure is caused by constipation or traumatism. It is usually posterior.

The **symptom** is violent, burning pain, sometimes beginning during defecation, but usually at the end of the act, and lasting for some hours. Constipation exists, and often pruritus. Examination discloses a fissure, usually at the posterior margin, running up the bowel $\frac{1}{4}$ to $\frac{1}{2}$ inch. Piles often exist with fissure.

Treatment.—The *palliative treatment* is to prevent constipation, to wash out the rectum with cold water, and apply an ointment made by evaporating 2 oz. of the juice of conium down to 2 dr., and adding it to 1 oz. of lanolin and 12 gr. of persulphate of iron. Pure ichthyol frequently promotes healing unless the edges are thick or the base indurated, hen operation must be done. Many cases are so sensitive and painful to the touch that medication and examination are almost impossible. Pain may be made bearable by insufflations of orthoform.

Operative Treatment.—Anesthetize the patient. Thoroughly cleanse the parts. Some surgeons advocate operation without stretching the sphincter. It has always been my custom to stretch the sphincter for fissure. Stretching gives us room in which to work, and by thus paralyzing the muscular fibers the raw surface is put at rest and paroxysms of pain cease to occur. In order to stretch the sphincter the patient is anesthetized, the surgeon's thumbs are inserted into the rectum, and the parts are stretched slowly until the thumbs touch the ischia. After stretching the sphincter the fissure is incised through its base $\frac{1}{4}$ inch deeper than the deepest part of the ulcer, extending $\frac{1}{4}$ inch above and below the diseased tissues, so that the healthy muscular fibers at either end are divided. In cases in which the ulcer is at either the anterior or posterior commissure a V-shaped incision is made, the apex of which should begin $\frac{1}{4}$ inch above the highest point of the ulcer and the diverging line running close to the sides of the fissure, but in healthy tissue.

A search is made by a probe to be sure no pockets exist. Any pocket must be opened and scraped. The floor should be curetted and touched with the solid stick of nitrate of silver. If there are redundant edges, exuberant granulations, a sentinel pile, or a polypus, they should be curetted or excised. The wound is then packed lightly with gauze and the patient kept in bed for twenty-four hours.

Hemorrhoids, or Piles.—There are three varieties of varicose tumors of the rectum, namely, *external*, which take origin without the external sphincter; *internal*, which take origin within the external sphincter; and *mixed* hemorrhoids, which are a combination of the two.

External hemorrhoids are covered with skin. Internal hemorrhoids are covered with mucous membrane. The term "external hemorrhoids" is not strictly accurate, as hemorrhage does not occur in external piles, and all external piles are not related to the external hemorrhoidal veins. An external pile may involve the veins of the skin.

External hemorrhoids are classified as thrombotic, varicose, inflammatory, and connective-tissue external hemorrhoids (Tuttle).

Thrombotic External Hemorrhoids.—These are external hemorrhoidal veins filled with clot. When an external hemorrhoidal vein inflames the parts become itchy, painful and swollen, and defecation increases the pain. The blood clots in the inflamed vein and sometimes the vessel ruptures.

Symptoms and Treatment.—External piles of this variety are usually, but not always, multiple. Small oval tumors appear beneath the skin or the junction of the skin and mucous membrane. They appear suddenly. The parts itch and pain, defecation increases the pain, and each pile increases rapidly in size. When the vein ruptures, a livid, soft enlargement rapidly forms. External piles of this variety may be absorbed, may become organized into a scar, or may suppurate. These piles do not bleed. In treating external hemorrhoids some surgeons merely use remedies to combat the inflammation. An old plan of treatment is to incise the blood-tumor, turn out the clot, and pack with a bit of iodoform gauze. Mathews freezes the part or injects cocain, catches up the blood-tumor with a volsellum, excises the tumor and the tabs of inflamed skin, dusts the part with iodoform, and dresses it with antiseptic gauze. The bowels should not be allowed to move for two days. Never inject external piles with carbolic acid; it causes great inflammation, violent pain, sloughing, and is not free from danger. If the patient declines operation, order rest, a non-stimulating diet, avoidance of tobacco (Mathews), the use of saline purgatives, injections into the rectum of cold water several times a day, sponging of the anus frequently with hot water, and the application of hot poultices. As the acute symptoms begin to disappear use extract of hamamelis locally; when they have nearly subsided, apply zinc ointment.

Varicose External Hemorrhoids.—They are varicose external hemorrhoidal veins and are visible at the anal margin when the patient strains. They rarely produce pain or discomfort, and it is seldom that operation is necessary. The bowels should be moved daily, but not with violent purgatives, and after each movement cold should be applied to the anus, while the patient is recumbent. Tuttle advocates the use at night of an ointment containing 2 dr. of suprarenal extract and 6 dr. of lanolin; this is spread on cotton-wool, which is applied to the anus and held in place by a T-bandage.

Inflammatory Piles.—By this term we mean edematous inflammation of the anal folds. The inflammation may be due to a traumatism, the presence of an ulcer or fissure, etc. There are burning, itching, and swelling of the anus, which are all greatly increased by defecation. One or more pear-shaped swellings can be seen at the anal margin.

In some cases medical treatment produces cure. This treatment consists, during the first twenty-four hours, in the use of cold and of rest in bed. After this period heat should be employed. Tuttle applies gauze soaked in a 25 per cent. solution of boroglycerid and places a hot-water bag over this. He also recommends the following ointment, to be applied two or three times a day:

℞. Morphinæ sulph. ..... gr. v–x;
Ichthyol. ..... ℥iv;
Ung. belladonnæ }
Ung. stramonii } ..... āā ℥j.
Sig.—Apply two or three times a day.

If these means fail, ether is given, the sphincter is stretched, and the tumors are cut away.

Connective-tissue External Hemorrhoids (Skin Tabs).—They are due to hypertrophy of mucocutaneous tissue at the anal margin. Usually they result from acute inflammatory external piles; sometimes they arise gradually as a result of chronic anal or rectal inflammation or irritation, and they may be due to varicose or thrombotic external piles (Tuttle). They produce no trouble when not inflamed. If they cause serious annoyance the treatment is extirpation.

Internal hemorrhoids are varicose tumors of the internal hemorrhoidal plexus, and are found internal to the external sphincter, just within the anus, and they prolapse easily. They are not simply varicosities, but new tissue has been formed, and they are, in reality, vascular tumors. They are covered with mucous membrane. *Capillary* piles are small, sessile, with a surface like a mulberry, and bleed freely. Children are not very liable to develop piles, excepting the capillary form. *Venous*

piles are the most common variety. They extend from just above the anal canal for an inch or more. They are purple in color, soft, irregular in outline, and are usually multiple. They bleed when irritated by hard fecal masses, but not so easily as the capillary piles. Each pile is composed of a varicose vein, some fibrous tissue, and a few arterial twigs. *Arterial* piles are very unusual. They are large, smooth, pedunculated, bleed easily and freely, and contain, besides a distended vein, arteries of some size.

Anything producing venous congestion in the rectum—constipation, diverticulitis of the sigmoid, diseases of the rectum, enlargement of the prostate, pregnancy, tumors of the womb, congestion of the liver, cirrhosis of the liver, certain diseases of the heart and lungs, sedentary occupations, relaxing climate, and stricture of the urethra—may cause hemorrhoids.

Symptoms and Treatment.—If there is neither bleeding nor protrusion the piles give no trouble. The first symptom is usually hemorrhage, and rectal examination by the speculum will make clear the condition. After a time, during defecation, the piles protrude; they may reduce themselves when the patient stands up, or it may be necessary to push them in. Pain does not exist in uncomplicated cases, and pain during or after protrusion means "abrasion, fissure, or ulceration" (Mathews).

Palliative Treatment.—This will not cure, but it will give great comfort. Some people only suffer at rare times when the liver is congested, and such subjects will not submit to operation. Remove, if possible, the cause (alcohol, irritating foods, want of exercise, etc.); restrict the diet; insist on regular exercise; give a course of Carlsbad salt, and follow this by the administration of bichlorid of mercury (1/24 gr. after each meal). Prevent constipation by a nightly dose of extract of cascara. After each bowel movement wash the parts with a soft sponge soaked in cold water, and syringe out the rectum with cold water and dry outwardly with a soft rag. If the hemorrhoids prolapse, after restoring them and injecting cold water, insert a suppository containing 10 gr. of the extract of hamamelis and use another suppository at bedtime. A useful suppository for prolapse is that employed by Tuttle: it contains 5 gr. of ichthyol, 5 gr. of tannic acid, $\frac{1}{3}$ gr. of ext. of stramonium, $\frac{1}{3}$ gr. of ext. of belladonna, and 10 gr. of ext. of hamamelis. Bleeding may be arrested by suppositories, each containing 5 gr. of suprarenal extract. When the piles prolapse and inflame, rub Allingham's ointment on the parts (2 dr. each of ext. of conium and ext. of hyoscyamus, 1 dr. of ext. of belladonna, and 1 oz. of cosmolin). Mathews uses 12 gr. of cocain, 1 dr. of iodoform, $\frac{1}{2}$ dr. of ext. of opium, and 1 oz. of cosmolin. Grant uses an ointment containing 8 gr. of morphin, 12 gr. of calomel, and 1 oz. of vaselin. A small quantity of this is applied after bathing the part with hot water. If the piles are protruding and reduction cannot be effected, put the patient to bed, give a hypodermic injection of morphin, and apply hot poultices. If reduction cannot soon be effected, divulsion of the sphincter must be practised or radical operation must be resorted to.

Operative Treatment.—Give a saline the morning before and an enema the evening before the operation, and wash out the rectum well the morning of the operation. In treating by *injection of carbolic acid* the sphincter should be divulsed while the patient is under the influence of nitrous oxid gas unless the pile be thrombotic. "Under gas muscular relaxation does not obtain as in the use of ether. Hence dilatation under gas can be more rapidly induced, as we have the sphincteric rigidity as a guide in knowing exactly how much force may be employed in the individual case" (Lewis H. Adler, Jr., in "Jour. Amer. Med. Assoc.," Jan. 21, 1905). The surgeon must be careful not to tear the parts. The tumors are drawn out or, if gas has not been given, the patient strains them out. An injection is given by a hypodermic syringe into the center of the pile, and as each pile is injected it is pushed into the rectum. Only one or two piles are injected at each séance, and the operation is not repeated for one week (Geo. W. Gay in "Boston Med. and Surg. Jour.," Dec. 5, 1901). The dose for each pile is 1 or 2 min. of a 10 per cent. solution of carbolic acid. The injections relieve the condition, but are rarely absolutely curative and are not without danger, and may produce abscess, sloughing, hemorrhage, phlebitis, pyemia, stricture, and even death (W. T. Bull, Kelsey). Dr. Collier F. Martin ("American Medicine," Aug. 27, 1904) maintains that the method is safe and satisfactory. He injects equal parts of a French preparation of phenol and distilled water, freshly mixed and filtered. From 7 to 15 min. are injected into a pile and only one pile is injected at a séance. In from five days to one week another injection may be given. Before beginning a course of injections the sphincter is stretched while the patient is under nitrous oxid and oxygen. It is not necessary to repeat nitrous oxid anesthesia for future injec-

tions. During injection a special speculum is used. The pile protrudes into the speculum, is cleansed with a 1 per cent. solution of creolin, and the injection is thrown into the most prominent part of the pile. The speculum is withdrawn before pulling out the needle. This maneuver prevents escape of injection and arrests bleeding. I seldom employ the injection treatment. I never use it if the patient consents to the clamp and cautery operation or to ligation. The *clamp and cautery* is, in the great majority of cases, the operation of choice. It requires but a few minutes to do it; after it is done there is little or no postoperative pain, in very many cases retention

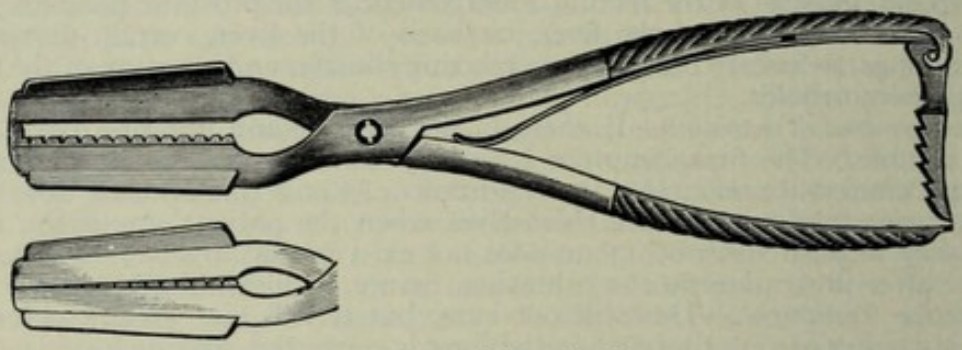


FIG. 967.—Brick's pile clamp.

of urine does not occur, and the patient usually is about again within ten days. The patient is anesthetized and the sphincter is carefully and thoroughly stretched. The stretching of the sphincter is very important. It gives free access to the parts, prevents subsequent spasm and pain, and lessens the likelihood of venous bleeding after operation. The pile is caught by forceps and drawn outside of the sphincter. Many use Smith's clamp. It is applied with the ivory surface against the mucous membrane of the bowel. I use the clamp devised by Dr. J. Coles Brick (Fig. 967). From the bite of Brick's clamp the pile cannot slip, as the blades come evenly and firmly together. The pile is cut off and the stump is seared with the Paquelin cautery at a dull-red heat. Pile after pile may be thus treated, care being taken to leave some mucous membrane at each side of every pile. If this precaution be not taken, healing will be slow and stricture will result. After cauterization is complete a speculum is

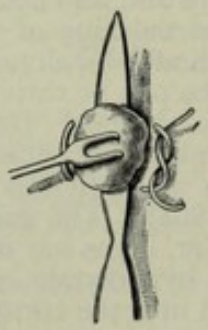


FIG. 968.—Extirpation of hemorrhoids (Esmarch and Kowalzig).

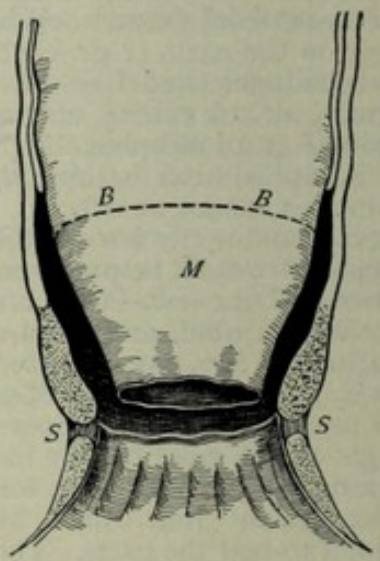


FIG. 969.—*S*, *S*, The lower circular incision along Hilton's white line; *M*, tube of mucous membrane dissected from the sphincter; *B*, *B*, dotted line showing the place for the upper circular incision (Edmund Andrews).

inserted and the blades are widely opened. Any bleeding points are at once ligated. This is a most important precaution. Packing is never inserted. I formerly used it, but have given it up. It is of no service and produces severe pain and edema. The treatment from this point is identical with that advised below after the use of the ligature. *Excision* is preferred by Allingham. He stretches the sphincter, holds it open with a retractor, catches up the pile, cuts it off, and twists the bleeding vessels. Some prefer to pass a silk or catgut suture, cut off the tumor, and tie the thread (Fig. 968). *Whitehead's operation* (Fig. 969) is only to be performed

in severe cases, when the piles are extremely large and form a protruding circular mass. Primary union is rarely secured. When first introduced the operation was viewed with favor, but experience shows it is sometimes followed by disastrous consequences.[1] Stricture not infrequently arises after its performance; fecal incontinence occasionally results, and anal anesthesia with inability to restrain the passage of gas is common. After this operation the anus is permanently more or less moist. The entire pile-bearing area of mucous membrane is dissected out and the cut margin of mucous membrane is pulled down and stitched to the surface. The sphincter may be dilated as a preliminary measure.

The *application of the ligature* is an easy and useful method. It is not so rapid as the cautery, is followed by more pain, healing requires a longer time, and stricture is more common. In this operation, after anesthetizing, stretch the sphincter and treat each hemorrhoid separately. Catch a pile with a pair of forceps or a volsellum, pull it down, and cut a gutter through the skin margin if the pile is of the mixed variety; tie the small piles without transfixing, but transfix the large piles; tie with silk (coarse silk for the large piles, finer silk for the small piles), cut off each tumor beyond the thread, and cut the ligatures short. Treat the other piles in the same manner. Irri-



FIG. 970.—Rectal prolapse.

gate with hot normal salt solution. Do not insert packing. After an operation place a 2-gr. opium suppository in the rectum. Apply a gauze pad and a T-bandage over the anus. The opium locks up the bowels. The patient is kept on a light diet for three days, at the end of which time a saline may be given. Just before the bowels act remove the dressings and give an enema of warm water or of glycerin or of glycerin mixed with olive or linseed oil. After the movement wash the parts first with dilute peroxid of hydrogen and next with hot salt solution, dry carefully, and apply a gauze pad over the anus. Irrigate daily until healing is complete. After the tenth day, if ligatures were used, examine with a speculum to see that the ligatures have come away; if any are found in place, remove them.

Prolapse of the Rectum.—If the mucous membrane is prolapsed the condition is commonly called *prolapsus ani;* if the entire thickness of the rectal wall is prolapsed, it is commonly called *prolapsus recti* (Fig. 970). The term "prolapse of the anus" is an incorrect and objectionable one, and we should designate such cases *prolapse of the rectal mucous membrane, incomplete* or *partial prolapse.* If all the coats of the bowel descend the condition should be called *complete prolapse* or *procidentia.*

[1] Andrews in "Mathew's Medical Quarterly," Oct., 1895.

Incomplete Prolapse (Partial Prolapse).—In this condition the mucous membrane of the rectum protrudes from the anus. Under normal conditions the membrane protrudes during defecation and at once retracts when the act of defecation terminates. In the condition under discussion the mucous membrane remains protruded because the submucous tissues, being stretched and relaxed, find it difficult or are unable to draw the mucous membrane in again. In this condition a ring of mucous membrane or only a portion of its circumference may protrude. It is particularly common in early youth and in old age, is apt to occur from excessive straining at stool, and is commonest in feeble, ill-nourished children. A polypus may be the cause. Piles and worms may lead to prolapse. Straining from phimosis, stone in the bladder, or urethral stricture may be causative. Its development is favored by the use of articles of food which cause frequent movements of the bowels. If an individual sits a long time on the seat of the closet or on the chamber the development of prolapse is favored. The condition comes on gradually and is at first painless. For some time it reduces itself spontaneously after defecation, but reduction becomes more and more difficult. A common custom of sufferers is to push it by the fingers above the grasp of the sphincter. Sometimes, but seldom, it becomes strangulated. A recent prolapse is pink, an older one is angry red; one which is firmly caught is purple; a strangulated one is deep purple and soon becomes black from gangrene. If the prolapse be of the entire circumference it shows radial folds of mucous membrane. It frequently bleeds. Prolapse, be it large or small, tends to recur again and again, and eventually the mucous membrane inflames, ulcerates, or sloughs. Prolapse of all the coats may ensue (see below). Partial prolapse is sometimes confused with hemorrhoids, but in prolapse the protruding mass is circular and has a depression in the center, whereas hemorrhoids are distinct masses. Further, hemorrhoids are very rare in children. Hemorrhoids often exist with prolapse of the mucous membrane and frequently cause it. In prolapse of the mucous membrane there is no sulcus between the sphincter muscle and the anterior portion of the protrusion; in complete prolapse there is.

Treatment.—*Palliative* treatment forbids straining at stool and amends an improper diet. Phimosis must be corrected; stone in the bladder must be removed; stricture must be dilated; hemorrhoids and polypi are to be removed. Give an enema of cold water just before going to stool in order to hurry the emptying of the rectum. If prolapse occurs, the protrusion must be bathed with cold water and restored. Constipation must be prevented (enemata of water or glycerin may be used), and after each movement several ounces of an infusion of white oak bark (1 ounce of quercus to a pint of water) should be injected. If a prolapse is caught firmly, paint it with cocain and adrenalin, place the patient in the knee-chest position, apply hot compresses, grease it with cosmolin, insert a finger into the rectum, and apply taxis around the finger (Mathews). If this fails, cover a finger with a handkerchief and insert the wrapped digit into the rectum; if this proves futile, invert the patient before manipulation. Do not give a general anesthetic unless it is imperatively necessary; the vomiting so often caused by ether and chloroform might reproduce the prolapse. After reduction apply a large compress to the anus, strap the buttocks together, and restrain the patient to bed for seven or eight days. Keep the bowels constipated. When a bowel movement impends have the patient lying on the side, give an injection of cold water containing an astringent (tannin or fluidextract of hydrastis), permit the feces to flow out under the compress, and then cleanse the parts and reapply dressings. Most cases in children can be cured without operation. Some cases in adults and obstinate cases in children may be treated by painting the prolapse with fuming nitric acid, greasing it with olive oil, and restoring it. Some cases require excision of the mucous membrane, the divided edge of this membrane being stitched to the skin. In other cases the protrusion is stroked longitudinally with the actual cautery and restored. When the surgeon comes to operate for recurring prolapse, it will often be found to have modestly withdrawn and he may be obliged to stretch the sphincter to bring it into view.

Complete Prolapse (Procidentia).—In this condition all of the rectal coats protrude. There are said to be three degrees of this condition. In the first degree the prolapse begins at the anal margin and its outer surface is continuous with the perianal skin, there being no sulcus between. Such a prolapse is a consequence of prolapse of the mucous membrane. In the second degree (genuine procidentia) the prolapse begins on a level or above the level of the lower margin of the peritoneum and projects out of the anus. In the third degree the prolapse begins at the origin of the rectum or in the sigmoid, and is, in reality, a protruding intussusception. Some cases become

obvious suddenly. The prolapse of the first degree has no furrow between it and the perianal skin, and the folds are circular instead of longitudinal. It is usually treated as is prolapse of the mucous membrane. If simple methods fail, it will be necessary to do a more radical operation upon the anal orifice. In prolapse of the third degree the treatment is as for intussusception. It is prolapse of the second degree that we consider here. It is more common in adults than in children. There are many theories as to its causation. Esmarch regards it as due to inflammation of the rectum, which spreads to all the coats and also to the perirectal structures. Another theory (Jeannel's) is that the small intestine is in a state of ptosis, and by falling into Douglas's culdesac presses upon and causes atrophy of the levator ani muscle. The most probable theory is that the condition is, in reality, hernia (Waldeyer, Zuckerkandl, Moschcowitz). Moschcowitz ("Surg., Gynec., and Obstet.," July, 1912) makes a powerful argument to prove that the intestine in Douglas's culdesac causes a bulge of the anterior rectal wall, that this bulging part of the wall grows larger and descends, and that finally the entire circumference of the rectum is dragged down. It is certain that muscular weakness and high intra-abdominal pressure are the underlying causes.

Complete prolapse is usually preceded by chronic constipation, great straining being necessary to effect defecation. Chronic rectal catarrh is also a common antecedent.

A mass sticks out of the rectum and there is a purulent discharge which often contains blood. The protruding mass (which is seldom over 6 inches in length) is covered externally with mucous membrane (which may be normal, inflamed, ulcerated, or bleeding) and is lined by normal mucous membrane (Moschcowitz, Ibid.). The opening is at the apex of a canal directed backward. The anterior part of the protrusion is much larger than the posterior part, the anterior part is usually tympanitic, and the posterior part is dull on percussion (Moschcowitz, Ibid.). There is a deep furrow between the anterior portion of the sulcus and the anal margin. The furrow, as a rule, is about 1 inch deep (see Fig. 970).

Early in the case the prolapse is reduced spontaneously, later it must be reduced by the hand. It may become irreducible or strangulated. The protrusion when strangulated becomes gangrenous.

Treatment.—In children the condition may often be cured by the methods used for prolapse of the mucous membrane. If a prolapse is caught tightly, apply hot compresses to reduce swelling, paint it with cocain and adrenalin, put the patient in the knee-chest position, and reduce as described under Partial Prolapse. After reduction apply a support and strap the buttocks. After-treatment is as for the partial form. Electricity is used by some, injections of astringents under the mucous membrane by others. Operation is necessary for prolapse in most adults and in some children. As a preliminary, hemorrhoids, ulcerations, etc., must be cured. A multitude of operations have been recommended. Some try to constrict the anal opening (cauterization by the actual cautery, nitric acid or chlorid of zinc; removing a wedge-shaped piece from the posterior rectal wall followed by suturing; twisting the rectum; injections of paraffin about the sphincter, and various other plans). Such operations are entirely inefficient. Some operate on the bowel higher up, striving to increase support. Moschcowitz also mentions "methods which pay particular attention to the fixation apparatus of the rectum." One plan is to operate through an abdominal incision, fixing the sigmoid to the abdominal wall—an unphilosophic operation "because the distal end of the sigmoid is fixed to the sacrum, and pulling can have very little, if any, effect upon the prolapse of the rectum" (Moschcowitz, Ibid.).

I have abandoned the operation of stitching the sigmoid to the abdominal wall (*colopexy*) because it is dangerous thus to anchor the gut, and because, I believe, it always fails to cure. Mikulicz's operation of excision of the prolapse has elements of decided danger, but may cure the case. I apparently cured 1 case this way, but in another case the condition recurred.

Von Eiselsberg resected the sigmoid flexure, drew up the rectum, and made an anastomosis.

Moschcowitz's operation is the most reasonable one. The abdomen is opened, the rectum is held taut, and the culdesac of Douglas is obliterated by silk or linen sutures. The pelvic fascia is included in the sutures.

All the above operations are serious and are particularly dangerous in children.

D'Espine's Alcohol Injections.—This method was introduced by D'Espine, of Geneva, in 1919 (Findlay in "Brit. Jour. Child. Dis.," 1921, vol. xviii). The results

obtained by D'Espine, Findlay, and Alexander have been excellent. Alexander, following Findlay, operates as follows ("Annals of Surg.," Oct., 1922): Enema. General anesthesia. Finger in rectum. Needle inserted 8 mm. from the anal margin and carried along the side of the bowel just outside of the mucous membrane to a depth of 7 cm. About 1.5 c.c. of ordinary alcohol injected. Repeat on opposite side. Seal punctures with collodion. Apply pad and strap buttocks. In bed eight or ten days. Precautions as to bowel movements as set forth on page 1182.

Ulcers of the rectum are divided into the simple traumatic, the syphilitic, the tuberculous, the dysenteric, the gonorrheal, and the malignant. *Simple* ulceration is due to abrasion with fecal masses or a foreign body, the abraded area ulcerating. It may follow an operation for piles and also protracted labor ("Diseases of the Rectum," by Allingham), and is apt to be single. The base and edges of a simple ulcer are neither prominent nor hard and stricture rarely forms. *Syphilitic* ulceration is a tertiary lesion commonest in women. There are numerous small ulcers of the mucous coat or submucous tissue, but little indurated, with sharp-cut edges which are not undermined. These ulcers fuse and constitute one large irregular ulcer; fibrous tissue forms in the wall of the bowel, induration becomes noticeable, and stricture

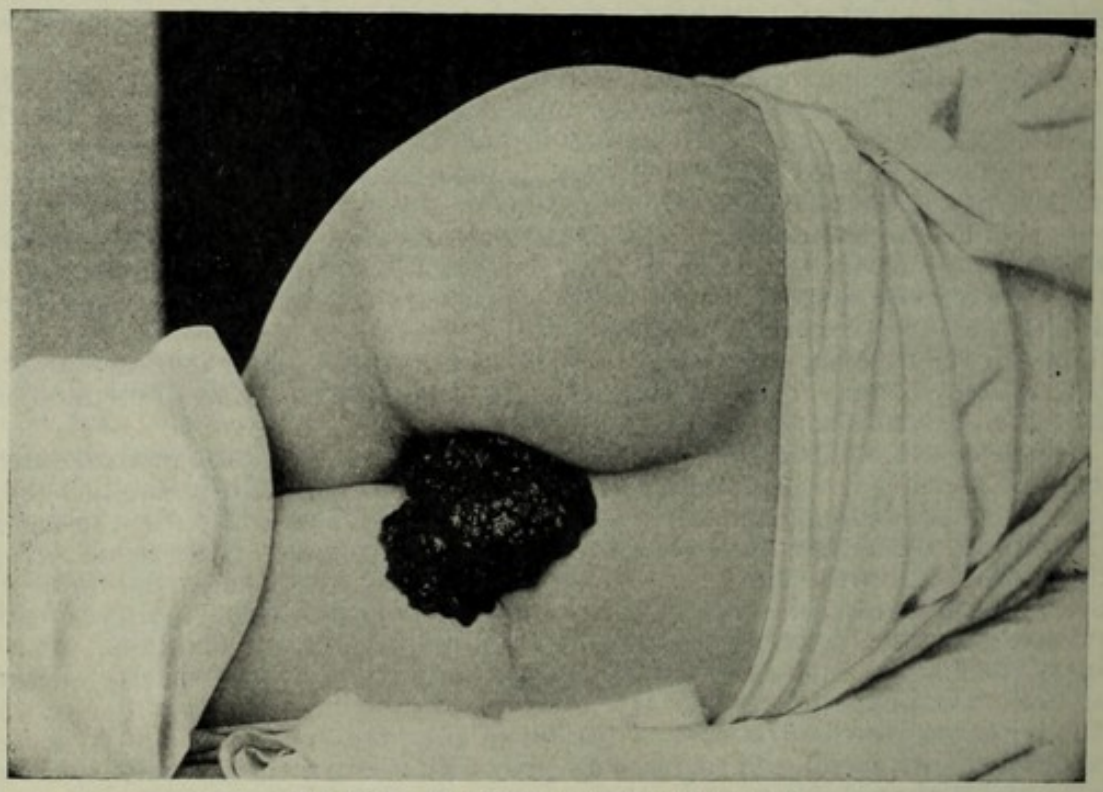


FIG. 971.—Papilloma of anus and rectum.

follows. There is profuse discharge and fistulæ are apt to form. Such ulcers may be surrounded by nodules of a bluish color. In many cases the first condition is stricture due to the formation of masses of fibrous tissue in the rectal walls, and ulceration occurs secondarily. In syphilis there may be a breaking down of a huge gummy mass or of multiple gummata. It has been proved by the microscope that tuberculous ulceration may arise in the rectum. *Tuberculous* ulceration presents a conical ulcer with overhanging edges and a pale red base. There is some mucous discharge, some tenesmus, and a little pain. Tuberculosis is seldom *directly* responsible for stricture (see page 1174). Dysentery, catarrh, diabetes, Bright's disease, neoplasms, and foreign bodies may produce ulceration of the rectum.

Symptoms.—There may be merely uneasiness about the rectum, but sometimes there is severe burning pain on defecation, and perhaps for some time after the act. There may be constipation or diarrhea; the patient strains at stool, and the stools may contain blood, mucus, or pus. As a rule, there are two movements soon after rising in the morning, the first movement consisting of blood and mucus. After it there is the sense of an uncompleted act. The next movement is fecal and usually satisfying. The history should be carefully inquired into; tuberculosis should be sought for; the question of syphilis should be investigated. A digital examination enables

the surgeon to feel the ulcer, and an examination by means of an ordinary speculum or an electric proctoscope brings it into view.

Treatment.—In *simple* ulcer empty the bowel by the administration of a saline cathartic, wash out the rectum with hot water after the saline has acted, introduce a speculum, touch the ulcer with pure carbolic acid or silver nitrate (40 gr. to 1 oz.), place the patient in bed, restrict him to a liquid diet, and every day inject iodoform and olive oil (10 per cent.) or insufflate iodoform into the rectum. If this fails, give ether, stretch the sphincter, incise the ulcer through its entire thickness, and cauterize with fuming nitric acid, caring for the case subsequently as we would a patient who had had piles ligated. In *tuberculous* ulcer improve the general health, send the patient to a genial climate, or at least into the sunlight and fresh air, prevent constipation, give nutritious food, especially fats, wash out the rectum every day with hot water, and insufflate iodoform or inject iodoform emulsion. Touch the ulcer once a week with silver nitrate (10 gr. to 1 oz.). For *syphilitic* ulcer give antisyphilitic treatment and treat the ulcer locally, as is done for tuberculous ulcer. *Dysenteric* ulcer requires injections of hot water, the touching of the ulcer with pure carbolic acid, insufflations of iodoform, and special treatment for the dysentery.

Benign Tumors of the Rectum and Anus.—These tumors may be of the lower connective, epithelial, or muscular tissue type. Of the first there are fibroma, enchondroma, lymphadenoma, lipoma, and myxoma; of the second, adenoma and papilloma; of the third, myoma and fibromyoma. Many benign tumors appear in polypoid form. A polyp is a tumor with a pedicle. A polyp may be a fibroma, myxoma, myoma, papilloma, or adenoma. Papilloma is a rare growth, usually has a broad pedicle, but may have no pedicle (Fig. 971). It does not occur in childhood. A papilloma bleeds profusely and causes a discharge of mucus. A poylp causes no pain unless ulceration occurs. It causes bleeding and mucous discharge. On coming from stool the patient feels as though the rectum still contains feces. A polyp may protrude during defecation. It can be detected by digital examination and can be readily seen through a proctoscope. There may be one polyp; two, several, or many polypi. Some forms of polypi are most common in children. (See Adler in "Annals of Surgery," Dec., 1909.) The most common forms of tumor are the myxoma, hypertrophied solitary follicles, adenoma, fibroma, and lipoma. Myxoma is most common in children. Fibroma originates in the connective tissue or the submucosa and is very rare. It may arise at the upper end of a fissure. It has a long pedicle and may become very large.

Symptoms of tumor are dull, aching pain, tenesmus, frequent defecation, and sometimes ulceration of the mucous membrane. In a non-polypoid benign tumor there is absence of hemorrhages and of mucous discharges.

Treatment.—Remove the tumor after dilating the sphincter. In tying or snaring off polypi it should be borne in mind that the peritoneum may be invaginated in the pedicle and, therefore, no traction on it should be made when operating. Sessile growths are dissected out. The postoperative treatment is practically the same as for hemorrhoids.

Cryptitis (*Inflammation of the Crypts of Morgagni*).—These crypts, five to ten in number, are situated in the mucous membrane of the rectum, about 3 cm. from the anus. They occasionally become packed with mucus or feces. There is quite severe pain referred to the site, especially after defecation. In this condition the examination of the anus by the finger is extremely painful. The inflamed crypts may be detected by examination through the speculum.

Treatment.—Divide the affected crypts, curet away any granulations, and allow the parts to heal.

Non-cancerous stricture of the rectum may be congenital or acquired. There are two forms of acquired stricture: first, stricture due to external pressure; second, stricture due to primary narrowing of the rectal lumen.[1] Stricture due to external pressure is very rarely complete, and may be caused by bands of adhesions or a tumor growth. The second form may be produced by syphilitic tissue; ordinary inflammatory tissue; cicatrices after operations; sloughing; tuberculous, syphilitic, or dysenteric ulceration; rectal gonorrhea, or traumatism. The usual seat of simple stricture is from 1 inch to 1½ inches above the anus. The deposit may be limited to the submucous coat or all the coats may be involved. It is very seldom that stricture arises as a result of abrasion from fecal masses or foreign bodies. It may follow an operation for piles if considerable tissue was removed, and is an occasional sequence

[1] Reuben Peterson in "Jour. Amer. Med. Assoc.," Feb. 3, 1900.

of Whitehead's operation. A perirectal inflammation may be responsible. Stricture due to dysentery is extremely rare, and no case has ever been reported to the United States Pension Office (Peterson). The existence of stricture as a result of rectal gonorrhea has not been positively proved. A majority of sufferers from non-cancerous rectal stricture have labored under syphilis, but it is not probable that the lesion is syphilitic in all or even in most of them. The stricture may be due to the formation of fibrous tissue and ulceration may or may not occur. It may be caused by the contraction and healing of a large ulcer. Along with syphilitic ulceration comes great connective-tissue hyperplasia, a hyperplasia so great that the rectum becomes a thick rigid, nodular, immovable tube. Most cases of syphilitic stricture occur in women. It seems certain that tuberculous stricture can occur. Mathews dissents from this view and points out that the tendency of tuberculous matter is to break down, and before the rectum can form a stricture from tuberculosis it breaks down from ulceration. Peterson[1] says a large proportion of the victims of rectal stricture die of phthisis, and that one-third of so-called syphilitic cases are tuberculous. It may begin as an ulcer or as an infiltration of submucous tissue. Although a syphilitic or a tuberculous lesion may cause rectal stricture, in most cases such lesions simply expose the tissues to infection, and benign rectal stenosis results from the infection. Tuberculosis may cause stricture, but does so indirectly rather than directly.

The **symptoms** of rectal stricture are constipation, pain on defecation, straining at stool, perhaps the presence of blood and mucus in the stools, an open anus, and the passage of stools flattened out into ribbons if the stricture be low down. In some cases there is fluid diarrhea, solid fecal matter being retained above the stricture. The stricture is found by the finger or by the soft-rubber bougie, used with the utmost gentleness and care. A stiff instrument or the rough use of any instrument would be dangerous and might rupture the rectum. In syphilitic cases, in tuberculous cases, and in benign cases the fibrous thickening is usually in the submucous coat, and in syphilitic and tuberculous cases the mucous membrane is apt to ulcerate. It is said that complete obstruction may arise. I have seen obstructive symptoms, but never *complete* obstruction in rectal stricture. Distention of the abdomen and colic are very usual.

The **treatment** of non-cancerous and primary narrowing of the rectal canal is rest, non-stimulating diet, warm-water injections, mild laxatives, and hot hip-baths. Cocain suppositories may be needed. Any existing disease is treated. Bougies are passed every other day. Use a soft-rubber bougie, warmed and oiled, and introduce it gently. If the method of gradual dilatation alone be employed the patient must, during the remainder of his life, pass a bougie from time to time. For fibrous strictures forcible dilatation (*divulsion*) by a special instrument is employed by some or perhaps incision is practised. Incision (*proctotomy*) may be either external or internal. In internal proctotomy one or more incisions are made from the rectum through the stricture down to healthy tissue, the first cut being in the middle line posteriorly. External proctotomy, which divides the sphincters, is apt to leave incontinence as a legacy. Electrolysis finds some advocates, but on what grounds it is difficult to see. In some cases the rectum should be removed by Kraske's resection, the sphincters being spared and the ends of the gut being united. In incurable cases perform iliac colostomy.

Cancer of the rectum is the cancer of the bowel most often met with. According to Abbe ("Keen's Surgery") rectal carcinomata constitute three-fourths of all intestinal tumors. The growth may be primarily malignant or may arise from an adenoma. The commonest growths are composed of columnar cells, and may be either soft or scirrhous. In cases secondary to epithelioma of the anus ordinary epithelioma arises.

In most rectal carcinomata the cells present a tubular arrangement surrounded by a more or less plentiful stroma of connective tissue. In soft tumors the connective tissue is scanty; in hard tumors it is plentiful. The softer the growth, the greater its malignancy and the more rapid its progress. Adenocarcinoma is the most common form (McVay in "Annals of Surg.," Dec., 1922). Scirrhus is met with more frequently than encephaloid. Either form may undergo colloidal change. Scirrhus begins as a nodule in and under the mucous membrane and ulceration is late. In soft cancer ulceration is early.

Sixty-five per cent. of cases are in men. Cancer is most common after the age of

[1] Reuben Peterson in "Jour. Amer. Med. Assoc.," Feb. 3, 1900.

forty, but it not unusually occurs before the thirty-fifth year, and is sometimes seen as early as the twenty-fourth year or even earlier. I operated upon a man of twenty-seven and upon another of thirty-one. "Of 115 cases of cancer of the rectum at the Rostock Clinic, 4 occurred in patients between fourteen and seventeen years of age" (Miles Porter in "New York Med. Jour.," Feb. 10, 1912). Most growths are between the rectal ampulla and the beginning of the sigmoid. The size of the growth is no index of the extent of lymphatic involvement or the probability of metastasis. Most commonly the lower margin of the growth is on a level with the internal sphincter. Extensive ulceration occurs in the growth and may also occur above the growth. If a hard ring encircles the rectum the lumen of the tube is greatly and progressively diminished. In cases of diffuse infiltration the lumen is not greatly lessened. In growths involving the anus the inguinal glands are involved and also the glands in the hollow of the sacrum. In growths limited to the rectum proper the glands back of the peritoneum in the sacral hollow are involved, and the inguinal glands are involved late or not at all.

Symptoms.—In the beginning and for a considerable time after there are no symptoms. There may be none for a year or more. Symptoms begin with ulceration or constriction. The symptoms of rectal cancer are like those of non-malignant stricture, except that the pain is usually greater and the hemorrhage more severe. Constipation is apt to alternate with diarrhea. The diarrhea is usually in the morning. On rising there is a small and soft movement containing blood, a sense of incompleteness remaining. Later there is a larger, a harder, and a more satisfactory movement. Unfortunately, in many cases symptoms are long trivial; in fact, pain may be absent until the disease is far advanced. Mucopurulent or bloody stools are often thought to result from dysentery or hemorrhoids, when, as a matter of fact, they accompany rectal cancer. The above symptoms may, on the patient's say-so, have been accepted by the physician, without any local examination, as caused by hemorrhoids. The patient, again, may have only imagined the presence of hemorrhoids, since, according to his notion, the above symptoms must result from hemorrhoids, with which condition so many of his friends with like discharges are afflicted. Loss of strength, emaciation, and cachexia are generally noticeable in the late stages only of rectal cancer. Tenesmus eventually becomes unbearable. In the very latest stages only is the characteristic odor perceptible, the patient becomes septic, and abscesses attended by gangrene may form (Ernest Jonas in "Interstate Med. Jour.," No. 4, 1906). The finger and the speculum make the diagnosis. The finger and speculum must be inserted most gently lest perforation be caused. In many cases of cancer the anus becomes funnel shaped because contraction shortens the rectum and much wasting of fat occurs. Glands in hollow of sacrum become involved. Metastasis occurs late. The most favorable cases for operation are those in which the growth is small and movable. Accurately define the extent of the growth, and endeavor to make out if it has invaded the cellular tissue outside of the rectum, the prostate, the bladder, the sacrum, the uterus, etc. Invasion of the bladder or prostate soon causes very distressing symptoms. Sooner or later metastasis occurs to the liver. If unoperated upon, cancer of the rectum gives a prospect of life of from one to five years. I have seen nodules in the liver three months after the first symptoms of rectal cancer were observed and I have seen a man alive six years after symptoms appeared.

Treatment.—In every case of cancer of the rectum the following questions must be considered: Shall we perform a radical operation in hope of producing cure or, at least, greatly prolonging life? In what cases should a radical operation be attempted? It is the proper procedure if there are no metastatic deposits, if the patient is in fair general condition and free from serious organic disease, and if the cancerous bowel is movable and not fixed by dissemination to adjacent structures. As W. Watson Cheyne ("Brit. Med. Jour.," June 13, 1903) says, a slight adhesion to the vagina is not a contraindication, because this portion of the vagina can be readily removed with the diseased rectum. Some surgeons will not attempt radical operation if they cannot pass a finger through the growth. I do not regard high position as forbidding operation, although, of course, it makes it more dangerous to life and less promising as to cure. Cheyne is of the same opinion. When the surgeon is first called to a case of cancer of the rectum it is usually found to be so far advanced as to be inoperable. In at least 75 per cent. of my cases radical extirpation was impossible when I first saw the case. The rectum was first excised in 1878 by Volkmann, of Halle.

If a radical operation be determined on, the next question to answer is, Shall we, or shall we not, perform *preliminary colostomy?* If the cancer is very low down, in-

volves the anal canal, and is to be removed from the perineum, preliminary colostomy is rejected by many. I believe that even in such cases it should be done. If the cancer be high up and we propose to attack it by Weir's method or the Quénu-Mayo method, preliminary colostomy should not be done. If Kraske's operation is to be performed, I believe preliminary colostomy is usually indicated. It enables us to cleanse the area upon which operation is to be performed, and to keep the wound clean, and gives us a much better chance of obtaining primary union. In cases in which the sphincter is retained and it is possible to anastomose the divided ends of the gut together, colostomy is not necessary; and if an artificial anus has been made in such a case, another operation will be required to close it. As a matter of fact, I have found it always difficult and usually impossible to suture the divided ends of the gut together after Kraske's operation, and I now follow the advice of Keen, and always precede Kraske's operation by colostomy. The abdominal incision necessary to reach the bowel to do colostomy may be used to permit of exploration, but it is wiser to have a median incision for this purpose. I consider exploration of the first importance. It enables the surgeon to examine the outer surface of the rectum, to detect glandular involvement, to find out if there has been metastasis to the liver, and to determine with certainty whether or not the cancer is operable. Several times in cases of small and apparently operable cancers of the rectum I have found on opening the abdomen extensive glandular involvement or unsuspected metastasis to the liver, and once I found another cancer 4 inches above the one to which attention had been directed. It is my custom to make a median incision for exploration and then a small inguinal incision through which to bring out the gut for colostomy. A large abdominal incision for colostomy is objectionable. I strongly object to operating at all on rectal cancer without a preliminary exploratory operation. If radical operation be rejected (and about three-fourths of the cases, when first seen by the surgeon, are obviously beyond such aid), palliative treatment is desirable. The best palliative treatment is the operation of inguinal colostomy. If this be refused, what shall be done? One plan is to introduce a tube through the stricture daily, wash out the rectum with warm water, and after washing inject emulsion of iodoform (10 gr. to 1 oz. of sweet oil). Injections of chlorid of zinc (1 gr. to 1 oz. of water) lessen the foulness of the discharge. The bowels are opened regularly by laxatives, and in some cases, if the growth causes obstructive symptoms, it is scraped away with a sharp spoon. Opium is given to relieve pain. The advantage of this plan is that the patient does not suffer from the unpleasantness of an artificial anus. Sooner or later, however, the growth gets outside of the bowel, and terrible pain will arise from involvement of the sacral plexus. W. Watson Cheyne ("Brit. Med. Jour.," June 13, 1903) would restrict palliative treatment of this character to cases in which fungating masses grow from one side of the bowel.

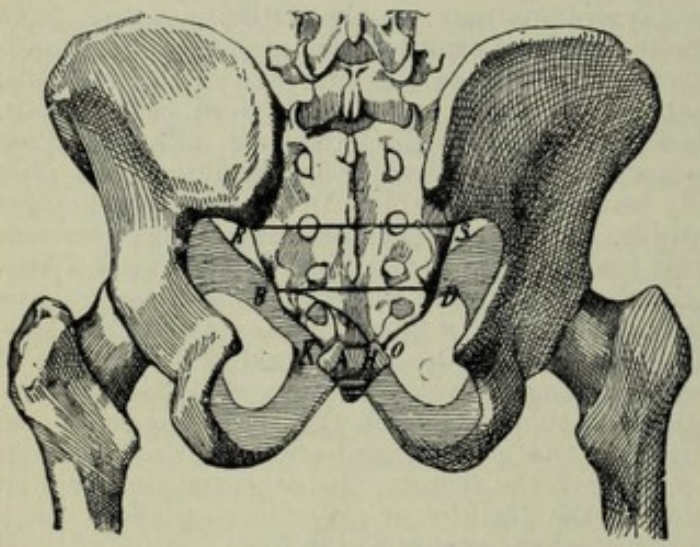


FIG. 972.—Different levels of resection of the sacrum: *K–O*, Kocher's line; *B–O*, Kraske's; *B–H*, Hochenegg's; *B–D*, Bardenheuer's; *R–S*, Rose's (Mass.).

If a growth encircles the bowel and produces symptoms of obstruction, *palliative colostomy* should be performed. This operation gives great comfort to the patient and allays pain by intercepting the feces before they reach the cancer. I am not convinced that it distinctly retards the growth of the cancer or notably prolongs life. Unfortunately, colostomy does not do away with pain if the sacral plexus be involved. I have had little experience with radium in inoperable cancer of the rectum and have never seen the *x*-rays produce any marked or lasting improvement. *Radically operative treatment* includes one of several procedures. Excision of the rectum from below (*Cripps's operation*) is practised by some if not more than 3 inches require removal, if the peritoneum is not invaded, and if the adjacent organs are free from disease. The peritoneum must not be opened in Cripps's operation. After the growth is removed

the divided rectum is pulled down and sutured to the skin. As the sphincter is sacrificed, the condition would be dreadful without an artificial anus. A perineal anus without a sphincter is vastly more distressing than an inguinal anus. I no longer do perineal excision (it does not permit any considerable removal of lymph-glands). In some cases in women it may be possible to remove a low growth without damage to the sphincter through an incision in the posterior vaginal wall. Excision of the rectum after excision of the coccyx and a portion of the sacrum (*Kraske's operation*, Fig. 972, *B–O*) is a procedure which permits removal of the entire tube, portions of the colon, and even of adjacent parts. The peritoneum is opened deliberately in this operation, and is subsequently closed with sutures before the gut is opened. The glands in the mesocolon are always removed. The lower end of the proximal segment of bowel is fastened in the wound, or, if colostomy has been previously performed, may be closed. The operation is best suited to low cancers. I have given up all attempts to save the sphincter and to restore the continuity of the canal and elect to retain permanently the artificial anus. Kraske's operation may be done by an osteoplastic method, the bone not being re-

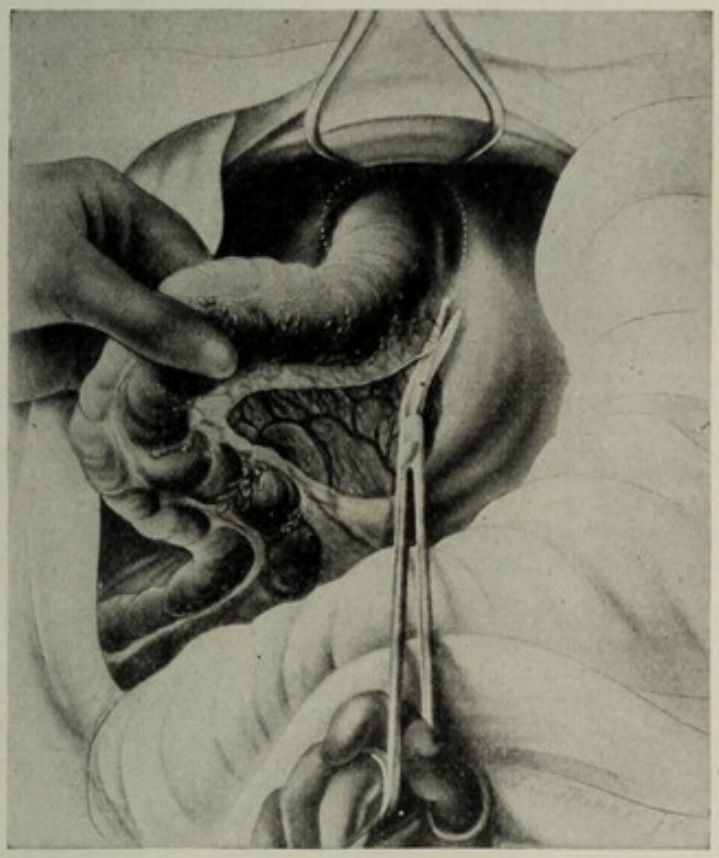


FIG. 973.—The sigmoid is mobilized by cutting the peritoneum on each side of its mesentery. Dotted line indicates incision of peritoneum of culdesac around rectum and between bladder and rectum with long-handled angle scissors (Coffey).

moved. It is wise to precede a Kraske operation two weeks by an inguinal colostomy, which permits of cleansing the lower bowel of feces and lessens the chance of severe wound infection and delayed healing after the removal of the rectum. Preliminary colostomy may make the operation of extirpation more difficult by fixing the intestine, and thus interfering with the necessary drawing down of the gut ("Operative Surgery," by E. H. Taylor). If the growth is extensive and the mesocolon short, it may be best to perform right inguinal colostomy, but in most cases left inguinal colostomy is preferred (Gerster). The colostomy remains open during the patient's life. In 12 cases of Kraske's operation I had 1 death.

Coffey's Operation (Robert C. Coffey, "Annals of Surgery," Oct., 1922).—Doctor Coffey long ago became impressed with the high mortality of the Kraske operation. He says that the earlier operations had a mortality of 50 to 60 per cent. At the present time the mortality is from 12 to 18 per cent. in the Kraske method. The minor operation (the artificial anus) is done first, the major operation second.

Coffey reverses this procedure and does the major operation first and the minor

operation second. His operation commends itself highly to surgeons. I believe it to be the best method we possess. Coffey divides the operation into two types: (1) Cancer of the lower rectum into which a tube can be passed above the growth,

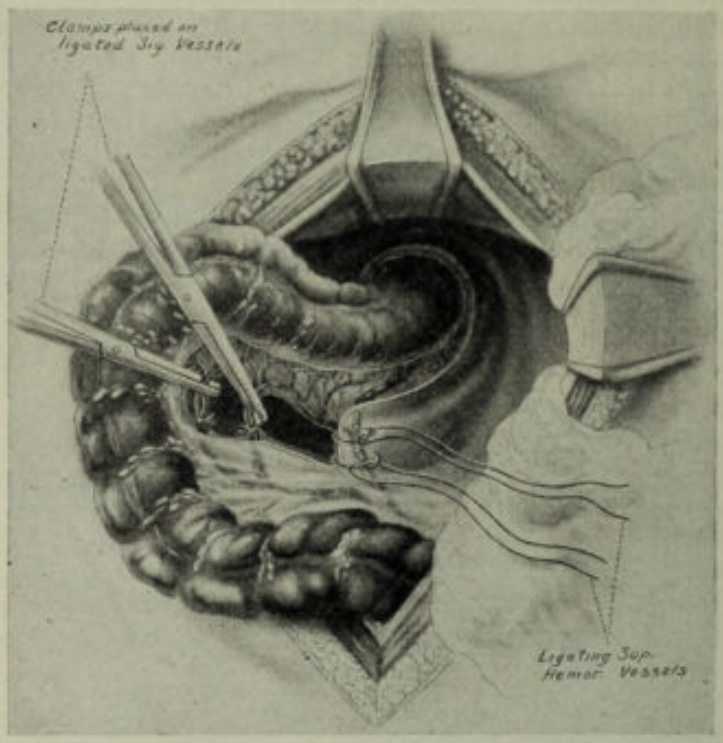


FIG. 974.—Two ligatures placed around the superior hemorrhoidal vessels about 1 inch apart. The sigmoid arteries tied on one side and clamped on the other (Coffey).

and (2) growths higher up in which stricture and obstruction are the first serious indications.

1. Operation for cancer of the lower rectum: The first stage is as follows: (*a*) A rectal tube is passed through the anus to above the growth. (*b*) An ample incision

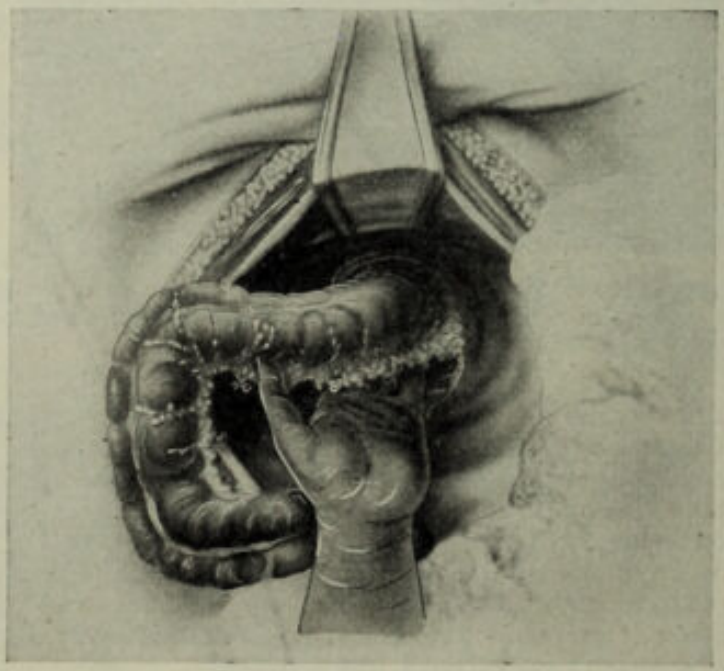


FIG. 975.—The fingers of the left hand, insinuated between the severed ends of the superior hemorrhoidal vessels and between the cut peritoneal edges of the mesosigmoid, are lifting the fat from the hollow of the sacrum down to the coccyx (Coffey).

is made through the right rectus muscle about an inch to the right of the umbilicus. This permits exploration and the determination as to whether or not extirpation is

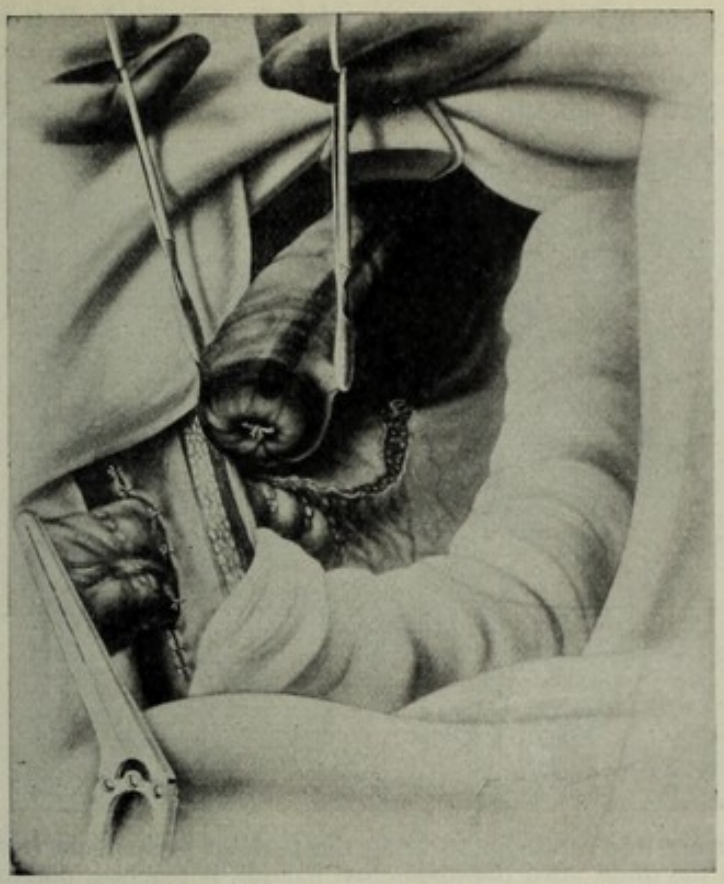


FIG. 976.—Proximal sigmoid has been fastened to layers of abdominal wall and its end held closed with a clamp. Tube is passed up to end of distal sigmoid, where it is fastened by a strong double suture passed through the intestine and eyes of tube and tied. By pulling on the tube the sigmoid is inverted and drawn out through the anus (Coffey).

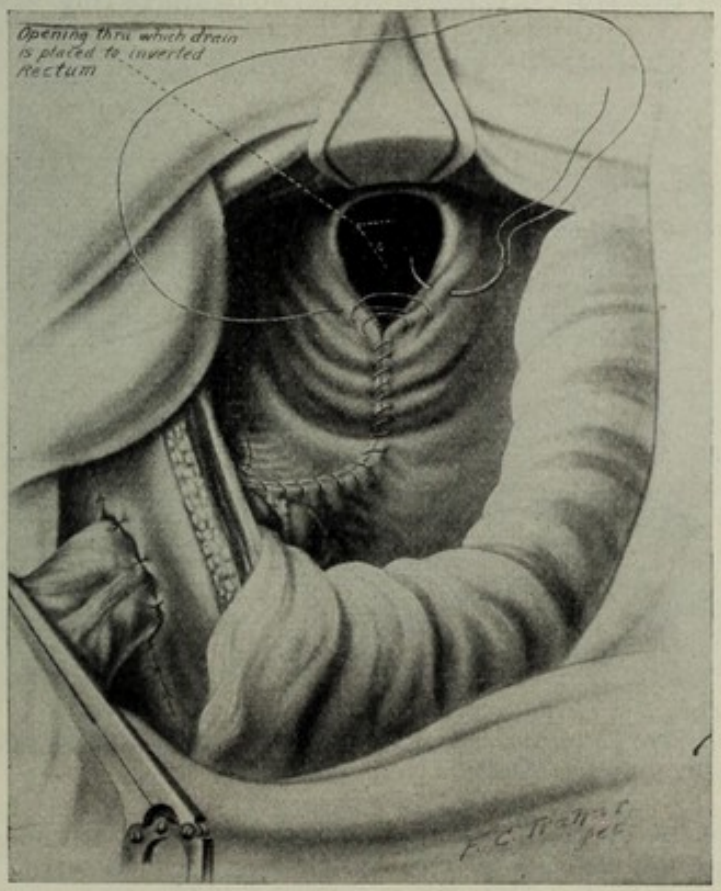


FIG. 977.—After the space between the sigmoid and the left lateral parietal peritoneum has been closed by suture a continuous catgut is run along the mesosigmoid, covering the raw fat edges with peritoneum down to the narrow portion of the culdesac, where drain is inserted (Coffey).

justifiable. If it is not justifiable, an artificial anus is made. If it is justifiable, the patient is put in the Trendelenburg position and all the intestines except the sigmoid are packed away with moist gauze. (*c*) The peritoneum on either side of the meso-sigmoid is cut by means of scissors, only the blood-vessels and the fat in the mesentery

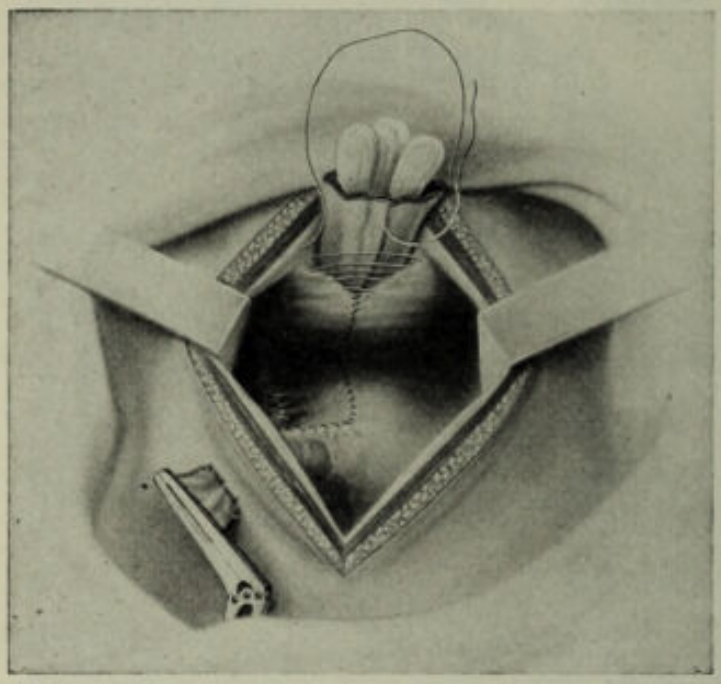


FIG. 978.—The suture line continues to bring the parietal peritoneum from the sides of the narrow pelvis around the drain until the abdominal incision is reached, making the drain extra-peritoneal (Coffey).

being left (Fig. 973). The cutting is extended around the rectum between the bladder and rectum in a man and between the uterus and the rectum in a woman. (*d*) The superior hemorrhoidal vessels are divided between two ligatures (Fig. 974). (*e*) The vessels

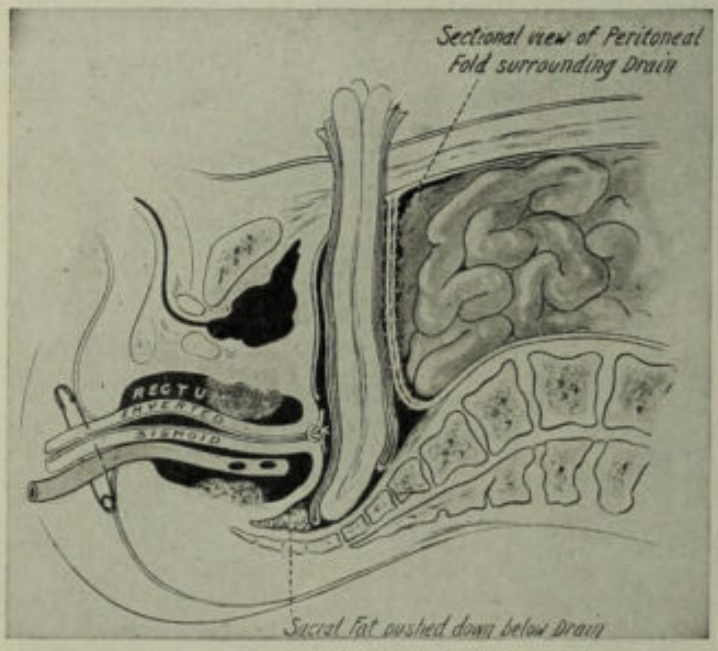


FIG. 979.—Sectional view of drains which have been tubularized by the peritoneum of the pelvic wall. Fat in hollow of sacrum is pushed down, a drainage-tube in rectum and inverted sigmoid held down by a safety-pin (Coffey).

near the sigmoid are cut, clamped, and tied. The fingers of the left hand are carried into the hollow of the sacrum and the fat and connective tissue are separated from the hollow of the sacrum (Fig. 975). After the completion of this procedure a pack of gauze is placed in the hollow of the sacrum. (*f*) An incision $1\frac{1}{2}$ inches in length is made

longitudinally through the left rectus muscle about its middle, the fibers being separated. This incision is 1½ inches below the level of the umbilicus. A clamp inserted through this new incision seizes the sigmoid at the point where permanent colostomy is to be made, care being taken to observe that this end has a blood-supply. A clamp passed through the first incision catches the bowel a little lower down. The intestine is

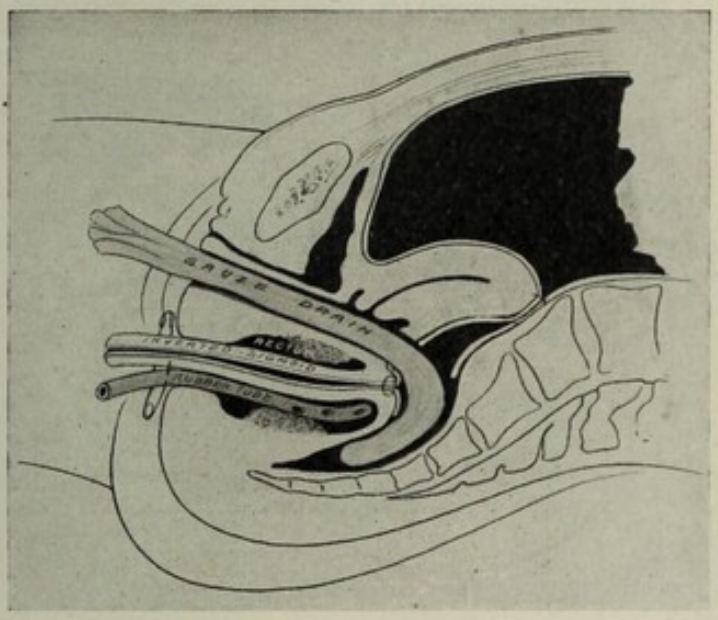


FIG. 980.—Sectional view of quarantine drain surrounding inverted end of growth and emerging from the vagina (Coffey).

divided between the clamps by means of the cautery, and the proximal end of the sigmoid is pulled out through the wound in the left rectus muscle and is attached to the belly wall (Fig. 976). The clamp is left on, the proximal end is strapped to the belly wall for twenty-four to forty-eight hours. (*g*) Invert the distal end of the sigmoid by means of a purse-string stitch. Separate the mesenteric fat from its sides. Pass a strong suture through the eye of the rectal tube to the walls of the intestine. By pulling upon

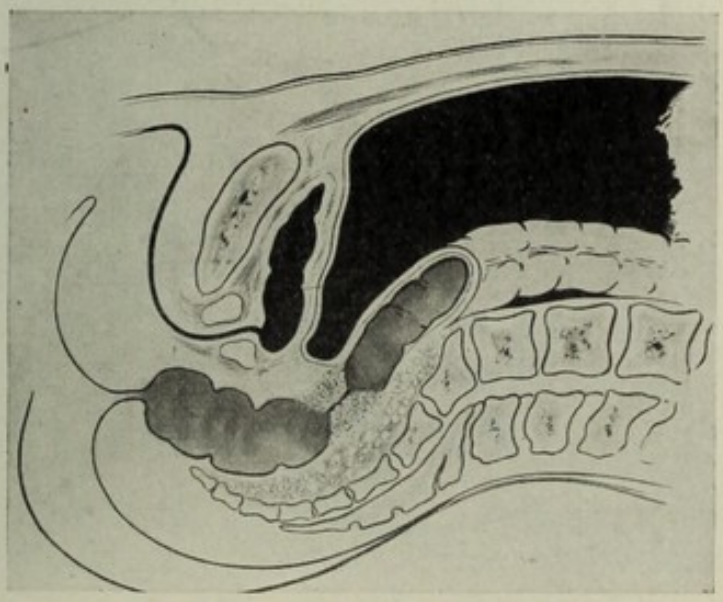


FIG. 981.—High rectal cancer producing stricture (Coffey).

the external end of this tube the sigmoid is pulled out through the anus. The protruding end is clamped to prevent its reduction. (*h*) The unbroken peritoneal cavity is restored. "The space external to the point where the sigmoid comes through the left rectus muscle should be closed by suture, bringing the anterior, posterior, and lateral peritoneal surfaces together with a firm line of sutures up to and including

the mesentery of the sigmoid. From this point the posterior parietal peritoneum is drawn over the raw edges where the mesosigmoid has been cut. This line of sutures continues down to a point where it is necessary to insert the drainage" (Fig. 977). In a woman the drainage is made through the posterior vaginal wall and then the running

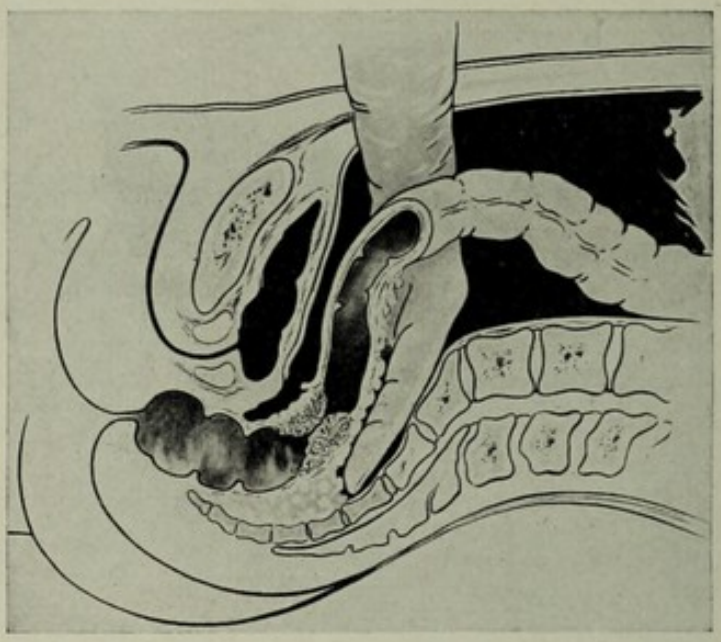


FIG. 982.—Sigmoid has been mobilized. Peritoneum around the rectum has been cut, the bladder separated from rectum down to the prostate, fingers of left hand being insinuated between rectum and sacrum down to point of coccyx (Coffey).

suture is carried across the culdesac which closes all the spaces (Fig. 980). In a man the peritoneum is stitched to the point where the drain must be inserted (Fig. 978). A large cigarette drain is carried into the hollow of the sacrum back of the inverted rectum. The suture is continued and comes forward toward the abdominal wall, until finally a diaph-

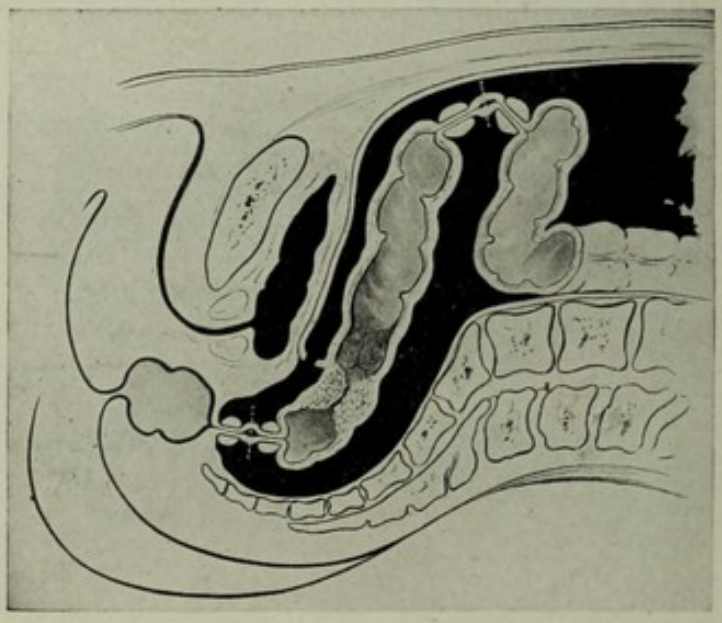


FIG. 983.—The freed bowel is doubly clamped above by Payr's clamp and severed. Below, it is doubly clamped by long-handled clamps and severed, after which intestine with growth is removed (Coffey).

ragm is made which absolutely separates the general peritoneal cavity from the canal for drainage. The drain will now be extraperitoneal and is kept in place until the time of the second operation (Fig. 979). The first incision which was made through the right rectus is closed and covered by gauze and collodion. This is covered by gutta-

percha and a layer of gauze and collodion placed over this. A drain is placed alongside of the protruding and inverted sigmoid (Fig. 979).

The second stage of the operation is a simple affair. The fecal current has been entirely cut off and hemorrhage and consequent shock have been prevented and all

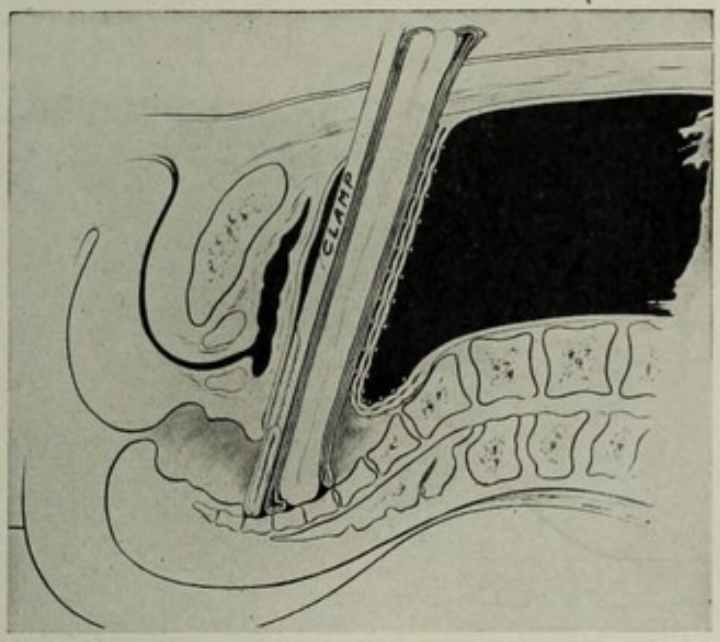


FIG. 984.—The handle of clamp holding stub of rectum is brought out through peritoneal tube with cigarette drain (Coffey).

the fat and connective tissue from the hollow of the sacrum are then easily reached from below. In the female the removal may be effected after splitting the vagina. In the male the coccyx is first removed, the parts are excised, the cavity is left wide

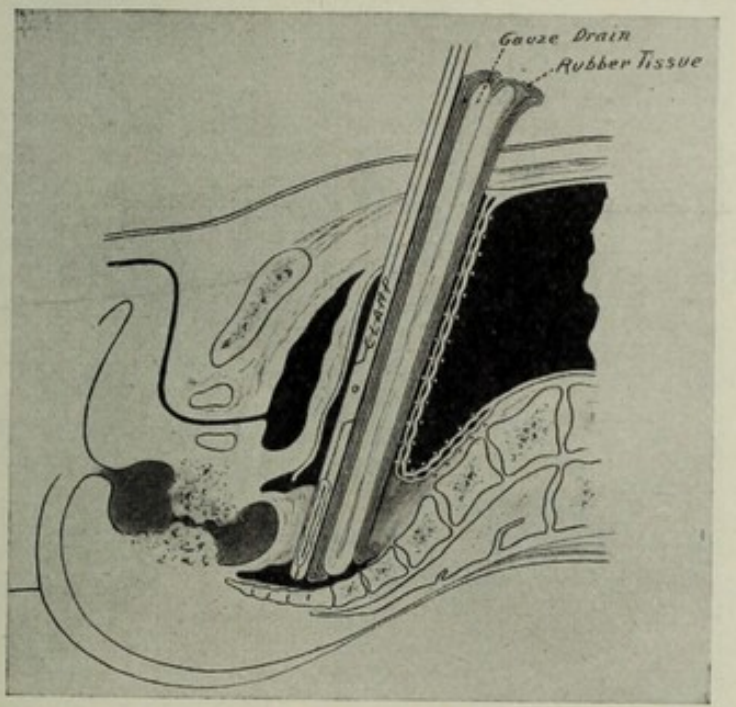


FIG. 985.—Obstructing low cancer of the rectum. Devascularization and removal of sigmoid has been performed as in the standard operation. A clamp has been placed on the intestine above growth and brought out with the quarantine drain (Coffey).

open, and is packed with gauze for three or four days. It can be readily irrigated from the front drainage opening. The patient is walking in two weeks, but, of course, it takes some weeks for the wound to heal completely.

Coffey's Operation for Cancer of the Upper Rectum or Rectosigmoid.—(*a*) Mobilize the sigmoid as previously described. Also separate the bowel and the perirectal tissue from the hollow of the sacrum down to the end of the coccyx and separate the rectum from the bladder down to the prostate. (*b*) Divide the bowel and bring the

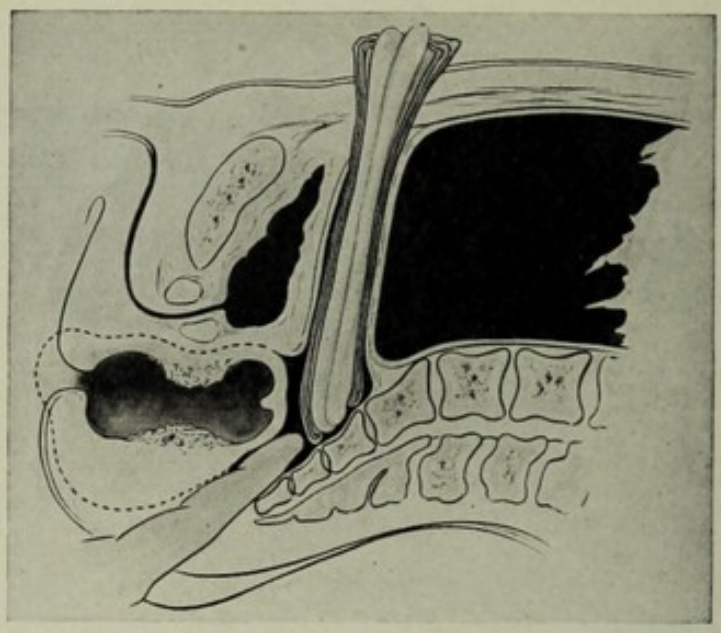


FIG. 986.—Coccyx and last joint of sacrum have been removed; finger inserted into the cavity around the drain (Coffey).

proximal end into the wound as previously described. Grasp the rectum with a hysterectomy clamp within 1 inch or 2 inches of the sphincter. Place another clamp a little above it and divide the gut by means of the cautery. Such an incision will be at least 2 inches below the growth. Remove the divided part of the sigmoid, most of the rectum, and all of the fat and tissue from the hollow of the sacrum. The handle of



FIG. 987.—Space from which rectum has been removed, connected with abdominal drainage canal through which irrigation may be conveniently made (Coffey).

the lower clamp is brought out through the abdominal wound, which holds the cigarette drain and is left in place for forty-eight hours (Figs. 986, 987). At the second operation make an incision through the sphincter to the tip of the coccyx and peel out the structures, taking out and removing the sphincters as one may wish.

Full details of this operation will be found in the extremely valuable article above quoted.

Coffey has treated 37 cases by the two-stage method, doing the major procedure first and has had but 2 deaths, one from tearing the internal iliac and ureteral vessels in a very advanced case of cancer and the other from uremia. The mortality is, therefore, 5.4 per cent. There is almost complete absence of shock and of complications not unusual in other methods. He says that by doing most of the work from the abdominal side and removing all elements of danger at the first operation which could cause complications at the second operation, he no longer considers any case of cancer of the rectum incurable, "except insofar as it involves other important adjacent organs or metastatic areas."

The mortality of Kraske's operation is from 12 to 15 per cent. Twenty-eight per cent. of Kocher's cases of extirpation of cancer of the rectum remained well from three to sixteen years after operation (W. W. Cheyne, "Brit. Med. Jour.," June 13, 1903). Charles H. Mayo ("Annals of Surgery," Feb., 1917) reports 753 cases of cancer of the



FIG. 988.—The vaginal wall has been split. Finger is passing around the end of inverted bowel enucleating the growth without removal of the coccyx (Coffey).

rectum. Four hundred and thirty radical operations were performed, with a mortality of 15.5 per cent. Before 1913 the mortality was 17.7 per cent. During 1915 it was reduced to 12.5 per cent.

XXVIII. ANESTHESIA AND ANESTHETICS

Surgical anesthesia is a condition of insensibility or loss of feeling artificially produced. An **anesthetic** is an agent which produces insensibility or loss of feeling. Anesthetics are divided into—(1) *general anesthetics*, as ethylene, chloroform, chlorid of ethyl, ether, bromid of ethyl, nitrous oxid, and bichlorid of methylene; (2) *local anesthetics*, as alcohol, bisulphid of carbon, carbolic acid, ether spray, cocain, eucain, stovain, novocain, ice and salt, rhigolene spray, and ethyl chlorid spray.

Anesthesia may be induced by a general anesthetic to abolish the usual pain of labor and of surgical procedures; to produce muscular relaxation in tetanus, herniæ, dislocations, and fractures; and to aid in diagnosticating abdominal tumors, joint diseases, fractures, and malingering.

Ether was first used as a surgical anesthetic by Crawford W. Long, of Georgia, in 1842, but he did not publish his cases until after William T. G. Morton, of Hartford, had given ether in public in 1846. The ether was given to a patient of Dr. Warren. Dr. W. W. Keen says ("Ether Day Address," 1915): "We, who are accustomed to anesthesia, can hardly appreciate the courage of Warren and Morton on that memorable sixteenth of October, 1846. Surely also the bravery of the patient himself should not be overlooked. The name of Gilbert Abbott should always be held in remembrance."

Horace Wells gave nitrous oxid in 1844. Sir James Y. Simpson introduced chloroform in 1847.

Death-rate from Anesthetic Agents.—Sir Frederic W. Hewitt ("Anesthetics and Their Administration") combines the statistics of Julliard and Ormsby, with the following result:

Anesthetic.	Total number of administrations.	Total number of deaths.	Death-rate.
Chloroform	676,767	214	1 in 3,162
Ether	407,553	25	1 in 16,302

Hewitt regards the St. Bartholomew Hospital records as furnishing the most reliable statistics accessible. He takes them from 1875–1900. The fatality from chloroform was 1 in 1300; from ether (and gas and ether), 1 in 9319. It is to be noted that statistics covering many countries would indicate that chloroform becomes relatively safer in warm regions. In temperate regions it is relatively safer (compared with ether) in summer than in winter. Hewitt is of the opinion that ether is six times as safe as chloroform. Gwathmey ("Jour. Amer. Med. Assoc.," Nov. 23, 1912) collects statistics from American sources. In 157,453 administrations of ether there were 28 deaths (about 1 death in 5623 administrations). In 16,390 administrations of chloroform there were 8 deaths (about 1 death in 2049 administrations).

Hewitt finds that during a period of forty years only 30 fatalities were recorded as produced by nitrous oxid, and he thinks several of these should be excluded. It is practically certain, however, that many deaths, or at least some deaths, have not been recorded.

Seitz collected 16,000 instances of anesthesia by chlorid of ethyl, with 1 death. During a hospital experience of forty years I have seen anesthetics (particularly ether) given many thousand times. For five years I gave ether and chloroform for Professor Keen. I have witnessed 3 deaths, each of which at the time was thought to be directly due to the anesthetic, and 1 of them was so caused. One death resulted from pouring a quantity of chloroform upon an Allis inhaler, the bandage of which had been saturated with ether. At the time the chloroform was poured in the inhaler the patient had just been struggling and consequently was breathing deeply. One death resulted from giving ether on a thick cone made of several towels with paper between the folds. The towels were saturated with ether, the patient got no air at all, and was asphyxiated, as she might have been had the cone been wet with water only. The third case was a man who had an impacted hip fracture. He became cyanotic under ether while the impaction was being pulled apart and later died. The death was supposed to be due to ether, but necropsy discovered fat emboli in the brain and lungs. I believe that for a huge majority of surgical cases ether is the best and safest general anesthetic, and that other general anesthetics are to be used exceptionally and for well-defined reasons.

Preparation of the Patient.—Whenever possible prepare a patient before administering a general anesthetic, and prepare him, if the case admits of it, during two or more days. Heart disease is not a positive contraindication to surgical anesthesia. It is quite true that anesthetics are dangerous to people with fatty hearts, but shock is also dangerous, and the surgeon stands between the Scylla of anesthesia and the Charybdis of shock. Gallant truly says that not enough attention is paid to the "character of the pulse and action of the heart before operation, by which to compare its work during anesthesia, and after the operation is over, and this neglect leads to unnecessary stimulation and overdriving a heart which is doing its average best."[1] Always examine the urine if the nature of the case allows time. If albumin be found, operation is not contraindicated, but the peril of anesthesia is greater, and certain dangers are to be watched for and guarded against. If much albumin is present, postpone operation except in an emergency case. If sugar be found, the danger is considerable, as diabetic coma occasionally develops. The percentage of sugar in the urine does not determine the amount of danger. Estimate the amount of blood-sugar. Coma may arise when only a little sugar is present in the urine, and may not arise when there is a considerable amount. The presence of aceto-

[1] "Medical Record," Feb. 2, 1899.

acetic acid in urine is more ominous than is the presence of sugar. Empty the intestinal canal by purgation a number of hours before anesthetization. It is well to give the bowel six to twelve hours' rest before operation. The usual custom is to give a saline cathartic the evening before operation and an enema early on the morning of the operation. Frequently the nature of the case or the necessity for haste does not permit of preliminary emptying of the intestine by the administration of cathartics. During the twenty-four hours preceding operation food should be taken in small amounts and in forms easily digestible. During a day or so before operation there is usually impaired digestion, and no undue strain should be put upon the stomach. In the morning allow no breakfast if the operation is to be performed at an early hour, but if the patient be very weak, order a little brandy and beef-tea. If the operation is to be about noon, give a breakfast of beef-tea and toast or a little consommé; *never* give any food within three hours of the operation, but brandy is admissible if stimulation be required. If the stomach is not empty at the time of operation, vomiting will be almost inevitable, and portions of food may enter the windpipe; if the stomach contains no food, vomiting is far less likely to happen; and even if it occurs and vomited matter should enter the windpipe, it may do little harm, as it consists chiefly of liquid mucus. In cases of intestinal obstruction in which there has been stercoraceous vomiting there is much danger that vomiting will occur during anesthetization. In some cases of intestinal obstruction, during the administration of the anesthetic and during the anesthetic state, a stream of stinking brown fluid may flow without effort from the mouth. Vomiting or regurgitation of stercoraceous material is profuse, sudden, and dangerous. It may flood the bronchial tubes during inspiration and cause death by suffocation. In a case in which stercoraceous vomiting has occurred wash out the stomach before administering the anesthetic. If a patient with intestinal obstruction is too weak to permit of lavage, a local anesthetic should be used instead of a general anesthetic. Vomiting while the patient is partially under the influence of an anesthetic is dangerous in any case, because of the great cardiac weakness which precedes and follows it. If a patient sleeps well the night before an operation, he will probably take the anesthetic better than if he sleeps poorly. Effort should be made to obtain a night's sleep. An excellent expedient is a hot ammonia bath, followed by a rub-down with weak alcohol.[1] It may be necessary to administer trional or bromid. About fifteen minutes before giving the anesthetic let the patient drink a glass of hot water. Water protects the stomach from the irritant effects of any anesthetic which may be swallowed. Before giving the anesthetic see that artificial teeth on a plate are removed and that the patient does not have a piece of candy, gum, or tobacco in the mouth. Always have a third party present as a witness, because in an anesthetic sleep vivid dreams occur, and erotic dreams in women may lead to damaging accusations against the surgeon. Place the patient recumbent. The effort should be to place him in as comfortable a position as possible, if this position be consistent with operative necessities. Put a small pillow under him, so as to support the normal lumbar curve and prevent postoperative backache. See that the clothing is loose, particularly that there is no constriction about the neck and abdomen. Do not have the head high unless this position is demanded by the exigencies of the operation. The anesthetist must have a mouth-gag and a pair of tongue forceps at hand. It is very wrong to say that a mouth-gag and tongue forceps are never necessary. It is quite true they are often used when not needed, but this does not justify us in being without them when they are needed, and they may be needed very badly. The anesthetist should also have a pair of artery forceps and some small gauze sponges with which to swab out the mouth and throat. A hypodermic syringe in *working* order, and solutions of strychnin, atropin, and brandy are to be in an accessible place; oxygen must be ready for administration, and it is well to have an electric battery adjacent. Be ready to attempt resuscitation by intracardiac injection of adrenalin and have on hand a spinal puncture needle and a 1 : 1000 solution of adrenalin. Accidents, it is true, are rare, but they may happen at any time, and hence the surgeon should always be prepared for them. Any danger which arises must be met promptly and decisively, or action will be of no avail. As Professor Keen says: "Every case of anesthesia, irrespective of the method employed, requires unremitting watchfulness from first to last" (Ether Day Address at Massachusetts General Hospital, Oct. 16, 1915). Many surgeons give a hypodermic injection of morphin a short time before operation to steady the heart, to prevent vomiting during anesthetization, to shorten the stage of excitement, to prevent rigidity, and to aid the bringing about of insensibility with

[1] A. Ernest Gallant, "Med. Record," Dec. 30, 1899.

very little of the anesthetic. The method has been tried by many during the last fifty odd years. It is used in drunkards (as their muscles tend to remain rigid in the anesthetic state), in those whom it is difficult to make completely unconscious, in neurotic individuals, and in badly frightened subjects. Epileptics are very apt to clench the jaws, become cyanotic, and get convulsions when anesthetized. A preliminary injection of morphin lessens their liability to such disorders. Its greatest use has been in operations about the mouth and face, for in these procedures if an anesthetic has been given on a towel or inhaler, it has been of necessity given intermittently; a preliminary dose of morphin will keep the patients from rousing during the intervals. At present intratracheal anesthesia does away with the need of morphin in operations about the mouth and face. There are objections to giving morphin before anesthesia, and its use should be the exception and not the rule. It should not be used in children, in cases of stupor, or in cases in which the respiratory center is disordered. It depresses respiration, lowers temperature, and thus perhaps increases operative shock, interferes with the pupillary phenomena of anesthesia, delays awakening from the anesthetic sleep, adds to subsequent abdominal distention and headache, and actually favors postanesthetic vomiting. Hewitt ("Anesthetics and Their Administration") says that several recorded fatalities were due to the combination. If the surgeon determines to give morphin, he gives $\frac{1}{6}$ to $\frac{1}{4}$ gr. twenty minutes before the anesthetist begins to give the anesthetic. Hewitt (Ibid.) says: "The anesthetic should be given until the usual signs of anesthesia commence to appear. It should then be discontinued for a few moments and only reapplied as occasion may require. As little as possible of the ether or chloroform should be subsequently administered; the conjunctival reflex should be retained." In the clinic of the Jefferson Hospital the elder Gross long used as a routine the preliminary administration of opium, but during his later years he used it exceptionally. His successor, the younger Gross, used morphin hypodermically, exceptionally. In some cases we many anticipate trouble from an anesthetic. Cyanosis may occur in drunkards; in fat, thick-necked individuals of the Major Bagstock type, who are short of breath and congested in appearance; in individuals with some disease of the lungs, bronchi, pharynx, larynx, or trachea (empyema, emphysema, chronic bronchitis, croup, cancer of the larynx, etc.); in individuals suffering from fatty heart or valvular incompetence. Buxton points out that an individual without teeth and with stenosis of the nares is apt to become cyanotic under an anesthetic, because the lips and pillars of the fauces are drawn in like valves during inspiration.

Ether and Chloroform.—The two favorite anesthetics are ether and chloroform. Only the very best ether or chloroform should be used. It is a good plan, in order to lessen bronchitis, to mix with ether turpentine of Pinus pumilio in the proportion of 20 drops to 6½ oz. (Becker in "Centralbl. f. Chir.," June 1, 1901). Chloroform is more dangerous than ether in general cases, though it is more agreeable, less irritant to the lungs and kidneys, and quicker in its action. Chloroform, compared to ether, is relatively safer in warm than in cold countries. In fact, in the tropics it is a matter of considerable difficulty to use ether because of its great volatility. It should, however, be noted that Squire used ether successfully when the temperature was 120° F. in the shade ("Lancet," vol. i, 1913). Chloroform is preferred in campaigns, because less is required and transportation is easier. Recovery from chloroform is quicker and quieter than it is from ether, but chloroform vomiting lasts longer than ether vomiting. Chloroform may induce sudden and even fatal syncope. Hare's experiments on animals indicate that chloroform may kill by respiratory failure occurring secondarily to failure of the vasomotor center; but certain it is that clinically a danger of chloroform is paralysis of the heart, and this condition may come on so rapidly that death may occur almost before an attempt can be made to save life. Heart flutter may be the cause of sudden death. Leonard Hill has proved that most chloroform deaths that take place after a considerable amount of the anesthetic has been taken arise from paralytic distention of the heart. Sudden death, when inhalations of chloroform have just commenced, may be due to the irritant vapor acting on the nasal mucous membrane, exciting a nasal reflex, and powerfully stimulating cardiac inhibition. If ether produces danger it does so usually through the respiration, and not the heart, and there is generally time to undertake resuscitation, which is apt to be successful. Chloroform is preferred to ether by many surgeons for children under ten years of age, in whom ether causes a great outflow of bronchial mucus, which may asphyxiate; and for people over sixty, entirely free from myocardial disease, at which age most persons have some bronchitis, and ether chokes them up with mucus. Ether

also irritates the kidneys, which at the latter age are apt to be weak or diseased. Personally, I give ether even to infants (if they are free from bronchitis) and to old subjects without marked respiratory trouble. Chloroform is given if the actual cautery is to be used about the face, neck, or mouth, because ether vapor may take fire and chloroform vapor will not. Chloroform is preferred for labor cases, when moderate anesthesia only is required, and was preferred for operations on the mouth and nose before the advent of intratracheal anesthesia. In cleft-palate operations chloroform is usually preferred, because it causes but little cough and salivary flow. In ligation of a large artery which is overlaid by a vein ether greatly enlarges the vein, but this is no real embarrassment to an experienced surgeon. In goiter operations ether will decidedly enlarge the veins. Most goiters may be, and some should be, removed with the aid of local anesthesia only. Chloroform is particularly dangerous when there is myocardial disease, and is apt to produce cyanosis and embarrassed respiration. In valvular heart disease chloroform is more dangerous than ether, and even in functional heart trouble it is an undesirable anesthetic. It should not be used in those who smoke or chew tobacco to excess, or who overindulge in coffee or alcohol. Chloroform is more dangerous in shock than ether. A patient in dangerous shock requiring operation should, if possible, have the nerves coming from the part injected with novocain so as to cause the "physiologic block" of Crile (see page 191). Chloroform is preferred for patients with difficult respiration from any cause other than heart disease (in emphysema, bronchitis, or pulmonary tuberculosis), and for patients with kidney disease. I am convinced that etherization is sometimes responsible for a latent area of pulmonary tuberculosis becoming active. Some surgeons do not use ether in abdominal operations because they believe it may cause persistent oozing of blood, but this view is not in accord with the author's experience. Ether is the best and safest anesthetic for general use. It is much safer than chloroform in valvular disease and functional heart trouble. It is dangerous in myocardial disease, but not nearly so dangerous as chloroform. In valvular disease without heightened arterial tension it is reasonably safe, but in valvular disease with heightened arterial tension it is dangerous. Ether is dangerous when atheroma exists. The question as to the effect of ether on the kidneys is much disputed. Most surgeons believe that it tends to cause albuminuria or increase existing albuminuria. Nitrous oxid is very dangerous when there is vascular degeneration, and it may induce apoplexy. It is dangerous if the air-passages are narrowed, as by a goiter. Both ether and chloroform may induce changes in the blood.[1] In practically all cases they produce a diminution of hemoglobin and considerable leukocytosis. In some cases they produce alteration in the shape of the corpuscles. These changes are especially marked in anemic blood. Ether produces distinct leukocytosis, probably toxic in origin. Both ether and chloroform seem to lessen the phagocytic activity of leukocytes and hence to lower vital resistance (Ferguson in "New York Med. Jour.," May 11, 1912). These blood changes indicate that prolonged anesthesia must militate against recovery from a severe operation. If a patient's hemoglobin be below 30 per cent., a general anesthetic should not be given. During the state of anesthesia the temperature drops from 1 to 3 degrees or more, hence the patient should be carefully covered during the operation. Ether and chloroform lower temperature and so do other general anesthetics. The anesthetized patient responds to external heat and cold like a cold-blooded animal (Pembrey and Shipway in "Proc. Roy. Soc. Med.," 1916). This dissipation of body heat is a danger and calls for the protection of the patient against chilling during an operation. In giving ether or chloroform the administrator must devote his undivided attention to the task. He must note every symptom, must order or carry out proper treatment for complications, and must keep the operator informed as to the necessity for haste. The anesthetist must be a man who has a wholesome respect for ether and chloroform, although not afraid of them.

Can an anesthetic be administered to a sleeping person without waking him? I know that chloroform can be so given, for I have succeeded in giving it to a child without breaking the slumber. Probably, in most cases, an attempt will fail, but in some it will succeed. Stone ("Cleveland Med. Jour.," Jan., 1902) reports successful administration to sleeping children and also of chloroform to a resident physician while asleep. Paugh ("Jour. Amer. Med. Assoc.," May 18, 1901) reports three

[1] See the author on the "Blood-alterations of Ether-anesthesia," "Medical News," March 2, 1895; also the author and Kalteyer in "The Proceedings of the American Surgical Association for 1901."

successes with children. Ether, because of the irritant nature of its vapor, would be more apt to arouse a sleeper than chloroform.

Administration of Chloroform.—Chloroform should be given by a highly trained man only. In fact, safety in giving chloroform is dependent upon skill and experience more than in giving ether. No one should think of allowing anyone but a physician to give chloroform. A rule-of-thumb anesthetist is a fashionable peril. A real anesthetist should be able to select the proper anesthetic for a given case. No one but a physician can do this. The most dangerous period is when the patient is incompletely anesthetized, but is going under. Most deaths happen at this time. In administering chloroform have at hand a mouth-gag, tongue forceps, artery forceps, small gauze sponges, a clean towel, hypodermic syringes loaded with solutions of strychnin, atropin, and brandy, a syringe with a long and strong needle and charged with adrenalin (1:1000), an electric battery, white vaselin, and a can of oxygen. Use *pure* chloroform only. The patient should be recumbent. The erect or semi-erect positions are dangerous in chloroform anesthesia. The Trendelenburg position is admissible (see page 1047). No special inhaler is required, but the drug may be given upon a thin towel, a napkin, or a piece of lint. The mask of Skinner (Fig. 989) is very useful. Junker's inhaler (Fig. 990) is used by foreign anesthetists. In operations about the face Souchon's instrument is serviceable. Souchon's apparatus is so arranged that chloroform may be given through a tube which is introduced through the nose, the instrument being well out of the way of the operator. Some surgeons cocainize the nares before giving chloroform, so as to prevent the supposedly dangerous nasal reflex (Rosenberg). It is advisable to smear the lips and face (including the eye-

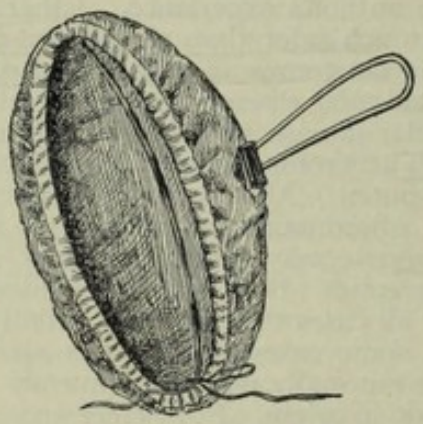


FIG. 989.—Skinner's mask.

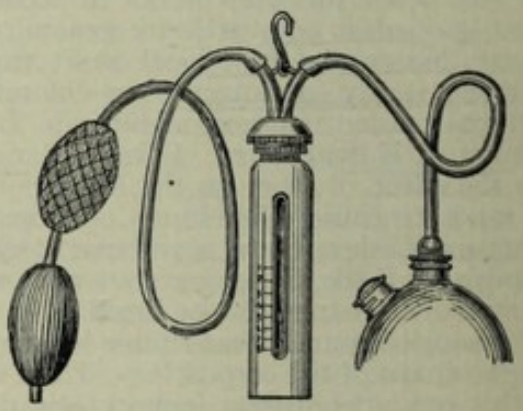


FIG. 990.—Junker's inhaler.

lids) with white vaselin to prevent blistering. The chloroform vapor must be well mixed with air. The chloroform is sprinkled on the fabric from a drop-bottle. Raise the napkin well above the mouth, add 5 drops of chloroform, and tell the patient to take deep and regular breaths, but do not tell him to breathe forcibly. Forcible respiration may lead to cessation of respiration. Add a few more drops of chloroform, and when the patient grows so accustomed to it that he or she does not choke, turn the wet part of the fabric toward the face and place it near the mouth; do not touch the mouth with the wet lint, because it will blister. If the drug be given *gradually*, struggling is not usually violent or prolonged. Never pour on a large amount at one time. Keep the lower jaw pushed forward during the time the chloroform is being given. Cough and vomiting at this time mean that the vapor is too strong. During the stage of excitement do not suspend the administration of chloroform unless respiration becomes difficult, in which cases suspend it until the patient takes one or two respirations. If the patient struggles, do not hold him, and push the administration of the drug. He holds his breath while struggling, and as struggling ceases takes full, deep breaths. If the inhaler be saturated with chloroform, he may inhale a dangerous amount during the deep respiration after struggling. Chloroform given in considerable amount when the patient is breathing deeply from the effects of ether is unsafe. If chloroform is given subsequent to anesthetization by ether, it should be given gradually and well mixed with air. When the patient becomes anesthetized, give just enough of the drug to keep him so. Before the attainment of unconsciousness hiccough usually means that vomiting is about to occur. If vomiting occurs at this time more chloroform must be given to abolish the reflexes. Deep and sighing respiration and

repeated swallowing indicate that more of the anesthetic is required. Stop the administration or give very little when shock becomes evident or when there is profuse hemorrhage. Chloroform vapor is not inflammable, hence it is safer than ether when a hot iron is to be used about the face and when there is a lighted lamp or a stove in a small room; but the presence of a naked gas-flame decomposes chloroform into irritant products of chlorin ($COCl_3$), which cause the patient and the surgeon to cough.

Chloroform and Oxygen.—The use of this mixture was suggested by Neudorfer. Some anesthetists advocate the mixture of chloroform and oxygen, asserting that it does not produce spasm of the glottis or muscles of respiration, that it does not produce cyanosis or weakness of circulation, that it does not irritate the kidneys, is safer to life than pure chloroform, and is less often productive of severe and prolonged vomiting. These alleged advantages are probably stated with rather undue emphasis, although I do believe the mixture has far less tendency to produce cyanosis than has the pure drug, does not so often induce vomiting, and is somewhat safer. Hewitt does not think that the method offers any "special advantages" ("Anesthetics and Their Administration," by Sir Frederic W. Hewitt). If this method be used, a bag containing oxygen is attached to the hand-bellows attachment of a Junker inhaler, and oxygen is forced through the chloroform and flows to the face-piece.

Administration of Ether.—The administration should not be intrusted to a novice. The anesthetist should be one of your most trusted men. I do not believe in allowing a nurse to give an anesthetic. She can have no useful views as to the selection



Fig. 991.—Allis's ether inhaler.

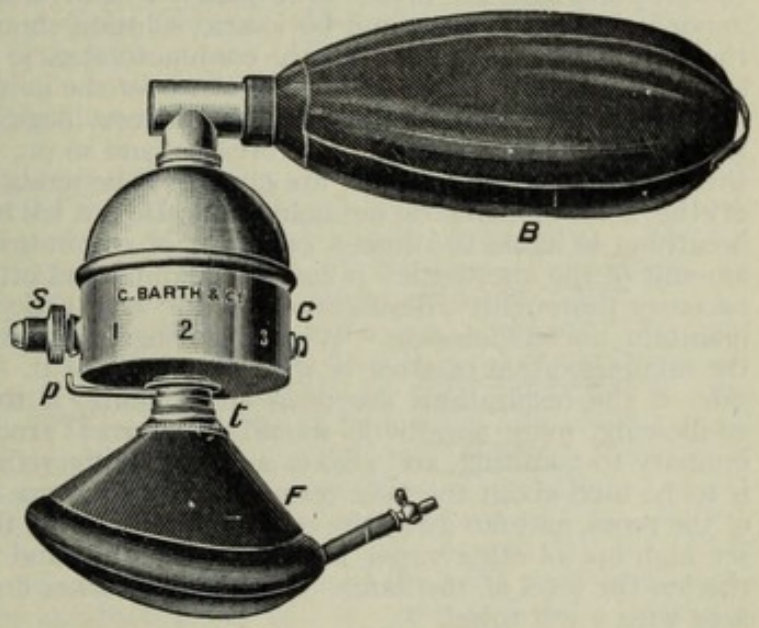


Fig. 992.—Clover's portable regulating ether inhaler.

of an anesthetic. She should no more be trusted to direct the amount of ether or chloroform to be given than she would be to direct the amount of atropin or morphin to be administered in a given case. She cannot have sufficient knowledge to observe incipient trouble, to anticipate untoward effects, and to do the correct thing at once when difficulty arises or calamity impends. She gets a high degree of rule-of-thumb skill, but rule-of-thumb skill is not sufficient. The moral responsibility and the legal responsibility demand that a physician give the ether. Usually the patient is recumbent, but if necessary he can be placed on the side, prone, semi-erect, or in the Trendelenburg position (see page 1047). Some anesthetists precede the administration of the ether by causing the patient to breathe the vapor of oil of orange. The patient finds it pleasant and loses some of his apprehension, and the oil so dulls the reflexes of the air passages that when ether is substituted for the orange it is "taken" more easily than otherwise would be the case. Pinus pumilio, 20 drops to 6½ oz. of ether, lessens somewhat bronchial irritation. Ether is best given from a partially open inhaler. The most satisfactory appliance is Allis's inhaler (Fig. 991). This inhaler secures a plentiful supply of air. Before being used the metal frame is scalded, dried, and threaded with a clean gauze bandage. The end of the frame which is to be toward the mouth is covered with one layer of gauze. The frame is then inserted in a clean metal case and the case is wrapped in a clean towel. The drug is given drop by drop, the drops following each other in regular sequence.

This is known as the *drop method*. The drop method is the safest plan and the most comfortable to the patient. Instead of Allis's inhaler a piece of gauze or an Esmarch inhaler may be used. When the patient's sensibilities begin to be blunted drop a little pure castor oil in each eye and cover the eyes with a soft handkerchief (Dudley W. Buxton). This procedure will prevent conjunctivitis. Some surgeons prefer closed inhalers. The Clover inhaler (Fig. 992) is popular in England. *F* is the face-piece; *C*, a reservoir of ether through which the air-current passes; *B* is an India-rubber bag. In this apparatus there is no provision for the entrance of fresh air. By turning the reservoir *C* on the tube *t* the amount of current passing over the ether can be regulated. When this apparatus is used, the ether vapor breathed into the lungs is expired into the bag and is rebreathed. The inhaler, if used by a skilful man, is very useful; but any lack of watchfulness or skill will permit of cyanosis, and the very young, the senile, the anemic, and feeble are best anesthetized by the open drop method described above.

An admirable detailed account of anesthetization by the closed method will be found in Sir Frederic W. Hewitt's treatise on "Anesthetics and Their Administration," and in Mr. Dudley W. Buxton's treatise on "Anesthetics, Their Uses and Administration." When giving ether, have at hand the same drugs and appliances as when chloroform is given, and keep the lower jaw pushed forward during the administration. When using Allis's inhaler, take every care that none of the ether runs through on to the face and into the eyes. If it does it will irritate and perhaps blister. Even the vapor irritates the eyes, and boric acid solution should be used now and then during the administration to flush out the conjunctival sacs. It is wise to grease the face and lips with vaselin. Place the dry inhaler over the mouth and nose, let the patient take several breaths, that he may gain confidence, begin to drop ether into the inhaler, let the patient take several more breaths, and so on, gradually increasing the rapidity with which the drops of ether are given. If he tends to struggle, diminish the amount of ether for a time, but do not hold him. Do not tell him to breathe forcibly. Forcible breathing is liable to cause a cessation of respiration. Never suddenly add a large amount of the anesthetic: it causes coughing and often vomiting. When the patient becomes thoroughly anesthetized, give a very little ether as often as is required to maintain unconsciousness. When bleeding is profuse or shock is marked, suspend the administration of ether or give very little of it. If he rolls his eyes from side to side, if the respirations are deep and sighing, if there are repeated movements of swallowing, more anesthetic should be given (Tarnowsky). Hiccough is often preliminary to vomiting, and always means that the reflexes are returning. If a hot iron is to be used about the face, open a window, remove the inhaler and ether bottle out of the room, and fan away the ether before bringing the cautery near. Have any light set high up, as ether vapor is heavier than air, and no explosion is possible until it reaches the level of the flame. If the vapor takes fire, cover the patient's mouth and nose with a wet towel.

The patient should be kept in a condition in which he feels no pain, makes no movement, and is not rigid. In this condition the cutaneous reflexes are abolished, the breathing is regular and quiet, the color is good, and the pupils react to light, though slowly. Just enough anesthetic must be given to cause the patient to pass into this condition and remain in it. To give any more is to poison him. The amount necessary varies with the individual and the operation, and requires skill, experience, and attention on the part of the anesthetist.

The old idea that we must poison a man into dangerous coma has been abandoned. When the breathing becomes louder, more rapid, or spasmodic, it means that reflexes are returning, and a little more anesthetic should be given.

The Cotton Process Ether.—Dr. James H. Cotton, of McGill University, after many experiments and observations published some novel views upon ether ("Jour. Canadian Med. Assoc.," Sept., 1917). The aim of the manufacturer has been to make ether as nearly pure as possible. The process of today makes purer ether than that made years ago, yet surgeons often feel that patients cannot be anesthetized as rapidly as in former days and that primary anesthesia is more difficult to obtain. Cotton believes that just as ether approaches to purity it loses more and more of its anesthetic power, that by removing impurities we remove valuable elements and that perfectly pure ether is not an anesthetic at all, but only serves to make a man drunk.

The impurity which produces anesthesia is, Cotton believes, a gas like ethylene. Another impurity contains an unidentified gas which produces the ordinary unpleasant symptoms which so commonly follow anesthesia (vomiting, headache, etc.).

Cotton makes a chemically pure ether and charges it with the desirable anesthetic gas.

The view that anesthesia is caused by the impurities in ether and not by pure ether is improbable and is positively denied by some able investigators. Stehle and Bourne ("Jour. Amer. Med. Assoc.," July 29, 1923) have obtained pure ether and have secured by means of it most satisfactory anesthesia. Dale, Hadfield, and King ("Lancet," Feb. 3, 1923) oppose the view that pure ether is not an anesthetic; point out that the ether made after the Cotton plan contains only 4 per cent. of butyl alcohol, and a small amount of aldehyd; and that there is no warrant for attributing the anesthesia to anything else than ether.

Ether and Oxygen.—This mixture is useful in certain cases in which respiratory difficulty exists, particularly in empyema. If during the administration of ether cyanosis tends to occur, it is often advantageous to give oxygen with the ether. The process of anesthetization by ether and oxygen is somewhat slower than by ether vapor mixed with air. It can be given by inserting beneath the Allis inhaler or pushing deep down into it, from above, a tube attached to a reservoir of oxygen and from which a stream of oxygen emerges. It can be given accurately as to percentage of oxygen to ether by means of a special apparatus.

Endotracheal Insufflation Anesthesia (Intratracheal Anesthesia) (Method of Meltzer and Auer).—A flexible elastic tube much smaller in diameter than the trachea is carried down almost to the tracheal bifurcation. When air is forced in, it emerges between the tube and the trachea. The addition of ether vapor to the air makes the maintenance of anesthesia easy. Ether can thus be administered by means of a tracheal tube, a Wolff bottle containing the ether, and a foot-bellows. I have had it given in this way a number of times. Elsberg's apparatus permits of the most desirable method.

The patient is first anesthetized by the ordinary method. When unconscious the head is dropped back over the end of the table, and the tube is passed into the trachea "under the guidance of the eye by means of a Jackson direct laryngoscope" (see Fig. 685). (See Brewer in "Keen's Surgery," vol. vi.) In this form of anesthesia the stream of air carries off ether vapor and prevents accumulation in the tubes.

A degree of anesthesia necessary to maintain muscular relaxation will not apparently cause dangerous symptoms. If the ether is given for a long time in unnecessarily large amounts danger may be reached, but the danger point is attained gradually and not suddenly and gives warning. If there should be an ominous fall in blood-pressure and respiratory failure, cut out the ether vapor and use the apparatus for artificial respiration. A patient remains very still under this method of anesthesia, awakes rapidly from it, and suffers little from shock and postoperative vomiting. Nitrous oxid and oxygen have been given by this method. Meltzer is studying chloroform so used ("Keen's Surgery," vol. vi). In operations about the head, mouth, and neck insufflation anesthesia keeps the anesthetist out of the operator's way. In operations about the mouth the method prevents the inhalation of blood or vomit. In goiter operations it is a safeguard against sudden suffocation. It is useful in brain operations, especially cerebellar operations. In intrathoracic operations it serves to prevent collapse of the lung. After the operation all ether vapor is driven out of the lungs by a stream of fresh air. Peck ("Annals of Surgery," July, 1912) maintains that the insufflation method is safe if certain rules are carefully followed. These rules are to avoid excessive pressure (which might rupture air-cells), to be sure not to spray liquid ether into the tracheal tube, not to carry the tube into the gullet, or beyond the tracheal bifurcation, and not to do damage by rough introduction.

I use the method frequently, find it extremely useful, and regard it as safe. Meltzer has only been able to learn of 4 or 5 deaths during the application of the method and he does not think one of them was due to the method. One was due to liquid ether being allowed to run into the tube; another to rupture of the lung brought about by the tube being pushed down too far; another death was due to the tube having been passed into the gullet; in another case the tube was forced, producing cyanosis, emphysema, and death. A tube with a safety-valve used with scrupulous care would probably have saved these lives. (Abstract in "Surg., Gynec., and Obstet.," Jan., 1915, from "Berlin klin. Wochen.," 1914, ii.)

Rectal Etherization.—Pirogoff suggested this method in 1847 and Roux employed it the same year. The method is recommended by some for operations upon the face, tongue, nasopharynx, pharynx, mouth, larynx, trachea, thyroid, or chest;

in other words, in cases in which, were the ether given by inhalation, the operator and anesthetist would interfere with each other. It is useful if a patient must assume a prone position (as in laminectomy, in head operations, if bronchitis exists, and in the aged). It is especially useful in fat alcoholics. It does not cause a sense of suffocation, the stage of excitement is brief and struggling is absent or trivial. Rectal anesthesia causes much less mucus to flow into the air-passages than does inhalation anesthesia. Postoperative nausea and vomiting are less common than after inhalation anesthesia. A badly frightened patient can by this method be anesthetized without his knowledge. It is contraindicated in pelvic operations, if there is irritation or inflammation of the intestines, and in laparotomy because gaseous distention of the gut interferes with work and necessitates much handling. Until recently the following rules were laid down for the administration. The rectum should be emptied by a purgative enema the day before the operation, and again the morning of the operation, and a short time before giving the ether the rectum should be irrigated with warm salt solution. A dose of laudanum is given a few hours before, or an injection of morphin and atropin twenty minutes before the administration of the ether. We should employ an apparatus of the type of Buxton's, which prevents liquid ether from passing into the rectum.

A tube containing ether is set in a vessel containing water at a temperature of 122° F. The ether tube is joined by a glass tube and rubber pipe to a glass globe, and the globe is connected by a rubber pipe to the tip, which is inserted into the rectum. If ether vapor condenses into liquid in the glass globe the globe should be at once emptied. During the administration abdominal distention occurs from unabsorbed ether, and from time to time the administration should be suspended temporarily to permit the gas to escape, otherwise too much will be given and prolonged stupor and postoperative colic may result. It takes much longer to obtain unconsciousness by rectal administration than by inhalation. This method never came into general use. It was found to irritate the large intestine, to produce colic in many cases, and sometimes to lead to protracted stupor ("Anesthetics and Their Administration," by Sir Frederic W. Hewitt). After one of Baum's cases intestinal hemorrhage occurred; in another, gangrene and perforation ("Zentral. für Chir.," March 13, 1909). Dudley W. Buxton, however, has employed it in many operations about the face, mouth, and larynx, and in some operations for empyema, and commends it. James T. Gwathmey ("New York Med. Jour.," 1913, xcviii; 1914, xcix) improved the method greatly. He calls the new method oil-ether anesthesia by the rectum. The mixture used consists of 4 ounces of olive oil and 2 ounces of ether. One ounce is given for each 20 pounds of the patient's body weight, but not more than 8 ounces are to be given. The night before the operation compound licorice powder or castor oil is given. A couple of hours before the injection the rectum is washed out. Forty minutes before operation a hypodermic injection is given. It contains $\frac{1}{4}$ gr. of morphin and $\frac{1}{100}$ gr. of atropin. At this time anesthetize the rectum by injecting into it 5 to 10 gr. of chloretone in ether and olive oil. Twenty minutes before operation the patient is placed in the Sims position and the mixture of oil and ether (which has been well shaken in a bottle) is introduced slowly into the rectum by means of a funnel and a rubber catheter. It is given at the rate of an ounce a minute. In five or six minutes the patient should be unconscious and in twenty minutes from beginning the injection anesthesia should be complete. In some cases anesthesia is not complete for thirty or forty minutes. The ocular reflexes must not be abolished and stertorous respiration is a danger sign (W. M. Johnston in "New York Med. Jour.," 1916, civ). Gwathmey insists that respiration should be smooth and easy, without stertor and with the retention of eyelid reflex. If danger signals arise, some or all of the mixture is withdrawn by lowering the tube. According to Gwathmey the method is less unpleasant than inhalation anesthesia and produces complete muscular relaxation. If we wish to deepen it, cover the face with a towel. Two ounces of ether an hour will keep a person under (Gwathmey). At the termination of the operation the mixture is withdrawn from the rectum, the rectum is well washed out with cold water containing soap, and a pint of cold water is left in the rectum (Gwathmey, "New York Med. Jour.," 1914, xcix). Sometimes the unconsciousness is inordinately prolonged. In some persons resistant to ether it is necessary to supplement rectal administration by inhalations of ether. I see no reason to doubt that rectal anesthesia is as dangerous as inhalation anesthesia. It is certainly less controllable. It is useful in certain cases but will not displace the inhalation method. Intratracheal insufflation anesthesia seems to have nearly done away with all need for rectal anesthesia.

Intravenous Etherization (Infusion Anesthesia).—This method was devised by Burkhardt, of Würzburg, and is still on trial. A 7½ per cent. solution of ether in normal salt solution is employed by Rood ("Lancet," March 23, 1912). He found that a 10 per cent. solution causes hemolysis and a 5 per cent. solution is inadequate. About three-quarters of an hour before operation he gives a hypodermic injection of ⅛ gr. of morphin, 1/100 gr. of scopolamin and 1/100 gr. of atropin. When ready to operate, a vein is selected, exposed and opened, and the cannula is introduced. The solution is warm. From ½ to 1 pint of the fluid is allowed to run in and anesthesia should be secured in from three to five minutes. Anesthesia is maintained by running in a constant succession of drops. If anesthesia becomes too deep the rate of flow is lessened, and vice versa. This method of anesthesia keeps the anesthetist out of the way in operations on the head, neck, and mouth. It is claimed that it enables us to measure the dose of anesthetic much more accurately than does the respiratory plan, and that by it we avoid irritation of the mucous membrane of the respiratory tract. The respiration must be watched just as carefully as in respiratory anesthesia. Rood ("Brit. Med. Jour.," Oct. 21, 1911) has had 136 cases and no bad results. It would seem, however, that there must be elements of danger, ecchymoses may appear on the back and buttocks, and it has been stated that there is a tendency to pulmonary edema ("The Art of Anesthesia," by P. J. Flagg).

Hedonal has been used for infusion anesthesia. It was suggested by Federoff, of St. Petersburg. Mr. Page, of London, has reported 75 cases ("Lancet," March 23, 1912). He uses a 0.75 per cent. solution in normal salt solution and gives it continuously. Ward ("Lancet," March 23, 1912) has reported a death from it.

Anesthetic State from Ether or Chloroform.—The inhalation of an anesthetic produces irritation of the fauces, often some cough, a profuse secretion of mucus, acts of swallowing, dilatation of the pupils, flushed face, and sometimes struggling (especially in children and in drunkards). If at the start the vapor be given in concentrated form, cough will be violent and will cause cyanosis. If the anesthetic be given gradually the cough soon ceases, the respirations become rapid and often convulsive, the pulse becomes frequent, and the patient passes into a condition of active intoxication with preservation of sight and touch, loss of hearing and smell, diminution of pain and sensibility, and often with illusions and hallucinations. In this stage the patient may struggle, and while efforts are being made to hold him, cyanosis may occur. From the stage of excitement just alluded to, many subjects (strong men and drunkards) pass into a stage of rigidity in which the muscles become firmly fixed, the breathing is impeded, the respirations are stertorous and the face is bluish and congested. Too rapid forcing of the anesthetic tends to cause rigidity, and a skilled anesthetist endeavors to avoid its production, because it is dangerous. The next stage is one of insensibility; the pupils are contracted and react sluggishly to light. If anesthesia is deep the contracted pupils will not react to light; if anesthesia is profound the pupils dilate, but will not react to light. In the anesthetic state conjunctival reflex is gone; the lids are closed; if the arm is lifted and allowed to fall, it drops as a dead weight; the skin is cool and moist and often wet with sweat; the respirations are easy and shallow; the pulse is slow, and there is complete unconsciousness to pain. The loss of conjunctival reflex is the usually accepted sign that the patient is unconscious. In a young child this reflex is soon exhausted by touching the eye, and the sign is unreliable. If a baby is to be anesthetized, the administrator places his finger in the infant's hand. The child grasps the finger, and relaxes its grasp when unconscious.

Always bear in mind that dilated pupils reacting to light and associated with preserved conjunctival reflex mean that anesthesia is not complete; that contracted pupils reacting to light and without conjunctival reflex mean moderate anesthesia; that contracted pupils not reacting to light and without conjunctival reflex mean deep anesthesia; that dilated pupils not reacting to light and associated with lost conjunctival reflex mean dangerously profound anesthesia. Sudden dilatation with fixation is always very ominous. The pupillary phenomena are very valuable when present, but unfortunately they are absent at some stage of the anesthesia in many cases. Inequality of the pupils is not unusual and fixation of one pupil or of both may occur. A preliminary dose of morphin or atropin interferes with the pupillary phenomena. Weak pulse and pallor may be due to nausea, but always require instant attention. Vomiting may be due to forcing strong vapor upon the patient, but may also be due to his partially emerging from a state of insensibility.

Watch the pulse carefully to see if it becomes very weak, irregular, abnormally

slow, abnormally fast, or if it suggests a fall of blood-pressure. The measure of the blood-pressure may give highly valuable information. Syncope may be due to nausea, shock, hemorrhage, or the giving of too much of the drug. Watch the respiration, and do not forget that the chest walls and belly may move when no air is entering the lungs; hence always *listen* to the breathing. *Cyanosis* is a dusky or bluish discoloration of the skin. This condition indicates want of oxygen in the blood. The individual may have been cyanotic or predisposed to cyanosis from the beginning; cyanosis may be due to pressure; to cough early in the administration; to struggling during the stage of excitement; to the gathering of mucus in the respiration tract; or to rigid fixation of the respiratory muscles. It may also be due to obstruction of the air-passages by some foreign matter, as blood or vomit, lodging in the bronchial tubes, windpipe, larynx, or pharynx; falling back of the tongue (*swallowing of the tongue*); closure of the epiglottis; or to the glottis being pushed against the pharyngeal wall by bending the head forward. Some patients with occluded nostrils may fail to get enough air because of closure of the lips. A patient may, while taking an anesthetic, lie perfectly quiet and appear to "forget to breathe." Ether and chloroform mitigate the causal mental phases of shock, but neither drug keeps nerves from conveying stimuli and each produces a fall of blood-pressure, chloroform directly by its action on the vasomotor center, ether by overstimulation of the vasomotor center (Buxton in "Proceedings of the Royal Soc. of Med.," April, 1909). Each produces a fall of temperature. Buxton heartily condemns the once common belief "that evidences of shock during a surgical operation are a proof that an insufficient quantity of the anesthetic has been given and that the symptoms of shock can be abrogated by increasing the depth of the narcosis" (Ibid.). Heavy anesthesia by ether or chloroform produces or adds to shock, Shock is manifested by deathly pallor, weak, rapid, and irregular pulse, notable fall of blood-pressure, slow respiration, cold extremities, and a drenching sweat. Edema of the lungs occasionally arises during or after anesthesia.

Treatment of Complications.—*Vomiting* due to too much anesthetic is corrected by giving a few breaths of air; vomiting due to incomplete anesthesia is amended by giving more of the vapor. While the patient vomits hold the head over the edge of the bed or table, and when vomiting ceases separate the jaws with the gag, and wipe out the vomited matter, mucus, and saliva. *Shock* is treated by diminishing the amount of the anesthetic that is being given, by the hypodermic injection of atropin (atropin is particularly useful when there is a profuse sweat), by the administration of hot saline fluid by the rectum, subcutaneously, or intravenously, by surrounding the patient with hot-water bottles, or by wrapping him in hot blankets, and by lowering the head of the bed. Syncope is sudden cerebral anemia and is usually due to a reflex cause. A tendency to *syncope* requires lowering of the head, suspension of the anesthetic, and hypodermic injection of strychnin. In *extreme syncope*, which is most apt to occur from chloroform, do not wait for breathing to cease, but suspend the anesthetic, lower the head of the bed, open the mouth with the gag, catch the tongue, and draw it forward while an assistant is making *slow* artificial respiration. If the patient does not *at once* improve, invert him completely, holding him by the legs and continuing artificial respiration by compressing the sternum (Nélaton's plan). By continuing artificial respiration the blood is urged on through the heart. Give hypodermic injections of atropin, ether, or even of ammonia. Put mustard over the heart and spine. Employ faradism to the phrenic nerve (one pole to the epigastric region, the other to the right side of the root of the neck). Let fresh air into the room, put hot-water bottles around the legs, apply friction to the extremities, wrap the patient in hot blankets, give an enema of hot salt solution, and hold ammonia to the nose. If such means do not succeed, promptly inject 5 c.c. of 1:1000 adrenalin solution into a chamber of the heart (*intracardiac injection of adrenalin*). This is the plan of D. W. Crile ("Surg., Gynec., and Obstet.," Dec., 1922). The surgeon knows the needle has entered the heart by the flow of blood. If the plan succeeds, cardiac contractions begin, the coronaries fill, the adrenalin gradually enters the circulation, and the brain and respiratory center are stimulated. There is no doubt of the value of this method. Reported cases prove it. The drug and syringe should always be ready for an emergency. In some cases of anesthetic poisoning *direct heart massage* has been successfully employed. The method was suggested by Schliff in 1874. Frazier was operating for hydrocele when the patient's respiration ceased and his pulse disappeared. Frazier at once opened the abdomen and, with one hand on the chest wall and the other against the diaphragm, "massaged the heart at the

rate of 15 to 20 movements a minute." In about two minutes cardiac contractions were perceptible. In about eight minutes resuscitation was complete ("Jour. Amer. Med. Assoc.," May 20, 1911). In Conkling's case there was a chest wound exposing the lung. The heart ceased to beat. The surgeon grasped the heart between the fingers and made compressions. In less than a minute he detected a thrill, and in a few seconds more regular pulsation began ("New York Med. Jour.," Sept. 2, 1905). In Sencert's successful case an operation was being done for gall-stones when collapse occurred, and the surgeon stroked and kneaded the heart through the diaphragm. In a case recorded in the "Brit. Med. Jour.," Nov. 18, 1905, respiration and pulse had ceased three minutes when the abdomen was opened and the heart was kneaded. Recovery ensued. Müller, of Hamburg, advocates exposing and opening the pericardium to perform massage, introducing oxygenated salt solution into a vein, opening the trachea, and performing artificial respiration. If a surgeon has the patient's abdomen open and the heart stops he should massage the heart from below the diaphragm. If there is no response in two or three minutes, he should make diaphragmatic incision under the left costal cartilages, insert two or three fingers, and finally get the hand into the thorax (Bost in "Surg., Gynec., and Obstet.," Feb., 1923). The cardiac base should be massaged very slowly. When the heart starts the massage is stopped. The wound in the diaphragm should be sutured with catgut. Frazier ("Progressive Medicine," March, 1911) publishes statistics of 50 collected cases. These figures indicate that the subdiaphragmatic method is more successful than either the direct method or the transdiaphragmatic method. The table is as follows:

	Successful.	Partially successful.	Failures.	Total.
Direct	2	8	18	28
Transdiaphragmatic	0	1	2	3
Subdiaphragmatic	8	5	6	19
	10	14	26	50

Leonard Hill holds that in the failure which arises *soon after administration of chloroform is begun* the trouble is due to vasomotor paralysis with starvation of the nerve-centers. In such a case he applies abdominal compression and inverts the patient, making artificial respiration at the same time. In the failure which occurs after *considerable chloroform has been taken* there are paralytic distention of the heart, fulness of the venous system, and loss of the compensations for the hydrostatic effects of gravity. In such a condition empty the distended heart of venous blood by raising the patient into an erect position, and after a moment place him recumbent and make artificial respiration.

Forgetting to breathe is met by removing the inhaler and waiting a moment; a breath will usually be taken soon; but if it is not taken, somewhat forcibly knead the structures in the arm-pit. If this fails, open the mouth and pull forward the tongue; this causes a reflex inspiration. Cyanosis is practically not encountered when oxygen is given with ether or chloroform. *Cyanosis*, if slight and due to cough or struggling, is met by removing the inhaler while the patient takes a breath or two of air. If position is responsible for cyanosis, correct it. In empyema, lying upon the sound side may produce it. Obstruction to breathing may be due to bending down the head. If due to stenosis of the nares in a person without teeth, hold the lips apart with a finger. If due to collection of mucus, wipe the mucus out of the mouth by means of bits of gauze firmly clamped in forceps; raise the shoulders, extend the head and place it on its side in order that mucus may run out of the angle of the mouth; and give a dose of atropin hypodermically. If the amount of mucus is large and the secretion is persistent, it may be necessary, especially in children, to empty the respiratory passages by inverting the patient. In cases of excessive bronchial secretion we fear the development of pulmonary edema or postoperative bronchopneumonia.

Dudley W. Buxton points out that duskiness will often pass away if ether is removed, one or two inhalations of chloroform given, and ether then continued, but I fear to give chloroform after ether. If in any case cyanosis is severe or grows worse, suspend the drug, dash cold water in the face, force open the jaws, pull forward the tongue, make artificial respiration until a breath is taken, and then give oxygen for a time. If these means fail, stretch the sphincter ani and bleed from the external jugular vein. If a breath is not now taken, do tracheotomy. In respiratory or heart failure forced artificial respiration by an apparatus may be of value. The pul-

motor or lungmotor, if at hand, enables the surgeon to maintain regular artificial respiration for an indefinite time (see page 833). *Swallowing the tongue* is corrected by pulling the tongue forward. If it tends to recur, lay the head upon its side or keep the tongue anchored with forceps. *Closure of the glottis* is corrected by pulling the patient's head over the edge of the table and pushing strongly back upon his forehead. This maneuver lifts the hyoid bone, and with it the epiglottis. The epiglottis can be lifted by passing a spoon-handle or the index-finger over the dorsum to the base of the tongue and pressing forward. If, in obstruction to respiration, the above means fail, make artificial respiration at once (see page 833); if obstruction continues, perform tracheotomy.

Edema of the lungs is treated by instant venesection, the inhalation of nitrite of amyl, and the administration of stimulants and nitroglycerin hypodermically. Sometimes during the anesthetic state the muscles of the belly become very *rigid*, a condition which greatly interferes with an abdominal operation. It may arise during cyanosis, and if so caused is amended, as cyanosis abates under proper treatment. In some cases it is due to the fact that sufficient anesthetic has not been given. If the air-passages are obstructed before operation, abdominal rigidity is apt to arise. In some cases it seems impossible to overcome it with ether. In such a case, if the anesthetist is a trusted man, anesthetize the patient with gas and ether and then give chloroform (Blumfield in "Lancet," May 31, 1902). A rule-of-thumb anesthetist cannot be trusted to do this.

The Reaction from Anesthesia.—When ether or chloroform is given, a considerable quantity is swallowed and either drug irritates the stomach and creates nausea and often vomiting. The longer the operation, the more of the anesthetic enters the stomach, and the greater the liability to subsequent vomiting. At the termination of a prolonged operation upon an adult, if the patient's condition admits of it, and if the nature of the operation does not forbid it, I like to have a stomach-tube passed and the stomach well washed out with warm water. The washings smell strongly of the anesthetic, and the procedure greatly lessens the severity and frequency of post-operative vomiting (Geo. S. Brown in "Surg., Gynec., and Obstet.," Aug., 1905). After the administration of the anesthetic has been suspended and the operation has been completed the temperature is usually subnormal. The patient must be watched until consciousness returns. If he is left alone, a change of posture may lead to arrest of feeble respiration, the assumption of the erect position may cause fatal syncope, and mucus or vomited matter may block the air-passages and cause suffocation. The best position to place him in is the recumbent, the head being level with the body or somewhat lower and the side of the face resting on the pillow. Shock is treated by ordinary methods (see page 194). The inhalation of oxygen is of great value in rousing a patient from the state of anesthesia, and will often prevent vomiting. If vomiting occurs, the head should be upon its side or should be held over the edge of the bed, and after the spell of vomiting the mouth must be wiped clean. The face should be washed with cold water and be fanned rather actively. It is the routine practice of some surgeons to administer vinegar by inhalation during the reaction from an anesthetic. This proceeding sometimes seems to prevent vomiting. Some patients awake from anesthesia as from a quiet sleep; others are noisy, turbulent, and violent. The duration of the period of reaction varies with the anesthetic used, the amount given, and the personal tendencies of the patient. The patient must not be allowed to sit up for several hours at least. No food is to be allowed for at least six hours. Unless the operation has been upon the stomach, I do not forbid water, but allow the patient to drink freely of hot water. This dilutes any irritant material in the stomach and dissolves mucus, and if vomiting does occur it serves to wash the stomach out. All fat patients, all patients with respiratory difficulties, or in whom we apprehend respiratory complications should, if there is no contraindication, be placed in a sitting or, at least, a semi-erect posture as soon as reaction from anesthesia is obtained. If this plan is followed, ether-pneumonia and other respiratory troubles will very seldom develop.

After-effects of Anesthetics.—Vomiting.—I am convinced that in many cases postanesthetic vomiting is due or is largely due to irritation of the stomach caused by swallowing considerable quantities of an irritant anesthetic. The liability to it is greatly lessened by washing out the stomach before the patient leaves the operating table, and allowing the patient (in suitable cases) to drink freely of hot water as soon as he returns to consciousness. Vomiting occurs in about 75 per cent. of those who have been given ether. After ether and oxygen about 30 per cent. vomit. If the

man has been drinking hot water an act of vomiting washes out his stomach and he may not vomit again. Violent vomiting may occur in spite of all our efforts, and may persist for hours, greatly exhausting the patient and doing infinite harm, it may be, especially if the operation has been upon the brain or an intra-abdominal structure. If vomiting continues, forbid food absolutely. Very hot water in doses of a teaspoonful should be given at frequent intervals. Drafts of hot water may relieve the condition by washing out the mucus from the stomach. Other remedies which may succeed are: inhalations of vinegar, hot black coffee by the mouth, a mustard plaster over the stomach, fresh air in the room, small pieces of ice placed in the mouth and sucked, small doses of iced champagne, and drop doses of a 3 per cent. solution of cocain or 3-drop doses of a 5 per cent. solution of eucain. The best remedy for persistent vomiting is lavage of the stomach. Some persons, as Dudley W. Buxton points out, suffer greatly from nausea, although there is little or no vomiting. In such cases Buxton uses 1 min. of tincture of nux vomica in a teaspoonful of hot water every ten minutes until 6 doses have been taken. If this plan fails, he gives drop doses of wine of ipecac or minim doses of dilute hydrocyanic acid.[1]

Vomiting from chloroform is usually more difficult to check than vomiting from ether. In any case of persistent vomiting examine for acidosis (see page 105).

Backache.—This is a very common and often a very distressing consequence of anesthesia. It is complained of soon after consciousness is regained, it may persist for several days, and it is a not uncommon cause of wakefulness. It is usually greatly aggravated by turning and twisting, and by attempting to rise up from the bed. The pain is located in the lumbar and sacral regions and is often accompanied by rigidity of the lumbar muscles. Various explanations have been given of it. One view is that it is due to renal congestion. Another is, that it results from congestion of the spinal cord. I believe that the explanation of most cases is that given by John Dunlop ("New York Med. Jour.," July 10, 1909), viz.: "The patient during the operation lay upon a flat table without support to the lumbar curve, consequently the sacro-iliac synchondroses were strained. The backache may be largely prevented by placing a small pillow so that it will support the lumbar curve during anesthesia."

Respiratory disorders are not uncommon after operations. "It now seems well established that 1 in every 50 patients operated upon develops a pulmonary complication and 1 in every 150 to 175 developing such complications die" (Walter Estell Lee in "Annals of Surgery," April, 1924). Such complications are not all due to general anesthesia, but may occur when no general anesthetic has been given. A general anesthetic often is a factor. Other factors are infection previous to or after operation, antecedent lung disease, old age, debility, and chilling of the surface of the body (Lee, Ibid.). Among the pulmonary complications are bronchitis, lobar pneumonia, bronchopneumonia, pulmonary embolism and infarction, and pulmonary collapse. The so-called ether pneumonia is a bronchopneumonia and is bilateral. An area of latent pulmonary tuberculosis may be lighted up by a general anesthetic and complications are more common after giving ether than after administering chloroform. Respiratory difficulties may be due to chilling the patient by bringing him from a warm operating room through a cold hall and into a cool bedroom or by failing to protect him during the operation. Bronchopneumonia is especially common in septic patients, and may be due in some cases to septic emboli and in others to aspiration of septic material into the bronchi (cases of cancer of the tongue and pharynx, and cases with stercoraceous vomiting). If chloroform is given when a gaslight is in the room the vapor is decomposed and certain highly irritant products are formed, which, when inhaled, produce laryngeal spasm and possibly bronchitis. The irritant material is probably $COCl_2$. The treatment is to admit fresh air freely into the room, and to have the patient inhale vinegar and, later, oxygen. Ether-pneumonia must not be confounded with postoperative pneumonia, described by Wm. H. Bennett.[2] This latter condition may arise from seven to fourteen days after operation in robust, gouty people, and is usually unilateral. If the patient is placed in a sitting position or, at least, semi-erect in bed, as soon as he reacts from the anesthetic the danger of serious respiratory disorder will be at a minimum.

Renal Complications.—After the administration of an anesthetic, blood, albumin, sugar, acetone, or diacetic acid may appear in the urine, and the secretion may become

[1] "Anesthetics," by Dudley W. Buxton.

[2] "Practitioner," December, 1896.

scanty or even be suppressed. It is usually maintained that chloroform is less apt to irritate the kidney epithelium than ether, but there has been much dispute on this point. If casts and albumin are present before anesthetization, the condition may be rendered worse if ether or chloroform is given. If neither casts nor albumin are present, they will not be so apt to appear after taking chloroform as after taking ether, but if they do appear after chloroform, they remain longer than after ether (Legrain). The truth of the matter probably is, that if the kidneys are healthy a small or moderate amount of either drug is not particularly irritant; but if the kidneys are diseased, a small amount, and even if they are healthy, a large amount, of either drug produces decided renal irritation. Chloroform is less irritant because less chloroform than ether is given to secure and maintain anesthesia. Scantiness or suppression of urine may be due to operative shock rather than to ether or chloroform. If the urine becomes somewhat scanty or if albumin appears in it, give non-irritant diuretics, diaphoretics and cathartics, and employ proctoclysis. The treatment of acidosis is set forth below. If the urine becomes very scanty, use hypodermoclysis. If postoperative suppression arises, it is the usual custom to give intravenous infusion of hot saline fluid, but I am doubtful of its value. Exposure of each kidney in the loin and incision of its capsule to relieve tension is justifiable and may do good.

Acid Intoxication.—This condition has been called *delayed poisoning*, *acetonuria*, and *acidosis*. Acidosis has been discussed on page 1005. Diabetic coma is due to acid intoxication. It is known that even in healthy urine there may be a trace, but a bare trace, of acetone. A diabetic individual deprived absolutely of carbohydrates is apt to get acetone and diacetic acid in the blood and urine. In such cases carbohydrates and insulin cause the prompt disappearance of the acetone and diacetic acid. Any victim of a wasting disease, of fear, of alcohol, of shock, and any person who is underfed may have acetonuria. If we purpose anesthetizing a person who is a victim of acetonuria adopt Bainbridge's plan. Purge, and for several days before operation give by mouth several ounces of milk-sugar a day. Render the urine alkaline by giving bicarbonate of soda by mouth and by rectum. Or for two days before operation give twice daily retention enemata of ½ ounce of glucose and ½ ounce of bicarbonate of sodium (Quillian in "Annals of Surgery," 1916, lxiii). Even people who do not suffer from acetonuria or diabetes may develop acetonuria after anesthesia. In certain cases in which dangerous symptoms arise after anesthesia the urine shows increased acidity, may contain albumin or casts, and contains acetone bodies (particularly β-oxybutyric acid), diacetic acid, or both of these substances. The blood contains an excess of free fat and shows diminution of alkalinity. Acid intoxication is very much commoner after the administration of chloroform than of ether, but may follow the giving of any general anesthetic. It may occur in individuals whose tissues contain areas of fatty degeneration, but it also occurs in those entirely free from degeneration; in fact, children particularly suffer in this way after the use of chloroform. The actual operation has nothing to do with the trouble, and sepsis is not causative. The drug used as an anesthetic may cause acute fatty degeneration of the liver and other organs, and if it does, quantities of acid bodies will be formed and will not be entirely eliminated and these acid bodies directly or indirectly cause the symptoms. Diacetic acid and β-oxybutyric acid are by-products of the process and are antecedents or precursors of acetone. The symptoms arise after the patient has emerged from anesthesia and reacted from shock. There is persistent vomiting of thin and foul fluid, the pulse is rapid, there is dyspnea, the patient is extremely restless and much excited, there may be delirium, but dulness and heaviness may take the place of restlessness and excitement and coma may arise. Usually the temperature is subnormal, but sometimes there is elevated temperature. In some cases jaundice arises. There is an odor of acetone on the breath. Latent cases free from symptoms usually get well. Slight cases and even some grave cases recover, but most of the grave cases die in from one to five days. A knowledge of this condition explains some otherwise inexplicable deaths, and also some cases of persistent postoperative vomiting and of retarded convalescence. In acid intoxication there is fatty degeneration of the kidneys, of the liver, of the suprarenal glands, and of the gastric mucosa. The occurrence of such a condition is an impressive admonition that a surgeon should operate quickly, that as little of the anesthetic should be given as possible, that the urine should be carefully examined each day after operation for certainly several days and that chloroform should not be used for prolonged administration. The treatment has been to saturate the patient with alkalies. Sodium carbonate was usually selected. It was given by the rectum, by the mouth, by hypodermoclysis, or intravenously. Rectal ad-

ministration produces irritation and diarrhea. In acetonuria without clinical symptoms alkalinize the urine by 4 or 5 dr. of sodium bicarbonate daily, given by the mouth. When the urine becomes alkaline it is to be kept so. When symptoms appear give from 10 to 20 teaspoonfuls a day by the mouth and give glucose and bicarbonate of soda by slow proctoclysis. If symptoms do not soon disappear give the drug intravenously. Severe acid intoxication is treated as follows: Encourage skin activity by wrapping the patient in blankets and surrounding him with hot-water bags. Give carbonate or bicarbonate of sodium intravenously, and a glucose drip into the rectum (5 per cent. solution of anhydrous glucose). A solution of bicarbonate of a strength of from 3 to 5 per cent. is used. Labbé gives from 1 to 2 liters. If the patient improves, the sodium bicarbonate is again given by mouth. Some surgeons give citrate of sodium. Drennan gives a salt of calcium. Treatment by insulin is highly valuable. It causes tissue to utilize carbohydrates and fats are oxidized. (Labbé in "Arch. gen. de med.," Dec., 1911, and in "Presse méd.," Feb. 5, 1910; Braun in "Brit. Med. Jour.," Feb. 25, 1911; Geo. W. Crile in "Annals of Surgery," 1915, lxii; A. G. Burnham in "Amer. Med.," 1916, xi; G. W. Quillian in "Annals of Surgery," 1916, lxiii; J. Harold Austin in "Penn. Med. Jour.," Feb., 1917.) The use of insulin is discussed on page 1007.

Postanesthetic Paralysis or Narcosis Palsy.—Paralysis may arise during anesthesia as a result of cerebral hemorrhage or embolism.

It sometimes happens that when a person has come out of the anesthetic sleep a palsy of some part is found to exist, the condition being peripheral and not central in origin. Peripheral narcosis palsies are pressure palsies or traction palsies, although it is held by some that the anesthetic has a toxic influence which distinctly lowers the capacity of the nerves to sustain pressure. Certain it is that palsy sometimes follows what seems a degree of pressure inadequate to cause such a result. Narcosis palsies may be due to pressure of an extremity upon a table edge or to pressure upon nerves by placing the patient in certain positions.[1] Such palsies are most common in the upper extremity, but may occur in the face or in the lower extremity. When the Trendelenburg position has been employed, the flexures of the knees are in contact with the edge of the table, and paralysis of one or both external popliteal nerves may be induced. When the patient lies upon the side any nerve of the arm or forearm may suffer, but the circumflex and radial are most liable to be damaged. When the arm is elevated to the side of the head, or when it is drawn out strongly from the body, the brachial plexus may be compressed by the head of the humerus (Braun in "Deutsche Med. Woch.," 1894). When the arm is in external rotation and is drawn backward and outward the median nerve is stretched, and when the forearm is flexed and supinated the ulnar nerve is stretched (Braun, Ibid.). In most cases the paralysis involves muscles supplied by the brachial plexus and is due to drawing the arm upward and backward over the head, a position which may squeeze the cords of the plexus between the collar-bone and the first rib. Garrigues shows that the plexus is particularly apt to be squeezed when it is stretched by the head being drawn to the opposite side or being allowed to fall back.[2] According to Büdinger the mounting up of the clavicle squeezes the plexus as its cords cross the first rib. This surgeon thinks that extreme abduction of the arm may squeeze the cords. Molinari (Abstract in "Surgery, Gynec., and Obstet.," Feb., 1914 from "Zentralbl. f. d. ges. Chir., u. i. Grenzgeb.") says: "If an individual is upon his back he can raise his arm forward higher than the shoulder without dragging on the plexus. When the arm is drawn backward there is tension of the plexus over the head of the humerus and tension becomes extreme when the upper arm is rotated inward and the head is turned toward the opposite side. If the arm is now raised to a vertical position the tension becomes greater and soon the plexus is squeezed between the clavicle and first rib."

The prognosis is good, as a rule. Slight cases are soon recovered from; more serious cases, in which degeneration occurs, may not be recovered from for months. The treatment is as for any pressure palsy.

Primary Anesthesia.—Instruct the patient to count aloud and hold one arm above his head. Give the ether rapidly. In a short time he becomes mixed in his count and his arm sways or drops to the side. There is now a period of insensibility to pain lasting only about half a minute, and during this period a minor operation can be performed. The patient quickly reacts from primary anesthesia without vomiting

[1] H. J. Garrigues in "Amer. Jour. Med. Sciences," Jan., 1897.
[2] Ibid.

(Packard). Primary anesthesia can be obtained by chloroform (Holm in "Minnesota Med. Jour.," July, 1912), but I believe ether to be safer.

Mixtures are used by some because of the belief that a mixture might eliminate some unpleasant feature or some danger from a particular anesthetic.

Mixture of Ether and Chloroform.—This may be used in varying proportions. Hewitt at times employs 2 parts of chloroform to 3 parts of ether.

Vienna mixture contains 1 part of chloroform and 3 parts of ether.

Mixture of Alcohol and Chloroform.—All the chloroform mixtures produce the effects of chloroform, but we are giving the drug in an unknown amount. It was believed by Sansom, who devised this mixture, that the alcohol prevents concentration of chloroform vapor by retarding evaporation. When used, 1 part of alcohol is added to 4 parts of chloroform.

Nitrous Oxid and Oxygen.—(See page 1217.)

A. C. E. Mixture.—This mixture was originally used by Harley in 1864. It is often valuable in cases in which pure ether cannot be given. It is composed of 1 part of alcohol, 2 parts of chloroform, and 3 parts of ether. Its action is supposed to be between that of chloroform and ether. The objection to the A. C. E. mixture, as to any mixture, is that the materials do not evaporate in the ratio in which they are mixed, hence an uncertain amount of chloroform vapor is being inhaled (Buxton). This mixture is given by some from a Junker and by others from an open inhaler. Plenty of air should be given with it. The anesthetic acts similarly to chloroform.

Billroth's mixture contains 1 part of alcohol, 3 parts of chloroform, and 1 part of ether.

Schleich's Mixture for General Anesthesia.—Schleich, in 1895, introduced a *new anesthetic agent* which he claims is safer than chloroform. This surgeon maintains that a material is safe as an anesthetic only when almost all of the amount taken in at an inspiration is expelled on expiration. The anesthetic is unsafe in direct proportion to the amount absorbed; and the lower the boiling-point of an anesthetic, the less is absorbed, hence an anesthetic agent, to be safe, should have a low boiling-point. Schleich makes three solutions. The first contains (by volume) 1½ oz. of chloroform, ½ oz. of petroleum ether, and 6 oz. of sulphuric ether. The second contains 1½ oz. of chloroform, ½ oz. of petroleum ether, and 5 oz. of sulphuric ether. The third contains 1 oz. of chloroform, ½ oz. of petroleum ether, and 2⅔ oz. of sulphuric ether. Number 1 is used for light anesthesia, No. 2 for medium anesthesia, and No. 3 for deep anesthesia. The anesthetic can be given from an open inhaler or a towel. The anesthetic state is quiet, reaction is rapid, and vomiting occurs in but half the cases. The superiority of Schleich's anesthetic has not been proved. It sometimes causes dangerous symptoms, and has produced death. Some surgeons, who formerly approved of it, have abandoned it. It will certainly not displace ether or chloroform. Schleich's mixtures are now seldom or never used in the United States. Petroleum ether has no anesthetic power, and Meltzer shows that it is dangerous and tends to paralyze the respiratory muscles. Willy Meyer ("Med. Record," Aug. 15, 1908) believes in the Schleich principle, but substitutes ethyl chlorid with a boiling-point of 59° F. for the petroleum ether. He uses 17 per cent. volume of ethyl chlorid with 83 per cent. volume of the molecular mixture of ether and chloroform.

Ethyl bromid was first used by Nunneley, of Leeds, in 1849. It was reintroduced in 1882 and again in 1896. It is still sometimes used for short operations. It is given while the patient is recumbent. The unconsciousness is obtained in from one to three minutes and is rapidly recovered from, and there is no after-sickness. The unconsciousness lasts about three minutes. Three drams are given to a child, and 6 dr. to an adult. A towel is put over the face and the entire amount is poured on at once, and as soon as the patient is unconscious the towel is taken away and no more of the drug is given (Cumston). Even if consciousness is regained too quickly to suit the purposes of the surgeon, it is not safe to give more of the drug, a notable objection which chlorid of ethyl does not possess. Cases have been reported in which sudden death has followed the administration of this drug, and it should not be given if there is disease of the heart, lungs, or kidneys.[1] Twenty-four deaths from bromid of ethyl are on record (Guadiana). If it kills, it acts like chloroform. It may be given *before* ether to prevent unpleasant effects, but it is usually not considered proper to give before chloroform. Zematski, however, has used it before chloroform in 2000 cases ("Vratch," Aug. 25, 1901). I know of 2 unpublished deaths from it in Philadelphia. I never use

[1] See Cumston in "Boston Med. and Surg. Jour.," Dec. 20, 1894.

it and regard it as unsafe. The drug rapidly deteriorates, and the deteriorated drug is very dangerous.

Chlorid of ethyl is a rapid anesthetic and statistics imply that it is a safe one. My faith in it has been greatly shaken by knowledge of 3 unpublished deaths in Philadelphia. It was first used by Heyfelder in 1848. A committee of the British Medical Association condemned it in 1880. Carlson and Thiesing reintroduced it in 1895 (McCardie in "Lancet," April 4, 1903). It may be sprayed upon a mask covered by six to eight layers of gauze, so that the drug will not evaporate too quickly in the air. Many anesthetists give it in a closed apparatus, the patient respiring into and from a rubber bag. I believe it should be mixed with air and that concentrated vapor is decidedly dangerous. The odor of the drug is agreeable. From 5 to 10 gm. of ethyl chlorid are given for a short operation if the mask is used. The patient must always be recumbent when taking it. Early in the inhalation the pulse and respiration become rapid. When unconsciousness comes they should be normal. The anesthetic state is induced, when the mask is used, in from two to three minutes, and as soon as it is obtained the patient is allowed to get air. If the closed inhaler is used unconsciousness is obtained more rapidly. Excitement does not precede unconsciousness. The anesthetic condition lasts from one to three minutes, and it is recovered from rapidly, usually without vomiting or unpleasant after-effects. If the patient recovers too rapidly for the surgeon's purpose, more ethyl chlorid can be given. It is to be noted that complete muscular relaxation does not occur, in many cases the conjunctival reflex is not completely abolished, and often the pupils do not dilate. It has no superiority over nitrous oxid, except as to cost and portability, and sometimes it fails to produce complete unconsciousness. A large dose rapidly given is dangerous, as it may cause cessation of respiration and spasm of the diaphragm. A contraindication to its use is any respiratory obstruction. In many cases spasm of the masseters arises. Concentrated vapor administered for a considerable time lowers the blood-pressure, induces cyanosis and asphyxia, and would eventually cause death by respiratory failure (McCardie, Ibid.). Lotheisser, in a study of 2500 cases of anesthesia by this agent, reports 1 death. Ware collected 12,436 cases, with 1 death ("Jour. Amer. Med. Assoc.," Nov. 8, 1902). Seitz, of Konstanz, collected 16,000 cases, with 1 death. Miller ("Jour. Amer. Med. Assoc.," Nov. 23, 1912) estimates that there is 1 death in 13,365 administrations. It is perhaps safer than chloroform, not nearly so safe as nitrous oxid and oxygen, and not so safe as ether. The drug is used for a brief operation or examination. It can be given to infants a few days old with reasonable safety, and it has been administered many times to the aged. When it kills, it acts in a similar manner to chloroform. I have often given it *before* ether to prevent unpleasant symptoms and to hasten the advent of anesthesia, but it must *never* be given before chloroform. Recently I have practically ceased to administer ethyl chlorid because I have grown afraid of it.

Nitrous oxid gas may be used to obtain anesthesia for brief operations. It is usually given mixed with oxygen. Nitrous oxid and oxygen is the best anesthetic for diabetics, for cases of acute nephritis, and for the victims of pulmonary disease. It is contraindicated when high-blood pressure indicates vascular degeneration because apoplexy may follow its administration. It should never be given when the air-channel is narrowed, as in Ludwig's angina, abscess in or below the tongue, and thyroid enlargement (F. W. Hewitt in "Lancet," July 20, 27, and Aug. 10, 1907). It should not be administered to children under ten years of age, to cardiac cases, when slight movements might prove disastrous and when it is imperative that there shall be no rigidity (P. I. Flagg in "New York State Jour. of Surg.," Sept., 1922). This gas is stored in steel cylinders, in which it is in liquid form. The pure gas is passed into a rubber bag (Fig. 993), and is given to the patient by means of a tube and a mouth-mask, a wedge being placed between the patient's molar teeth, and the nostrils being closed by the anesthetist's fingers. The wedge must be held by a string, so that it cannot be swallowed. The patient becomes unconscious in about one minute, and we know that he is anesthetized by the stertor and cyanosis and the insensitiveness of the conjunctivæ. The pulse should be watched, and if it flags the administration must be suspended at once. The striking phenomena are asphyxial, viz., stertorous respiration, cyanosis, and even convulsions, dilatation of the pupils, rapidity of the heart, and swelling of the tongue.[1] Muscular relaxation is not nearly as complete as in ether anesthesia. This rigidity is very objectionable in the setting of a fracture, the reduction of a dislocation, and the performance of an abdominal operation. Slowing of

[1] See Hewitt, "Brit. Med. Jour.," Feb. 18, 1899.

the heart is a danger sign. If nitrous oxid causes death, it does so by asphyxia or by asphyxia and cardiac inhibition. A person rouses very rapidly when the administration of nitrous oxid is suspended. It is a useful plan to give nitrous oxid first and follow this with ether (see page 1218). By this method the patient is anesthetized rapidly and pleasantly with the nitrous oxid, and the anesthesia is maintained by the ether.

It was formerly taught that nitrous oxid necessarily produces cyanosis, because the gas can only cause anesthesia by partially asphyxiating the patient. We know this is untrue, because if *nitrous oxid is mixed with oxygen* or atmospheric air anesthesia is obtained without cyanosis. Nitrous oxid is a genuine anesthetic agent. If

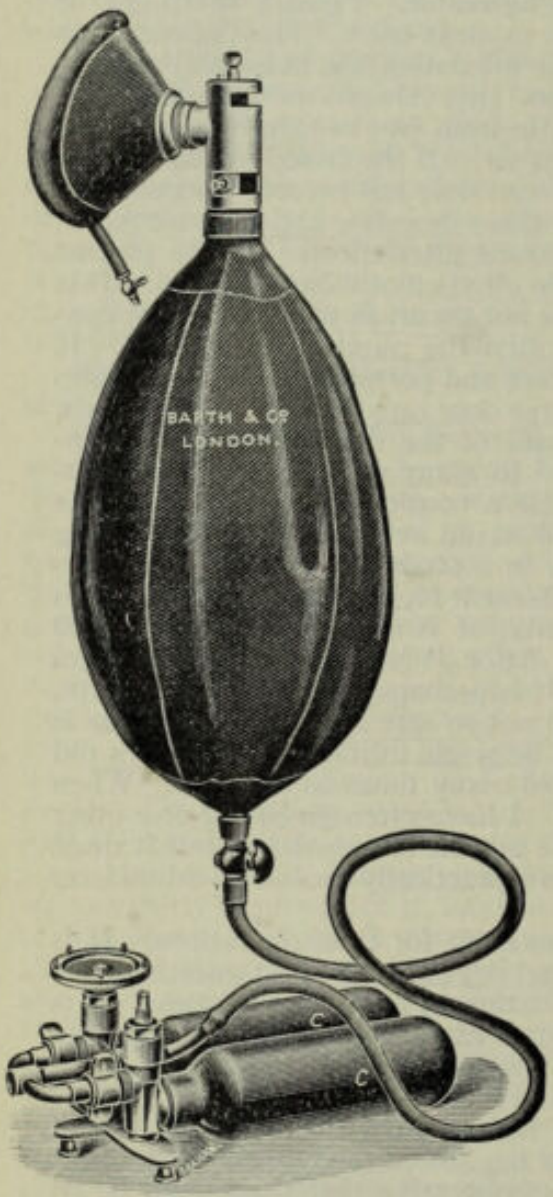


FIG. 993.—Hewitt's nitrous oxid apparatus.

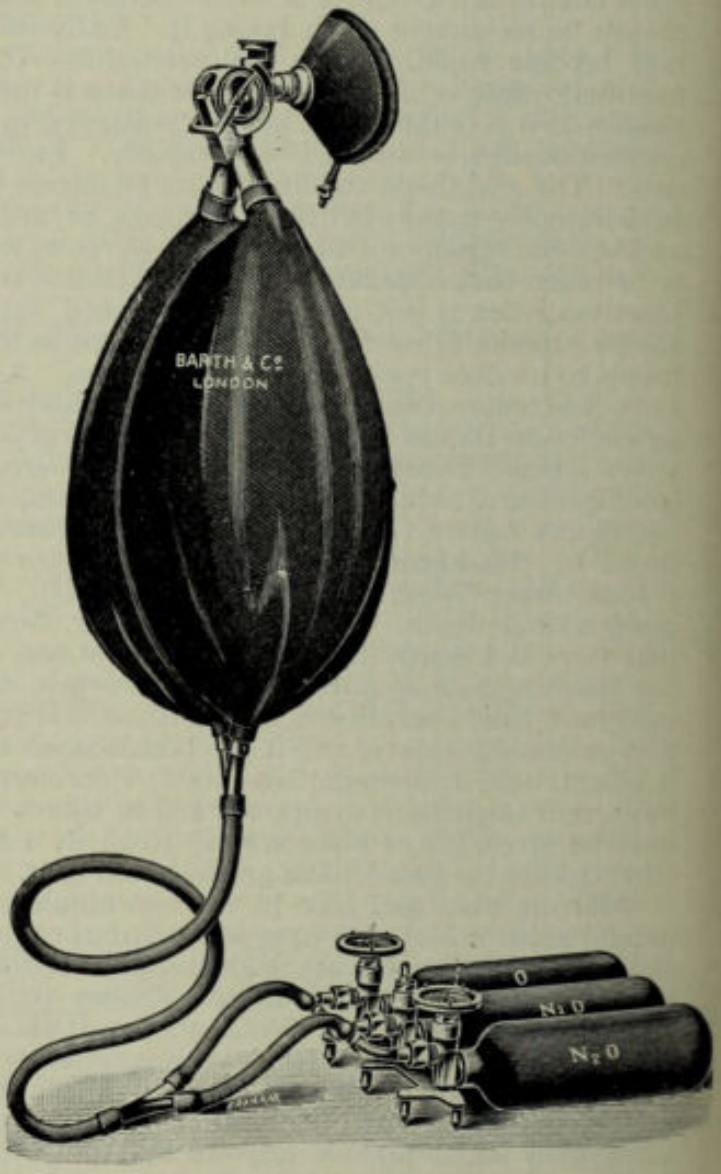


FIG. 994.—Hewitt's nitrous oxid and oxygen apparatus.

a prolonged administration of nitrous oxid is desired, pure nitrous oxid can be given, a breath of fresh air being allowed from time to time. By this method Preston has anesthetized many patients, the duration of the anesthesia being from ten to fifty minutes. A better plan is to give nitrous oxid and oxygen. I do not believe it is wise to give nitrous oxid even with oxygen over thirty minutes because of the destructive effect of the gas on hemoglobin. A trouble frequently encountered is persistent rigidity. This can often be prevented by a preliminary dose of morphin. Postanesthetic vomiting is rare (Teter on "Thirteen Thousand Administrations of Nitrous Oxid with Oxygen," "Jour. Amer. Med. Assoc.," Aug. 7, 1909). Hewitt[1] formulates the following views as to the use of oxygen and nitrous oxid:

[1] "Brit. Med. Jour.," Feb. 18, 1899.

"In order to obtain the best form of anesthesia oxygen should be administered with nitrous oxid by means of a regulating apparatus (Fig. 994), the percentage of the former gas being progressively increased from 2 to 3 per cent. at the commencement of the administration to 7, 8, 9, or 10 per cent., according to the circumstances of the case. The longer the administration lasts, the greater may be the percentage of oxygen admitted.

"The next best results to those obtainable by means of a regulating apparatus for nitrous oxid and oxygen are to be secured by administering certain constant mixtures of these two gases. Mixtures containing 5, 6, or 7 per cent. of oxygen are best for adult males, and mixtures containing 7, 8, or 9 per cent. are best for females and children. The next best results to those last mentioned are to be obtained by means of mixtures of nitrous oxid and air, from 14 to 18 per cent. of the latter being advisable in anesthetizing men and from 18 to 22 per cent. in anesthetizing women and children."

Crile uses nitrous oxid and oxygen as the anesthetic of choice for many operations, even major operations. He believes it produces less shock, less nausea, and less lowering of vital resistance to infection than does ether. He insists on the necessity of having a highly trained administrator and of keeping the patient *pink* during the administration. Respiratory failure is met at once by turning off the nitrous oxid and substituting pure oxygen. If relaxation is impossible (and it may be in a very muscular subject), ether is given until relaxation is attained and then a return is made to nitrous oxid ("Transactions of Southern Surg. and Gynec. Assoc.," 1909). Crile gives a small dose of morphin and scopolamin before operation to prevent too early postoperative appreciation of the "operative trauma."

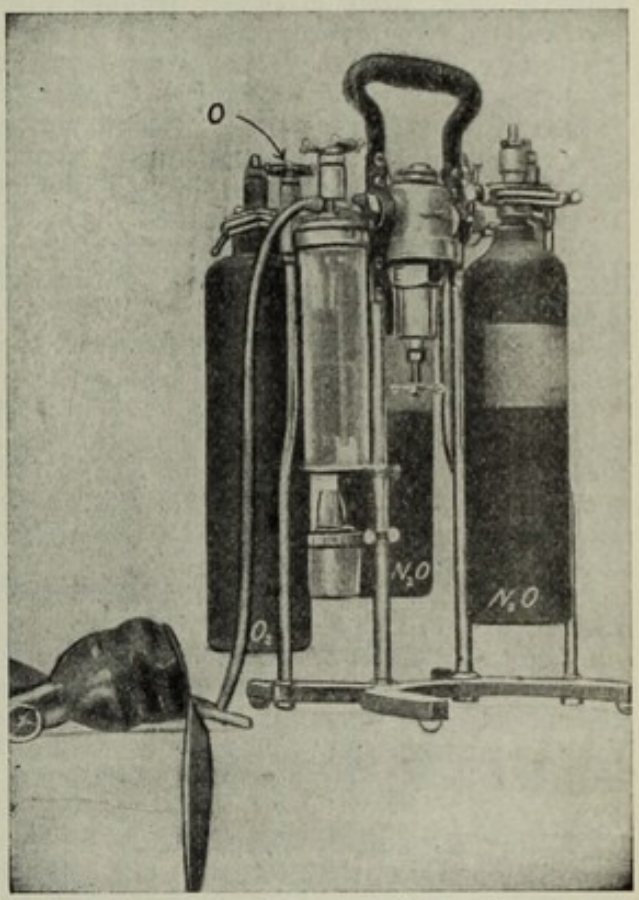


FIG. 995.—Gwathmey-Woolsey nitrous oxid oxygen apparatus with tanks in place: *O*, Regulating valve for oxygen; O_2, oxygen tank; N_2O, nitrous oxid tank.

The Gwathmey-Woolsey apparatus is a very useful one for nitrous oxid and oxygen administration (Fig. 995). When the operation is to be brief, when there is bronchial or pulmonary disorder, or when nephritis exists nitrous oxid with oxygen is the method of choice. I agree with Baldwin that it is not free from danger ("Med. Record," 1916, xc). A number of deaths have been reported. The method is expensive, requires a specially trained administrator, should not be adopted as a routine, and should not be used in operations requiring more than thirty minutes. Teter, of Cleveland, no longer depends on nitrous oxid and oxygen, but gives also a little warmed ether vapor. Ecker passes the nitrous oxid and oxygen over a 50 per cent. mixture of esthol and paraldehyd. Nitrous oxid is uncertain if rigidity must be abolished and varies in its effects on different individuals. Its greatest field of service is a preliminary to ether. The mortality has been estimated at 1 in 100,000. It is surely much greater than this. Many fatalities, especially those which occurred in dental offices, have not been reported. Baldwin collected 91 gas-oxygen deaths ("Practical Medicine Series," 1917, 1922; Ochsner's volume on "General Surgery"). When death occurs it is sudden. There are no warnings, hence the surgeon is helpless. The cause of death is unknown.

Bichlorid of Methylene.—The composition of the so-called bichlorid of methylene is a matter of dispute. Some high authorities believe it to be a mixture of methyl alcohol and chloroform. It rapidly produces unconsciousness and the patient returns quickly to consciousness when the administration is suspended. Some surgeons have

thought highly of it, and claimed that it is pleasant, safe, and is not followed by vomiting as often as chloroform. The weight of opinion is that it is dangerous, death being similar to death from chloroform. It is given by means of a Junker apparatus.

Ethylene (Olefiant Gas).—Ethylene and Oxygen.—Ethylene was used as an anesthetic (after mixture with chlorin) by Nunnely, of Leeds, in 1849. The use of the pure gas mixed with oxygen was suggested by A. B. Lockhardt (see Lockhardt and Lewis in "Jour. Amer. Med. Assoc.," Dec. 1, 1923). It has an unpleasant smell (of molasses and garlic) and a metallic taste. It comes in tanks containing a fluid (made so by great pressure). It is given mixed with oxygen and air is excluded. Herb uses 10 to 15 per cent. of oxygen. Death could be caused by suffocation were it given pure. It is claimed that it induces fairly rapid anesthesia, that the pulse remains reasonably slow, that the respiration remains normal, that there is seldom cyanosis, that there is no bronchial irritation, that it does not harm the kidney, and that it is less apt to cause shock than ether or chloroform. Anesthesia is induced with little excitement and struggling. It is praised as an anesthetic when there is kidney trouble, pulmonary disease, when the patient is *in extremis*, and in myocardial degeneration. Lundy uses it for infants ("Jour. Amer. Med. Assoc.," Feb. 9, 1924). It is supposed to cause less postoperative nausea and vomiting and less postoperative tympanites than ether. It is given by a nitrous oxid and oxygen apparatus. It causes vasomotor relaxation, and hence there may be more bleeding than usual during and after operation. For this reason it should not be used in operations on the gall-bladder and bile-ducts. It is violently explosive. In two of the explosions the cautery was being used. In both cases the windows were open. In 1 case the cautery was used in the axilla, in the other about the perineum. In 2 cases no cautery was used. A static spark came from the rubber tube. Lockhardt ("Jour. Amer. Med. Assoc.," May 17, 1924) says that a long-continued flow of ether and oxygen may develop static electricity and a jump spark may ignite the gas. He says the tubing should be metal and the tank should be grounded (Davis in "Jour. Amer. Med. Assoc.," May 17, 1924; Lockhardt and Carter, "Surg., Gynec., and Obstet.," May, 1924; Allgeyer in "New Orleans Med. Jour.," Feb., 1924; Horsley, "Virgin Med. Mo.," March, 1924). The anesthetic must not be used in any room with a sparking apparatus (cannot be used in an *x*-ray room). It is claimed that it is no more dangerous than ether and oxygen, but I know of no such bizarre accidents with the latter combination.

Anesthetic Successions.—Bromid of Ethyl Followed by Chloroform or Ether.—(See page 1214.)

Chlorid of Ethyl Followed by Ether.—(See page 1215.)

Chloroform Followed by Ether.—Chloroform is sometimes given until the sensation becomes more or less obtunded, when ether is substituted. This is done to save the patient from the unpleasant sensation of etherization. It is a practice not to be commended because it is precisely in the beginning that chloroformization is most dangerous.

Ether Followed by Chloroform.—When the patient cannot be relaxed or rendered unconscious by ether, or when some other complication develops, it is common practice to suspend ether and substitute chloroform. If the change is made, chloroform should be given cautiously. A large quantity should never be poured upon the inhaler at one time. The change should never be made when the patient is struggling because the deep respirations which attend or follow struggling may lead to the rapid inhalation of a dangerous dose of chloroform vapor. Further, as Hewitt points out, when the patient is deeply under the influence of ether the change should not be made unless it is imperatively necessary.

Nitrous Oxid Gas Followed by Ether (Gas and Ether).—This very valuable method was suggested by Clover. I have used it repeatedly, with great satisfaction. The patient is *made* unconscious by nitrous oxid and is *kept* unconscious by ether. Thus are avoided excitement, struggling, choking, and the very unpleasant sensations induced by ether. It lessens the amount of time requisite to obtain anesthesia and lessens the amount of ether used. More important even than this, the method is safe. It is more satisfactory in women and children than in men. In very muscular men and in very stout elderly men it should not be used. In many cases nitrous oxid causes a flow of mucus from the respiratory tract. Because of the frequency of this happening it is wise to precede gas and ether anesthesia twenty minutes by a hypodermic injection of morphin and atropin (Van Kaathoven in "Annals of Surgery," Sept., 1908), or of atropin alone. Many operators first anesthetize with nitrous

oxid, using an ordinary dental apparatus, and then give ether on an ordinary inhaler. The anesthetist must bear in mind that ether must be given gradually, not suddenly, and is never to be poured on the inhaler in large amount. Others prefer to use a combined gas-and-ether inhaler.

Hewitt ("Anesthetics and Their Administration") thus describes the administration by means of Clover's portable ether-inhaler fitted with a stop-cock and a detachable gas bag:

"If the patient be lying upon his back, his head should be turned to one side. The face-piece with the charged ether chamber is then applied during an expiration. Air will be breathed backward and forward. When the respiration is seen to be proceeding freely, and the face-piece fits well, the charged gas bag is attached to the ether chamber. Air will still be breathed, but not through the valves of the special stop-cock. When the valves are heard to be working properly 'gas' is turned on, and is likewise breathed through the valves. Three or four respirations (or about one-half of the contents of the bag) are allowed to escape. The valve action is now stopped by turning the tap at the upper part of the stop-cock. At the same moment at which the patient begins to breathe 'gas' backward and forward, the rotation of the ether chambers for the addition of ether vapor should be commenced. The administrator will, in fact, find that he can, in a few seconds from the commencement of the administration, rotate the ether chamber as far as '1' or '1½.' Should swallowing or coughing arise, he must rotate more slowly. Respiration soon becomes deep and regular, and more and more ether may be admitted. At about this juncture, if the apparatus has been fitting the face well, signs of nitrous oxid narcosis may appear, especially in those who are quickly affected by this gas. Should jerky breathing or 'jactitation' arise, one full inspiration of air may be admitted at the air-tap. It should be remembered, however, that in giving 'gas and ether' by this method, the object is just to steer clear of the clonus and 'stertor' of nitrous oxid narcosis and gradually but increasingly to mix ether with the gas.

"In muscular and vigorous subjects the quantity of gas above mentioned will be found to be, as a general rule, insufficient to lead to the usual signs of deep nitrous oxid anesthesia. The rotation of the ether chamber should be continued till the indicator points to '2,' '3,' or 'F.'

"The mistake that is most commonly made is that of admitting air too soon. Should air be given during the first half or three-quarters of a minute, the patient will partially come round, hold his breath, set his teeth, and give a good deal of trouble. Duskiness of the features must be expected. Speaking generally, air should not be allowed until the patient is stertorous, when one breath may be given. In this manner the patient will continue breathing a mixture of nitrous oxid, ether, and air till the usual signs of deep ether-anesthesia appear, when the gas bag may be detached, and the little bag ordinarily used with Clover's inhaler substituted."

Hewitt prefers to use a modified Clover inhaler, which permits of the introduction of ether after the inhalation of nitrous oxid has begun.

Morphin and Magnesium Sulphate Followed by Nitrous Oxid and Oxygen.—Gwathmey and Schwartz ("Med. Jour. and Record," Jan. 16, 1924) say that morphin and Epsom salts given by hypodermoclysis before the gas and oxygen secure prolonged anesthesia and less troublesome after-effects, but the effects of morphin are so much intensified by Epsom salts that poisoning may ensue. They now pursue the following plan: The night before the operation give an enema of soapsuds. At 7 A. M. the morning of the operation give another soapsuds enema. At 7.30 A. M. give by rectum 200 c.c. of a 4 per cent. solution of magnesium sulphate plus ℥iv of paraldehyd and then ⅛ gr. of morphin hypodermically. After twenty minutes give another dose of ⅛ gr. of morphin and after another twenty minutes another dose of ⅛ gr. (⅜ gr. of morphin in aggregate). By 8.30 A. M. the patient will be drowsy, a few inhalations of nitrous oxid and oxygen are given, the operation is begun and inhalations of the mixture are suspended. From time to time a few inhalations of gas and oxygen may be required. If viscera are to be dragged upon it may be necessary to add a little ether vapor to the gas and oxygen (James T. Gwathmey and Geo. Schwartz in "Med. Jour. and Record," Jan. 16, 1924). One rather wonders if Epsom salt can be absorbed from the rectum, and if so, how it is accomplished. Clinically there seems to be no doubt as to the value of the method.

Hypnotic Anesthesia.—It is well known that Esdaile in India did numbers of operations upon patients in hypnotic anesthesia. Cloquet, as long ago as 1829, amputated a breast of a woman who was held free from pain by hypnosis. In 1851 Guérineau

amputated the thigh of a hypnotized person and there was no sign of pain. But all subjects are not susceptible. Even susceptible subjects require to be hypnotized again and again for days before the operation. The method has its own dangers and has been entirely abandoned.

Scopolamin-morphin Anesthesia.—This method has been enthusiastically praised and I have used it with satisfaction in a number of cases, but I have grown somewhat afraid of it. In a patient in the Jefferson Hospital very dangerous symptoms arose after a dose of 1/100 gr. of scopolamin. Ely records a death from respiratory failure two hours after the administration of $\frac{1}{8}$ gr. of morphin and 1/100 gr. of scopolamin ("New York Med. Jour.," Oct. 20, 1906). A number of deaths have been reported following its use and there are, beyond doubt, unreported cases. Four deaths in 2400 cases were certainly directly due to it (H. J. Whitacre in "New York Med. Jour.," March 31, 1906). It has even been stated that the death-rate is 1 in 100 ("Semaine Medicale," Jan. 11, 1905). Scopolamin is chemically identical with hyoscin and must never be used unless fresh, as it decomposes in air and light. If given without morphin it is inefficient. Large doses are certainly dangerous, and the combination should never be given in sufficient amount to induce surgical anesthesia unaided. If used at all, it should only be as an aid to local anesthesia or to general anesthesia by ether or chloroform. I have used it as an aid to local anesthesia in 8 goiter operations, in 3 cases of removal of the Gasserian ganglion, and in several prostatectomies. It should not be used in heart disease (Hayem); in persons under sixteen or over sixty (Korff); in any one with a tendency to pulmonary edema or with any acute condition of the throat which interferes with respiration (A. C. Wood in "American Medicine," Nov. 11, 1905).

It produces a drowsy, heavy state or actual sleep, and the patient can be kept unconscious with an extremely small quantity of ether or chloroform. For five or six hours after the operation the sleep continues, and in most cases there is no postoperative vomiting.

If it be used, a mixture is freshly made containing 1/100 gr. of scopolamin and $\frac{1}{6}$ gr. of morphin, and this is given hypodermically one-half an hour before the operation. During the operation the sleep may be maintained by small amounts of ether or chloroform. If symptoms of poisoning occur, artificial respiration and oxygen inhalations may be required, external heat is needed, and nitroglycerin, strychnin, or caffein should be given.

I agree with Kochmann that we are not as yet justified in recommending this method of anesthesia ("Münchener medizinische Wochenschrift," 1905, No. 17). The Tubingen Clinic abandoned it after thorough trial.

Anesthesia in Obstetrics.—Light ether anesthesia is used by some, light chloroform anesthesia by others. If it is night and there is gas lamp or candle light be sure, if ether is used, that there is sufficient ventilation to prevent an explosion, and, if chloroform is used, to prevent the decomposition of chloroform vapor by naked flame into highly irritant gases. Scopolamin-morphin anesthesia was introduced by Steinbüchel in 1903. In 1906 it came to be called the Freiburg method of Gauss. It has since been widely and most improperly advertised as "twilight sleep." I leave the discussion of its merits or demerits to the obstetricians. In 1880 Klikowisch began to use nitrous oxid and oxygen in obstetrics. Webster took it up in 1905. He gives the gas during the pains and withdraws it between the pains. The administration is begun in the second stage of labor when the pains become severe. It is said to increase rather than to arrest expulsive contraction, the consciousness is retained and the child is not injured.

Local Anesthesia.—(In the revision of this article I had the valuable assistance of Dr. Charles F. Nassau, the chief surgeon of the Frankford Hospital and Associate Professor of Surgery in Jefferson Medical College.) In every case requiring operation we should inquire whether local anesthesia should be used instead of general anesthesia. Many really extensive operations can be done under the former, and its field has been greatly broadened by the knowledge that viscera innervated by purely visceral nerves are insensitive and sensation exists only in those which receive branches from the somatic nerves (K. G. Lennander in "Mittheilungen aus dem Grenzgebeiten der Medicin und Chirurgie," 1902, Bd. x, Heft. 1 and 2). Lennander claims that the parietal peritoneum is sensitive to pain, but not to touch—that the intestine, stomach, edge of the liver, mesentery, gall-bladder, urinary bladder, kidney parenchyma, lung, anterior wall of the trachea, testicle, and epididymis are insensitive, though the coverings of the testicle and epididymis are sensitive. We now know that

visceral peritoneum is more or less sensitive. My experience is that the viscera may usually be cut, sutured, and handled without any severe pain if they are not pulled upon. In removing an appendix the only pain felt will be when the meso-appendix is pulled upon or adhesions to the parietal peritoneum are separated. The advantages of operation under local anesthesia are freedom from the danger of anesthetic accidents, blood changes, and postanesthetic discomforts and dangers. The disadvantage is the knowledge of the patient as to what is taking place. He may become alarmed and turbulent, and may thus interfere with a necessary procedure at a vital moment. There are many methods of local anesthesia.

Freezing.—*Ice* and *salt* may be used. Take $\frac{1}{4}$ pound of ice, wrap it in a towel, and break it into fine bits; add $\frac{1}{8}$ pound of salt; then place the mixture in a gauze bag and lay it upon the part. The surface becomes pallid and numb, and, in about fifteen minutes, decidedly analgesic. A *spray of rhigolene* freezes a part in about ten seconds. It is highly inflammable. *Ether-spray* anesthesia was suggested by Benjamin Ward Richardson. *Chlorid of ethyl* comes in glass or metal tubes (Fig. 996). Remove the cap from the tip of the tube and hold the bulb in the palm: the warmth of the hand causes the fluid to spray out. Hold the tube some little distance from the part, and let the fine spray strike the surface. The skin blanches and whitens, and is ready for the operation in about thirty seconds. Freezing is only of value in a trivial operation and when only a single cut or stick is required.

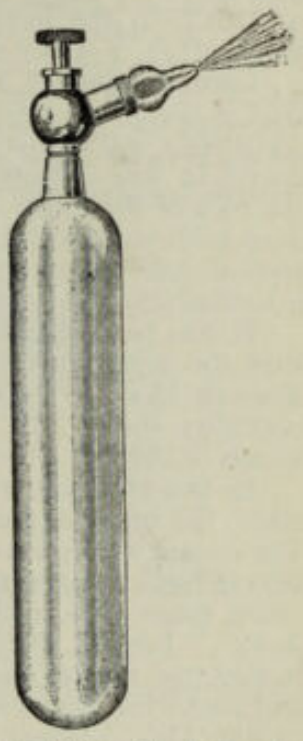


FIG. 996.—Gebauer's ethyl-chlorid tube.

Hypodermic Injection of Cocain Hydrochlorate.—Cocain was discovered by Gaedeke in 1855. In 1884 Köller, of Vienna, demonstrated the value of cocain as an analgesic in ophthalmic practice. In 1885 J. Leonard Corning, of New York, showed that cocain when applied to a mixed nerve in man abolished nerve conduction, as it was already known to do in the lower animals. In 1885 Halsted and Raymond induced anesthesia in the nerve distribution by injecting cocain about the inferior dental and lingual nerves (perineural injection). This was done before pulling a tooth. Schleich introduced infiltration anesthesia. Braun, Van Hook, and Matas did much to develop local anesthesia. A tremendous impetus was given to infiltration anesthesia by Harvey Cushing's report on herniotomy under local anesthesia ("Annals of Surgery," 1900, vol. xxxi). He used a very weak solution of cocain (1 : 1000). Cocain hydrochlorate is soluble in water, but should not be boiled. To boil it impairs its anesthetic power. A tablet of the drug should be sterilized by dry heat and dissolved in sterile water. Always bear in mind that cocain is sometimes a decidedly dangerous agent. There are a number of deaths from cocain on record. The urethra is a particularly dangerous region, and so is the face. It is undesirable to use more than $\frac{2}{3}$ gr. upon a mucous surface, and to inject hypodermically more than $\frac{1}{3}$ gr. The drug must not be injected into a vein. Moderately severe cases of cocain-poisoning are characterized by great tremor, restlessness, pallor, dry mouth, talkativeness, and weak pulse. In dangerous cases there is syncope or delirium. Death may arise from paralysis or from fixation of the respiratory muscles. Cases with a tendency to respiratory failure require the hypodermic injection of strychnin. In cases with tetanic rigidity of muscles hypodermic injections of nitroglycerin or inhalations of the nitrite of amyl should be given. In cases marked by delirium, if the circulation is good, hyoscin is given. In any case stimulants are given, a catheter is used, and diuresis encouraged. Cocain-poisoning is always followed by a wakeful night. Cocain should not be used in any considerable amount if the kidneys are inefficient. In using cocain try to prevent poisoning. Because of the dangers inherent in cocain, have the patient recumbent. One minute before giving the cocain administer hypodermically 1 drop of a 1 per cent. solution of nitroglycerin and repeat the dose once during the operation. In operating on a finger, after making the part anemic, tie a tube around the root of the digit before injecting cocain, and after the operation gradually loosen the tube. A hot solution of cocain is more efficient than a cold solution, hence hot solutions can be used in much less strength and are safer than cold solutions. The method of injection is as follows: A sharp needle is held

at an angle of 45 degrees to the surface and is pushed into the Malpighian layer of the skin (Fig. 997). One or 2 min. of a 2 per cent. solution are forced into the Malpighian layer, and a whitened elevation forms. The needle is withdrawn, at the margin of the wheal is reinserted, and more fluid is introduced, and so on until the region to be operated upon has been injected. After waiting five minutes the operation is begun. If, after cutting the skin, it is necessary to cut the subcutaneous tissue, inject a few drops of a 1 per cent. solution into the tissue. After the completion of the operation, if a rubber band has been used, it is loosened for a few seconds, tightened for a few minutes, again loosened and readjusted, and so on several times (Wyeth). In this way only a small quantity of cocain is admitted into the circulation at one time and toxic symptoms are prevented. For operations upon the eye a 1 to 4 per cent. solution is employed; 1 drop of fluid is instilled every ten minutes until 3 drops have been given. Rarely use over a 10 per cent. solution on mucous membrane, although in laryngeal operations a 20 per cent. solution may be required. For the nasal mucous membrane a bit of wool soaked in a 5 per cent. solution is inserted or a spray of 4 per cent. solution is thrown from an atomizer into the nostrils. In the rectum, vulva, vagina, and uterus use a 5 per cent. solution; in the urethra, a 4 per cent. solution, and in the bladder, a 2 per cent. solution.

Cocainization of a Nerve-trunk.—Krogius, Halsted, and Raymond pointed out that if cocain be injected into the tissue about a nerve-trunk (perineural injection), anesthesia will follow in the area supplied by the nerve. The anesthesia will be produced in five minutes, and will last fifteen minutes. If cocain be injected about the root of the finger, all of the tissues of the digit will become insensitive. Injection over both supra-orbital notches renders the middle of the forehead insensitive. Injection over the ulnar nerve causes complete anesthesia in its trajectory. This plan is extensively used in Helsingfors.

It has been demonstrated by Crile ("Jour. Amer. Med. Assoc.," Feb. 22, 1902) that the injection of cocain into a nerve-trunk (endoneural injection) interposes an absolute block to the transmission of afferent and efferent impulses and greatly lessens operative shock. In 3 cases I employed this method to secure anesthesia for amputation of the leg. None of the patients felt pain and shock was trivial.

In two amputations of the entire upper extremity, although the patient was under ether, the brachial plexus was cocainized to minimize shock and shock was very slight. The cocain was injected directly into the trunks (endoneural injection). The combination of local anesthesia and general anesthesia is part of Crile's *anoci-association operation* (page 194), a plan to rule out all noxious or noci influences ("Jour. Amer. Med. Assoc.," July 13, 1912). He points out that though a person under ether is without feeling, the greater part of the brain is still awake, nerve impulses still reach the brain and cause functional depression and morphologic alterations in the brain cells (Crile's "Ether Day Address," 1910). He would prepare a patient by filling him with calm confidence, giving him morphin and scopolamin previous to operation, administering nitrous oxid, and isolating the brain from the field of operation by infiltrating the region with 1 : 400 solution of novocain. At the conclusion of the operation the region may be injected with the hydrochlorid of quinin and urea.

Eucain hydrochlorate (β-eucain) is not entirely non-toxic, but is far safer than cocain used in full doses, and in many cases is to be preferred to it. It is injected in the strength of from 2 to 5 per cent. It is soluble in water and can be boiled without destroying its properties, and hence can be readily rendered sterile. It occasionally, though rarely, happens that the injection of eucain causes sloughing, especially at the extremities, in fatty tissue, in tendon-sheaths, and in bursæ. It can be used on mucous membranes.

Stovain.—This agent is a local anesthetic introduced by Fourneau. It is as powerfully analgesic as cocain, is only one-third as toxic, and is slightly germicidal. It is dissolved in col' vater or salt solution, and is used in a solution of the strength of 0.5 per cent. Adrenalin can be given with it. (See Sonnenburg in "Deutsche medizinische Wochenschrift," March, 1905.)

Quinin-urea hydrochlorid in from $\frac{1}{4}$ to 1 per cent. solution causes prolonged local anesthesia. A solution of 1 per cent. is too strong—it causes the wound to heal slowly and produces induration. The drug has no toxic effect and can be used in considerable quantity; it lessens bleeding, and, by producing an effect for many hours, lessens postoperative pain. Quinin-urea hydrochlorid is used by infiltration (see below). It is dissolved in water or normal salt solution.

Novocain.—It is given by infiltration. The drug is soluble in water and the

solution can be boiled without being impaired in anesthetic power. It is one-sixth as toxic as cocain. I have used 8 ounces of a ½ of 1 per cent. solution in an operation for umbilical hernia, without toxic symptoms. It is preferred by practically all surgeons for use in infiltration anesthesia. Except in toxic goiters and patients with very high blood-pressure, it is the custom to add a little adrenalin to the solution. In an area containing terminal vessels adrenalin is not used. For example, in the finger adrenalin might cause gangrene. The strength of the solution is ½ of 1 per cent. If adrenalin is to be employed add 6 to 8 drops of a 1 : 1000 solution of adrenalin to each ounce of the solution of novocain.

Infiltration anesthesia is in most instances the preferred method of local anesthesia. It is a term used to indicate a form of local anesthesia in which the tissues are not only injected, but are distended decidedly with a fluid anesthetic indifferent in nature. It is called *terminal anesthesia* because the anesthetic acts upon the terminal branches of sensory nerves. It is called *regional anesthesia* because the fluid injected affects a particular part of a sensory nerve in its course. Infiltration anesthesia was devised by Schleich, of Leipsic, who was dissatisfied with cocain, because it is not safe and sometimes fails to produce complete local anesthesia, owing to want of thorough diffusion. He found that salt solution (0.2 per cent.), if injected into uninflamed parts, produced anesthesia. To obtain this anesthesia the part must be distended by wide infiltration. If minute quantities of cocain, morphin, and carbolic acid are added to the solution, the anesthesia becomes more thorough and more prolonged, and can be obtained even in inflamed areas. Schleich used three solutions, viz., strong, medium and weak. These refinements are no longer of importance, as

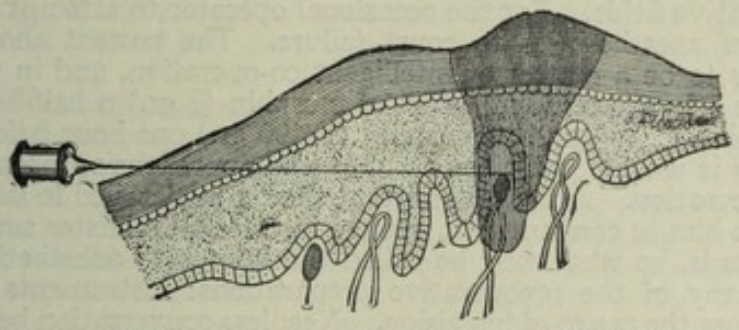


FIG. 997.—The syringe point stops at the papillary layer, and the fluid lodges in the skin itself (Van Hook).

novocain has replaced all other drugs for infiltration. The strength of the solution should be ½ of 1 per cent.

The addition of adrenalin chlorid to the novocain solution is an advantage, as it retards the circulation and hence favors analgesia and lessens bleeding during the operation.

Use a very fine needle for the first injection. Injections are begun *in* the skin, not *under* it (Fig. 997). The skin should be pinched at the point of injection to prevent pain. Injections are made one after another until the area to be operated upon is surrounded above, below, and on all sides with the fluid. At each infiltrated area a wheal forms in the skin. After infiltration of the skin with the novocain and adrenalin solution incision can be made at once; when deeper tissues are reached they are infiltrated before incising them. If a nerve comes in sight, inject it with a drop of the anesthetic solution. Van Hook says that the anesthesia obtained by this method is due to artificial ischemia, pressure upon the tissues, the direct action of the drugs, and the lowered temperature.[1] The method is very efficient, and can be used for operations of considerable magnitude. Matas uses a special apparatus to infiltrate the tissues. The fluid is driven by compressed air, and wide-spread or *massive infiltration* is produced.

An ideal fluid to be injected should be isotonic with the blood, and should contain the smallest percentage of chemical agent necessary to render the part anesthetic. As Karl G. Lennander ("Local and Subarachnoid (Spinal) Anesthesia," in "Keen's Surgery," vol. v, page 1045) has pointed out, "Cocain has a greater affinity for the sensory than for the motor nerves. The effect of cocain in a certain proper concentration upon peripheral mixed nerves is to abolish, first, the sense of tickling, then

[1] "Med. News," Nov. 16, 1895.

the sense of temperature, thereafter the sense of pain, and, lastly, the sense of touch (pressure), and only thereafter the motor faculty, which may remain unaffected, although all the modalities of sensation have been paralyzed. During the retrogression of poisoning the faculty of motion is the first to return, then the sense of pressure, next the sense of pain, and lastly the sense of temperature." The same things may be said of novocain. The addition of the adrenalin to the solution is an advantage, in that it retards the circulation by contracting non-striped muscle-fibers in arteries and capillaries. The drug is thus localized, its anesthetic action prolonged, and bleeding diminished during the operation. I do not believe that adrenalin in any way modifies the toxic action of a local anesthetic; indeed, Berry ("Amer. Jour. Med. Sci.," Nov., 1905) seems to prove that it actually increases it. Too great a strength of adrenalin may cause sloughing. Adrenalin is contraindicated in toxic goiter, in patients with high blood-pressure, and in operations upon regions containing terminal vessels. It may cause gangrene in a finger or toe.

The field of operative achievement under infiltration anesthesia has broadened to such an extent that it is difficult definitely to limit its possibilities when it is in the hands of one skilled in its use. It is necessary for the surgeon operating by this method to use an essentially different technic from that commonly employed in operations under a general anesthetic. He should be calm, equable, content to wait, and patient in spite of delay. He must be skilled in clean operative dissections, and accustomed to refrain from handling tissues unnecessarily. Failure is certain if the operator is not constantly engaged in this kind of work. He must have learned, above all things, gentleness and willingness to spend plenty of time, and must have acquainted himself accurately with the sensibilities of the various tissues encountered in different operative fields. For the occasional operator to attempt major operations under infiltration anesthesia is to court failure. The patient should be informed that operation is to be a matter of intelligent co-operation, and in major operations it is wise to give a hypodermic injection of morphin ($\frac{1}{4}$ gr.) a half-hour before beginning, or of morphin ($\frac{1}{4}$ gr.) and scopolamin (1/100 gr.) one hour before beginning the operation. This is usually sufficient to allay the apprehension natural in one about to undergo an operation. A tactful assistant should be detailed to sit by the patient's head and engage him in conversation, sponge his face, administer small sips of water, and, in other words, be what may be called the "psychic" anesthetist. The patient should not see any of the preoperative preparations; instruments should be carefully excluded from the range of his vision. Needless conversation between assistants, nurses and spectators, and other noise should be avoided.

The special instruments required are: Two good syringes of 10 and 20 c.c. capacity respectively. They may be either Record or Gentile. There are also types of syringes which fill themselves from a reservoir when the pistons are withdrawn. At the present time I prefer the Gentile syringe with the bayonet connection between syringe and needle, as recommended by Labat; one very fine short needle for the first injection; following the first infiltration wheal, much longer needles are more convenient. These can be bought in lengths varying from 5 to 12 cm. The other instruments are those used in any operative procedure. For example, let us take an appendectomy in a patient with a frank tuberculosis of the lung; a case in which general narcosis would cause damage and might prove fatal. The patient, having been prepared for operation (care having been taken to administer morphin a half-hour previously), is placed upon the operating table and made as comfortable as possible. The head is arranged upon a pillow, the arms are disposed comfortably at the sides, and a folded blanket is placed under the lumbar spine. The patient's wishes may be consulted as to whether he desires a piece of gauze placed over his eyes or not. Usually the patient, unless addressed, keeps his eyes closed. The "psychic" anesthetist engages the patient in conversation, the surgeon must show full confidence, be cheerful, though never painfully humorous, and should endeavor to communicate a confident frame of mind to his subject.

Under infiltration anesthesia the easiest method of approach to the appendix is McBurney's muscle-splitting incision. Fill the 10 c.c. syringe with $\frac{1}{2}$ per cent. novocain solution to which has been added 6 to 8 drops of adrenalin to the ounce. Use the short and finest needle. Pinch up a small piece of skin, informing the patient that he will feel only a fine needle-prick. Holding the needle almost parallel with the skin, barely insert the point under the epidermis, at the same time pressing on the piston of the syringe so as to obtain an infiltrated spot simultaneously with the introduction of the needle. The pain caused is trivial, and during the remainder of the infiltration

he will feel only a slight burning sensation if care has been taken to avoid puncturing unanesthetized skin. A small wheal is produced, and the integument assumes a blanched pig-skin appearance. From the center of this infiltrated circle the needle may now be inserted painlessly to its full length *in* the skin (not *under* the skin) and parallel with the surface. Do not insert the needle too deeply at this time. As the point of the needle travels, the solution should be fed from the syringe. After the superficial infiltration a coarser and longer needle should be used to infiltrate subcutaneous tissues. The incision may now be carried to the aponeurosis of the external oblique. Infiltrate the muscular and aponeurotic portions. Split the aponeurosis with a knife and continue the dissection with Mayo's scissors. Gentle clips with the scissors cause no more pain than knife dissection. Retract the aponeurotic layer; infiltrate the internal oblique and split it. Following this infiltrate the transversalis and peritoneum. These layers are then incised. Incision of all layers of the abdominal wall must be of ample size in order to avoid unduly strong retraction. Up to this stage the patient should experience no pain unless a vein has been thoughtlessly clamped without previous infiltration. The visceral peritoneum may be cut, clamped, burned, and stitched with impunity, but undue traction upon the mesentery immediately causes general cramp-like abdominal pain and consequent rigidity of the abdominal wall. The appendix is sought for by gently following the anterior longitudinal band on the cecum, rather than by attempting to pull the cecum out of the abdominal incision. Once the base of the appendix is found, the rest is easy. The meso-appendix should be infiltrated before tying and traction on it must be gentle. Crushing, ligation, and inversion of the base of the appendix are painless. Occasionally traction on the mesocolon will cause nausea which is relieved as soon as traction ceases. Suture of the abdominal wall now follows without special incident; in patients with over ½ inch of fat small rubber tissue drains should be inserted just under the skin.

By the use of infiltration anesthesia I have operated with satisfaction in the following cases: Tracheotomy, tuberculous glands of the neck, rib resection, goiter, trephining and drainage of a cerebral cyst, ligation of the thyroid arteries, gastrostomy, cranial decompression, trephining the skull for fracture, inguinal colostomy, typhoid perforation, abscess of the lung, chronic and acute appendicitis, gangrenous appendicitis, appendicitis in the interval, appendical abscess, jejunostomy, radical cure of inguinal, femoral, and umbilical hernia, strangulated hernia, incisional hernia, resection of the bowel, hysteropexy, hysterectomy, ovariotomy, suprapubic cystostomy, extirpation of the external carotid artery (Dawbarn's operation), ligation of the femoral artery, cholecystostomy, cholecystectomy, suture of fractured patella, amputation through the arm, amputation through the thigh, amputation of the leg, removal of stone from the pelvis of the kidney, gastro-enterostomy, kidney abscess, psoas abscess, varicocele, hydrocele, circumcision, and large numbers of minor conditions.

Patients after abdominal section under infiltration anesthesia very rarely vomit at all, never have as much postoperative pain as those who have been under a general anesthetic, and seldom have backache. Distention of the bowel is uncommon. The catheter is rarely required, and, of course, the blood changes, renal difficulties, and postoperative pneumonias are much less frequent than after general narcosis. Infiltration anesthesia cannot be ignored in such cases as diabetes, Addison's disease, sepsis, advanced Basedow's disease, diseases of the cardiac muscle, liver, both kidneys, etc. In children and high-strung individuals infiltration anesthesia is usually out of the question; in operations for extensive malignant growths, or on cases in which complete muscular relaxation must be obtained, this form of anesthesia is absolutely contraindicated.

To those interested in infiltration anesthesia I would suggest a careful study of Spalteholz's admirable illustrations of nerves (especially those of the extremities[1]), together with the perusal of the following writings:

H. Braun: "Die Lokalanästhesie, ihre wissenschaftlichen Grundlagen und praktische Anwendung," Leipzig, 1907. (A very full bibliography accompanies this excellent work.) Translated by Percy Shields. Lea & Febiger, 1914.

Harvey Cushing: "Observations Upon the Neural Anatomy of the Inguinal Region Relative to the Performance of Herniotomy Under Local Anesthesia," in "Annals of Surgery," 1900, vol. xxxi.

[1] "Hand Atlas of Human Anatomy," by Werner Spalteholz. Edited and translated by Lewellys F. Barker.

Theodor Kocher: "Text-book of Operative Surgery," third English edition, by Harold J. Stiles and C. Balfour Paul, vol. i, page 16.
Karl G. Lennander: "Local and Subarachnoid (Spinal) Anesthesia," in "Keen's Surgery," vol. v, page 1045.
James F. Mitchell: "The Production of Local Anesthesia for Surgical Purposes," in "American Practice of Surgery," by Bryant and Buck, vol. iv, page 231.
Carroll W. Allen: "Local and Regional Anesthesia." W. B. Saunders Co., 1918.
Arthur Schlesinger: "Local Anesthesia." Translated by F. S. Arnold. Rebman & Co.
Arthur E. Hertzler: "Surgical Operations with Local Anesthesia." Surgery Pub. Co., N. Y.
George Hirschell: "Text-book of Local Anesthesia." Translated by R. E. S. Krohn, Wm. Wood & Co.
Gaston Labat: "Regional Anesthesia." W. B. Saunders Co., 1922.
R. E. Farr: "Practical Local Anesthesia." Lea & Febiger, 1923.
Arthur E. Smith: "Block Anesthesia and Allied Subjects." C. V. Mosby & Co., 1920.

Bier's Intravenous Method of Local Anesthesia.—This plan was described by Bier at the German Surgical Congress of 1908.[1] It permits of serious operations upon the limbs, operations for which ordinary methods of local anesthesia would prove quite inefficient. Suppose the surgeon intends to resect an elbow-joint: Mark the position of the veins on the asepticized extremity. Apply an Esmarch bandage from the tips of the fingers to well above the elbow-joint. This is the expulsion bandage. A thin soft-rubber band is applied around the arm above the Esmarch bandage, the bandage is removed, and a rubber band is applied below the elbow. The anesthetic is injected into a superficial vein of this bloodless area (the basilic or cephalic). The tissues above and about the vein are infiltrated. The vein is exposed, the syringe of the cannula is introduced, and ligatures are used as though we were going to give an ordinary intravenous injection of salt solution, except that the cannula is pointed to the periphery. The fluid used is a 0.25 or 0.5 per cent. solution of novocain. The syringe, containing 50 c.c. of fluid, forces the solution downward into the veins and the limb swells.

If the stronger solution is used, 50 c.c. are enough; if the weaker solution is used, 100 c.c. will be required. If resecting the knee, the injection should be made into the internal saphenous vein using twice the amount advised for the elbow.

After injecting the strong solution operation may be begun at once. After injecting the weak solution we should wait ten minutes. The bloodless area between the bands becomes anesthetic very promptly after the injection—the bones as well as the soft parts. The peripheral portion of the limb beyond the area between the bands becomes anesthetic after a short time and motor paralysis may follow. Such paralysis is eventually recovered from. If anesthesia between the bands is not attained within five minutes there has been some failure in technic (Bier, "Edinburgh Med. Jour.," 1910, v, No. 2). The analgesia is entirely satisfactory and passes away as soon as the band is removed. When the operation has been completed, wash out the vein with salt solution in order to prevent toxic effects.

By this method the anesthetic passes through the vein walls and becomes fixed in the tissues, and when the bands are removed it returns very gradually to the circulation, hence we may give greatly larger doses than admissible by any other method. Adrenalin should not be given with the novocain. Toxic symptoms are rare. The method is contraindicated in arteriosclerosis. (See Carroll Smith in "Jour. Amer. Med. Assoc.," March 23, 1912; Page and McDonald in "Lancet," Oct. 16, 1909; Hitzrot in "Annals of Surgery," 1909, vol. i.) The method is not always satisfactory. In some cases ether must be given. Too tight bandaging is a discomfort and a danger.

Ransohoff's Intra-arterial Method.—Ransohoff ("Lancet Clinic," Aug. 7, 1900) applied an elastic bandage below the insertion of the deltoid, exposed the brachial artery under local anesthesia, and injected into the vessel a 2 per cent. solution of cocain (15 minims). In two minutes he was able to amputate without any pain.

Anesthesia by Infiltration with Sterile Water.—When the tissues are well infiltrated with warm or cold sterile water, anesthesia ensues promptly. I have not found it as complete as when novocain has been employed, even when a considerable amount of fluid is introduced. Gant uses it in rectal operations and commends it strongly ("New York and Phila. Med. Jour.," Jan. 28, 1904).

Spinal Analgesia.—J. Leonard Corning in 1885 discovered that cocain injected

[1] Bier: "Ueber einen neuen Weg Lokalanästhesia au den Gliedmazssen zu erzeugen," "Arch. f. klin. Chir.," 1908, lxxxvi, No. 4.

between the spines of the eleventh and twelfth dorsal vertebræ produced analgesia of the lower limbs ("New York Med. Jour.," Oct. 31, 1885). From this observation spinal anesthesia springs. Bier produced complete anesthesia of the entire body except the head by the injection of a small amount of cocain into the subarachnoid space of the spinal cord. A solution of cocain of a strength of from 0.5 to 1 per cent. is used by some, but cocain cannot be boiled without impairment of its anesthetic power, and carbolic acid must be added to it in small amount. Hence cocain so prepared is not certainly sterile, and the carbolic acid added may induce harmful symptoms. (See Neugebauer in "Wien. klin. Woch.," 1901, Nos. 50–52). Some surgeons use a solution of eucain which can be boiled, but it is not so rapid and certain as cocain. Some use tropacocain (Illwicz). A solution of this drug can be boiled, is less poisonous than cocain, and somewhat slower in action. Experimenters tell us that ½ to 1½ gr. of cocain may be given, but it is not wise to give over 0.5 gr. I have used stovain in a number of cases. Some combine it with adrenalin, but the combination is not desirable in the subarachnoid space. The dose is 1 c.c. of a 5 per cent. solution. The analgesia lasts from one-half an hour to an hour or more, and was followed in my cases by retention of urine. Some have used novocain alone or combined with adrenalin. Some use apothesine.

A. W. Morton ("Jour. Amer. Med. Assoc.," Nov. 8, 1902) takes chemically pure crystalline hydrochlorate of cocain, places it for fifteen minutes in a dry temperature of 300° F., and puts it in sterile tubes until wanted. The dose depends upon the locality in which he wishes to induce analgesia, and varies between 0.3 and 0.5 gr. The required dose is placed in the barrel of the sterile syringe and is dissolved in cerebrospinal fluid drawn into the syringe for that purpose. I now follow the plan of Mr. Arthur E. Barker. He believes that the specific gravity of the fluid containing the drug plays an important part in its localization within the canal ("Brit. Med. Jour.," March 16, 1912). He uses a fluid as nearly as possible isotonic with the blood. It consists by weight of 5 parts of stovain, 5 parts of glucose, and 90 parts of distilled water. Adrenalin is never added. It may do harm, it can do no good. This fluid seeks the lowest level it can find and mixes but little with the cerebrospinal fluid. The average dose is 1 c.c. of the 5 per cent. solution.

The syringe used is of glass and of a capacity of 2 c.c. The needle is the hollow one of Bier. The needle must be sharp, else it will not go through the dura. Barker's fine blunt cannula goes through the lumen of the needle.

The fluid to be injected is kept in sealed Jena glass ampules, and should not be more than a week or two old. The fluid is drawn into the syringe from the ampule. The patient lies upon his side with the head and shoulders well raised and with the back curved. The back has been previously sterilized. The dressings are removed and the region to be punctured is resterilized. The spines of the third and fourth lumbar vertebræ are located, and the needle is entered in the midline beneath the spine of the third or fourth lumbar vertebra and is pointed upward and forward. The surgeon determines that he has punctured the subarachnoid space by lessened resistance and the appearance of fluid at the needle opening. The injection is made slowly, the needle is withdrawn, and the puncture sealed by collodion. In performing the operation care must be taken to prevent the escape of the cerebrospinal fluid.

If the patient remains upon the side the nerve-roots of the dependent side are rendered analgesic some time before those of the uppermost side. If he be turned for a time upon the other side the nerve-roots of that side will quickly become anesthetized. To turn him upon the back will do the same thing, but less rapidly. If he is placed in a sitting position the rectum and anus are quickly rendered anesthetic.

The usual position for operation is that with the patient on his back, but he may perhaps be upon his side. When the patient is placed upon his back promptly after injection the anal region becomes anesthetic in from one to two minutes, the lower extremities in from three to six minutes, and the upper extremities in from fifteen to thirty minutes. The anesthetic condition lasts from one to three hours or even longer, and is due to the contact of the anesthetic with the nerve-roots (A. W. Morton, "Jour. Amer. Med. Assoc.," Nov. 8, 1902).

Some regard as a most satisfactory drug apothesine. It comes in ampules (1 gm. to 2 c.c. of distilled water). Rytina and Tolson ("Annals of Surgery," Feb., 1924) believe that the best preparation to use contains 1 gm. of apothesine, 1 gm. of lactose, and 2 c.c. of distilled water. As this solution is heavier than cerebrospinal fluid, when the patient's head is kept elevated the fluid tends to settle below. Many operators prefer to dissolve the drug selected in the spinal fluid. The theca is tapped and 25 c.c. of

spinal fluid are allowed to flow into an ampule containing novocain or apothesine. Rytina and Tolson (Ibid.) say: "After removing the stilet, 2 to 3 c.c. of spinal fluid is allowed to run into the ampule containing apothesine. The drug rapidly dissolves and the solution is aspirated into the syringe. Ten to 25 c.c. of spinal fluid is allowed to escape into a tube. The quantity of fluid removed is determined by the pressure and the extent of analgesia desired. The syringe is then adjusted to the spinal puncture needle and enough spinal fluid aspirated into the syringe to make 5 c.c. is then slowly injected without force and about 1 c.c. withdrawn. This maneuver is repeated until the entire quantity of solution has been introduced. After removing the needle, the patient is immediately placed in the prone position with head and shoulders elevated. With this method after fifteen minutes he may with safety be placed in the horizontal or even the Trendelenburg position.

"In using the solution of the drug in water or salt solution the technic differs from the above in that only 2 to 3 c.c. of spinal fluid is removed.

"The blood-pressure and pulse-rate is noted before the injection and every five minutes after the injection. It has been our custom to administer 5 minims of 1 : 1000 adrenalin solution together with strychnin, 1/30 gr., subcutaneously immediately after the subarachnoid injection. This is given with the idea of forestalling the fall in blood-pressure and slowing of the heart. If the blood-pressure falls to a marked degree, 10 to 15 minims of adrenalin solution is given intramuscularly. Should a marked slowing of the pulse occur, caffein-sodium-benzoate, 4 gr., is given intramuscularly. Strychnin is also a valuable stimulant in these cases. Elderly patients or patients with impaired myocardium often require stimulation. Sterile normal salt solution and apparatus for its administration intravenously should always be in readiness for fear of circulatory failure."

After cocainization of the spinal cord surgical operations can be performed on many regions without causing pain. Among the operations which have been performed are resection of the knee, resection of the ankle, osteotomy, amputation of the leg, amputation of the thigh, hysterectomy, perforation of gastric ulcer, intestinal obstruction, strangulated hernia, excision of bowel, acute appendicitis, gastro-enterostomy, oöphorectomy, removal of ovarian cysts, prostatectomy, and removal of the rectum.

Spinal analgesia is not growing in popularity. It is regarded by most surgeons as a method to be used in exceptional cases. It should never be used as a routine procedure, and it will not displace ether or chloroform. I see no occasion in the ninth edition of this book to alter the view which I put forth in the eighth edition. By the method analgesia can usually be secured. A. W. Morton (Ibid.) used it 673 times without a failure, and 60 of these operations were above the diaphragm. If we desire to obtain analgesia of the upper portion of the body the patient must be placed in the Trendelenburg position after the fluid has been injected. Most operators have had failures, especially above the diaphragm. In Sonnenburg's 1117 cases there were 78 utter failures. Bier says that failures occur in 4 per cent. of cases; Moynihan says in 14 per cent.; Legueu says in one-seventh of the cases. In Barker's last 100 cases there were 3 failures. No one should attempt it who is not well trained in aseptic methods, because infection of the cord or its membranes will prove fatal. Untoward effects are common, and they may arise during or after the operation.

Sonnenburg had them in 193 out of 1117 cases. Among the untoward effects reported are grave collapse, temporary paralysis of the abducens nerve, of the facial nerve, of the hypoglossal nerve, meningitis, retention of urine, chills, elevation of temperature, incontinence of urine, persistent paraplegia, pain in the back and legs, perhaps lasting for weeks or even for months, nausea and vomiting during and after the operation, sweating, overaction of the heart, dimness of vision, cramps in the limbs, dyspnea, violent headache, involuntary evacuation of feces, and cardiac overaction. Many of the immediate symptoms are probably due to the absorption of the drug injected. The headache is due to tension and is relieved when some cerebrospinal fluid is withdrawn by lumbar puncture. In 20 per cent. of Barker's cases there was more or less transient headache. In 16.3 per cent. there were nausea and vomiting.

Headache, vertigo, weakness, paresthesia, neuralgia may, in a few cases, persist for months or even years.

Whether or not permanent harm ever comes to the cord is not certain. Bristow ("Brooklyn Med. Jour.," 1902, xvi, page 410) reported the case of a man, fifty-five years of age, on whom he operated for hemorrhoids after spinal cocainization. An examination one month later indicated degeneration of the posterior and lateral

columns of the cord (spastic lower extremities, ataxic gait, increased knee-jerk, ankle-clonus, and inability to retain urine). Marx ("New York Med. Record," Dec. 22, 1900) states that 1 case in his experience, after cocainization of the spinal cord, developed typical locomotor ataxis. Dandois ("Jour. de Chir. Brux.," April–May, 1901) reports a case upon which he had operated for traumatic rupture of the urethra. Spinal cocainization was employed. Paraplegia developed and lasted two months. Several cases of hemorrhage into the subarachnoid space are on record. Legueu states that persistent paraplegia and persistent incontinence of urine may arise ("Rev. de Chir.," Oct., 1908). Spielmeyer studied the cords of 13 persons who died from spinal anesthesia. In all he found degeneration of the multipolar ganglion cells of the anterior horns.

Is there any danger of death from spinal analgesia? If the operation be not performed with scrupulous aseptic care it is very dangerous. Even when performed by the best surgeons death may occur. Tuffier placed the mortality as 3 in 2000, but excluded from consideration 3 deaths ("La Presse Médicale," vol. lv, 1901, page 190). Reclus found 6 deaths in less than 2000 cases (Address before the Paris Academie de Médicine, March 19, 1901). Hahn, in 1708 cases collected from literature, found 8 deaths ("Mitt. a. d. Grenzgeb. d. Med. u. Chir.," 1900, iii, 337). The mortality is usually supposed to be about 3 in every 1000 cases. Wm. N. Perkins ("New Orleans Med. Jour.," Jan.–Sept., 1902) collected 2345 cases, with 16 deaths or 1 death in 146 administrations. Strauss's table shows 46 deaths in 22,717 cases (quoted by Hardonin in "Archiv Générale de Chir.," Aug., 1908). In Barker's 2354 cases there were only 3 deaths "which could be in any way put down to the spinal method of anesthesia" ("Brit. Med. Jour.," March 16, 1912). Hohmeier and König ("Archiv für klin. Chir.," Oct. 8, 1910) collected 2400 cases of spinal anesthesia: 12 deaths were due to it directly; 4 of them died of paralysis of respiration; 7 of the fatal cases were over seventy years of age. One victim was only thirty-two. Some recent statistics are of the same tenor.

Cocain seems to act like a toxin on the pia and arachnoid. Examination of fluid withdrawn after cocainization shows that it contains polymorphic leukocytes (Ravant and Aubourg in "Gaz. Hebd. de Méd. et de Chir.," June 27, 1901). Some surgeons have had far better results than the above figures indicate. Babcock studied 15,000 cases ("Penn. Med. Jour.," Feb., 1923). He says, if applied to selected cases the mortality is less than 1 to 10,000. It is most dangerous if used for operations above the diaphragm. If used for such operations it should be directed by one specially trained. Pennington collected records of 17,593 from the clinics of 10 operators. There were 24 deaths (Ochsner's Surgical Volume in "Practical Medicine Series," 1923).

My belief is strong that the method should only be used for operations below the diaphragm, and I hold this belief in spite of the claim of Jonnesco that he operates with the aid of spinal anesthesia on any part of the body. It is most successful in operations below the umbilicus. I very seldom use it for operations above that level.

In a case in which, because of heart disease, pulmonary disease, kidney disease, or some other condition, a general anesthetic is inadmissible, spinal cocainization is justifiable. It should be reserved exclusively for cases in which other forms of anesthesia are positively contraindicated. The method should not be employed on those under fifteen years of age or on the subjects of central nervous disease. Barker disapproves of spinal anesthesia in "cases of extreme asthenia due to carcinoma, and of advanced toxemia depending upon septic peritonitis or obstruction, especially in later life," although some surgeons regard such conditions as particularly demanding spinal in preference to general anesthesia.

Myocardial degeneration, uncompensated valvular heart disease, pleural effusion, pericardial effusion, blood-pressure below 100, recent untreated syphilis are contraindications (Rytina and Tolson in "Annals of Surgery," Feb., 1924).

A solution of Epsom salts has been used by Blake, Haubold, and Willy Meyer. It was discovered (Meltzer and Auer, "Amer. Med.," Nov. 25, 1905) that subcutaneous injections of salts of magnesium produce local anesthesia. The same investigators later pointed out ("Med. Record," Dec. 16, 1905) that subarachnoid spinal injections of Epsom salts produce wide-spread and complete anesthesia. A 25 per cent. solution is used and 1 c.c. of this is given for every 25 pounds of body weight. After three or four hours the drug causes paralysis and analgesia of the legs and pelvic region. Sensation and motion do not return for from eight to fourteen hours. Retention of urine may last two days. The pulse and blood-pressure are unaffected, but the respiration is slowed. Large doses would endanger life by respiratory arrest. In view of the fact that in some cases the effect of the drug is inordinately prolonged, it is wise,

when the operation is completed, to puncture the theca of the cord again and wash it out with salt solution. Guthrie and Ryan ("Amer. Jour. of Phys.," Aug. 1, 1910) deny that magnesium salts have specific anesthetic properties and claim that anesthesia following an injection is due chiefly to asphyxia.

Caudal Anesthesia.—This is a form of spinal anesthesia in which the anesthetic is introduced through the sacral hiatus. A caudal block with anterior field block of the abdominal wall is very valuable, for instance, in prostatectomy. For the performance of operations around the terminal portion of the rectum, such as hemorrhoids, internal and external, fistulæ, etc., caudal anesthesia is the ideal procedure.

Caudal block is performed by introducing the anesthetic solution through the sacral hiatus so that the anesthetizing fluid bathes the terminal fibers of the spinal cord at a point below the subarachnoid space. In this way it differs from spinal anesthesia, and in this difference lies its complete safety. With the patient lying upon his face, the tip of the coccyx is determined by the finger, and then sliding the finger upward the sacral hiatus almost always can be felt. The needle, free from the syringe, is then introduced. The passage of the needle through the sacrococcygeal membrane is readily felt. The needle should be introduced into the canal about 5 or 6 cm. If the point of the needle strikes the edge of the bony canal, the point can be slightly withdrawn and the butt of the needle can be raised or depressed as needs be to facilitate its further introduction. The stilet of the needle is then withdrawn and careful observation is made to determine that neither blood nor cerebrospinal fluid comes out.

Failure to obtain caudal anesthesia is due frequently to the injection of an insufficient quantity of the anesthetic solution. From 60 to 90 c.c. of a 1 per cent. solution of novocain produces the most dependable anesthesia. It may be from ten to twenty minutes before relaxation of the sphincter is apparent. In the performance of a prostectomy, however, no time is lost in waiting for anesthesia, because the field block of the abdominal wall, filling of the bladder, etc., occupies a certain amount of time, at the end of which anesthesia of the perineum, base of the bladder, etc., is usually complete. In cystoscopic examinations of the bladder this method of anesthesia is without a peer.

Paravertebral and **parasacral anesthesia** was devised by Sellheim, of Freiburg, in 1905. He injected with cocain the intercostal nerves just after their emergence from the vertebral column, and the ilio-inguinal and iliohypogastric nerves on a level with the anterior superior spine of the ilium.

Braun injected the sacral nerves just as they emerge from the sacral foramina.

Novocain is much safer than cocain. Paravertebral anesthesia is successful in chest work and laparotomies, and parasacral anesthesia on vaginal and perineal operations. In certain pelvic operations both are used. (It is fully described by Kroenig and Siegel in "Surgery, Gynec., and Obstet.," May, 1916.)

Blocking of the nerves by transsacral, presacral, and sacral or caudal injections are but variations of the blocking of the nerves in other portions of the body, requiring, however, special study in order to reach the nerves in their various locations. (For the technic of blocking the spinal nerves see "Regional Anesthesia," 1922, Labat, and Warbasse's "Surgical Treatment.") While all of these procedures can be carried out successfully in a large proportion of patients upon whom it may be attempted, providing that the proper selection of patients is made for the method, yet, as a whole, unless there are very special reasons why a patient cannot take a general anesthetic, it is questionable whether these nerve blocks are to be preferred to some form of general anesthesia. Parasacral block, which is really a form of paravertebral anesthesia or transsacral block, is useful in operations in the pelvis when associated with field block of the abdominal wall. It is preferable to presacral block in that the injection can be made with practically no danger of damage to any structures, and it can be accomplished in a perfectly aseptic manner, which is something that cannot be said of the presacral block. The technical difficulties, however, of the accurate injection of the sacral foramina are so great that in a majority of instances the surgeon, unless he has particularly trained himself in the touch and visualization of the sacral landmarks, will be unable to accomplish it.

Blocking of Splanchnic Nerves for Operations in the Upper Abdomen.—Lennander said viscera are insensitive to pain. All admit that traction causes pain. Kappis showed in 1912 that the visceral peritoneum has some pain perception. Neumann, Kappis, and Hoffmann showed that "section of the splanchnic nerves abolishes pain in the stomach, intestines, and bile-ducts" (Gaston Labat in "Annals of Surgery," Aug., 1924). These observations led Kappis, in 1913, to produce regional anesthesia

in "abdominal operations by injecting the splanchnic nerves as they enter the semilunar ganglia" (Labat, Ibid.). The abdominal wall is anesthetized by massive infiltration.

Braun opens the abdomen and makes the splanchinc injection from in front. Kappis introduces his needle at the lower border of the twelfth rib posteriorly. The technic will be found in Labat's article (Ibid.). The method is of very definite value and is particularly suitable to bad risks. (See Labat, "Annals of Surgery," Aug., 1924; Kappis, "Grenzgeb. d. Medizin u. Chir.," 1913, Bd. xxvi; Kappis, "Beitr. z. klin. Chir.," 1919, cxv; Buhre in "Deutsche med. Wochen.," Berlin, Jan., 1920.)

XXIX. DISEASES OF THE SKIN AND NAILS

Dermatitis venenata is a dermatitis resulting from chemical irritants. It may be caused by wearing garments containing arsenic. A common cause is rhus-poisoning. Rhus-poisoning arises from the poison-oak (White, Editorial in "Jour. Amer. Med. Assoc.," Aug. 5, 1906), the poison-ash, the poison-ivy, or some other species of sumac. Actual touching of the plants is usually, but not always, necessary. Some suffer if they simply come near them, as the irritant can be carried by the wind. The irritant may be conveyed by tools, materials, or insects. The smoke of burning poison plants conveys the irritant. Some people are immune to rhus-poisoning, some are slightly susceptible, some are more strongly predisposed. It is believed by some that toxicodendric acid is the irritant agent. The poison is not bacterial, is not gaseous, is not volatile, and is contained in the resinous sap which exudes from an injured plant (McNair, quoted in editorial of "Jour. Amer. Med. Assoc.," Oct. 4, 1916). The condition is most apt to arise when the skin is moist from perspiration. Dermatitis may arise from handling objects coated with oriental lacquer work, the varnish of which contains an extract of rhus. Dermatitis venenata is liable to become fashionable, as cases have been reported due to the lacquer on the boxes of mah jongg sets (cases by Oscar L. Levin and Edwin P. Zeisler in "Jour. Amer. Med. Assoc.," Feb. 9, 1924).

The **symptoms** are burning, itching, redness, and edema of the affected parts. Vesicles or even blebs may form. The hands and forearms are most apt to suffer, but any part may be attacked. The palms seldom suffer. If the penis and scrotum suffer from rhus-poisoning there is great swelling from edema. The fluid of a vesicle cannot inaugurate inflammation on sound skin. Usually a vesicular eruption begins between the fingers. The eruption becomes violently inflammatory, and in the form of a fierce red edematous inflammation spreads widely over the body. There may be fever. The condition usually begins to abate in from three to six days and desquamation follows.

When one, knowing from experience that he is predisposed, feels the inaugural itching, he should at once apply to the parts a 1 per cent. solution of lactic acid in 95 per cent. alcohol (R. F. Ward in "New York Med. Jour.," Dec. 26, 1908).

The **treatment,** when a moderate area is involved, comprises the application of cloths wet with a wash of lead-water and laudanum, or a saturated solution of acetate of aluminum (R. F. Ward, Ibid.). If an extensive area be involved, apply grindelia rubusta (4 dr. to 1 pint of water) or moisten the surface frequently with sweet spirits of niter. Oxid of zinc ointment, containing 10 gr. of carbolic acid to 1 oz., gives great relief.

Sun Dermatitis.—After some hours of exposure the skin becomes red, swollen, shiny and glossy, and the seat of itching and burning pain. Conjunctivitis is not unusual. In very severe cases the patient is extremely irritable, there is fever, and a child may develop delirium and convulsions. In a few days the active stage passes away and the skin desquamates. The condition is not due to the heat of the sun, but is the result of the action of chemical rays. That it is not due to the heat of the sun is shown by the fact that the arc light, which is cold at a distance, can produce it. It is much more common and severe in blondes than in brunettes ("Heliotherapy," by Rollier).

Furuncle (Boil).—(See page 66.)

Oriental Sore.—(See page 67.)

Erysipelas.—(See page 131.)

Erysipeloid.—(See page 131.)

Clavus, or Corn.—A corn is a tender, painful, and circumscribed thickening of the epidermis, and is commonest over one of the joints of the toes. *Hard* corns are

situated on exposed parts of the digits; *soft* corns appear between the digits, where the parts are kept constantly moist. Corns are caused by pressure.

Treatment.—The wearing of well-fitting boots will usually cause a corn upon the toe to disappear. Soak the feet often in water containing bicarbonate of sodium, dry them, and apply a circular corn-plaster to the corn to take off the pressure of the boot. Another method is to touch the corn with iodin every night and pare away the hard tissue every morning. An old and valuable plan is to paint the corn every night and morning with a mixture composed of salicylic acid, 40 gr.; extract of cannabis indica, 10 gr.; and collodion and flexible collodion, of each 2 dr. After several days of the treatment soak the parts in hot water and scrape away the mass. *Soft* corns are treated by washing the feet often with ethereal soap, drying, gently removing the sodden epithelium, dusting the toes and between them with borated talc, and placing absorbent cotton between the digits. Incurable soft corns require the removal of the skin from the adjacent sides of the two toes and suturing the toes together (thus converting two toes into one). For inflamed corns employ rest and lead-water and laudanum, and let out pus when it forms. Remember that in old persons the cutting of a corn may cause senile gangrene, and in a diabetic, diabetic gangrene. In the inflamed and painful feet of a person who has corns nothing gives so much relief as washing the feet with ethereal soap, soaking in hot water, and wrapping the feet for half an hour in cloths wet with a mixture composed of linseed oil and lime-water, each 2 oz., and spirits of camphor, 1 dr.

Warts.—(See page 324.)

Onychia is inflammation of the matrix of the nail. Syphilis often causes severe onychia which requires specific treatment (see page 272). A *runaround*, or paronychia, is suppuration of the matrix at the root of the nail, and of the skin about it, of traumatic origin. It requires incision, trimming away of the buried edge of the nail, and packing with iodoform gauze. Syphilitic paronychia is not unusual (see page 272).

Malignant onychia, which is inflammation and ulceration of the entire matrix, occurs only in a person of dilapidated constitution. This condition requires removal of the entire nail, cauterization of the matrix, dressing with iodoform gauze, and the internal use of stimulants, tonics, and nourishing diet.

Ingrowing toe-nail (see page 85) is sometimes due to lateral hypertrophy of the edge of the nail, but usually to forcing of the soft tissues over the margin of the nail. An irritable ulcer arises. The condition is treated by splitting the nail, removing the ingrown piece, the soft tissue at the margin and the adjacent matrix, and dressing antiseptically.

XXX. DISEASES AND INJURIES OF THE THYROID GLAND[1]

The thyroid gland is an essential organ. It possesses functions of the first importance. It has a great influence upon nutrition. It acts by means of its secretion, which is an iodothyroglobulin.

An excess of this secretion if unneutralized in the body causes hyperthyroidism (see page 1238). A diminution of this secretion causes hypothyroidism (page 1233). If there be a very small thyroid or a functionally inactive thyroid from birth, the child is a cretin (page 1233). A great deal of the gland can be removed without harm. Charles H. Mayo estimates that one-sixth of the gland can furnish enough secretion for the body needs ("Illinois Med. Jour.," Feb., 1913). The older a person is, the less thyroid is apparently needed or, perhaps, the less the activity of the thyroid, the older a person actually is. "According to Lorand, the deferring of old age requires the continued presence of some of the thyroid throughout life" (Charles H. Mayo, Ibid.). The thyroid of a woman is apt to enlarge at puberty and to become swollen from congestion before a period of menstruation. During pregnancy or at the menopause the thyroid may enlarge and at these periods women are apt to exhibit symptoms of hypo- or hyperthyroidism. Ovid speaks of enlargement of the neck during the early months of pregnancy. Charles H. Mayo (Ibid.) points out that increased secretion does not, of necessity, cause symptoms. A considerable excess may be neutralized in the body. In such a condition of neutralization a shock may at once induce symptoms of hyperthyroidism. Entire loss of the thyroid in an adult causes myxedema. Kocher pointed out that its complete removal in a young or middle-aged person usually causes *operative myxedema* (*cachexia strumipriva*) and perhaps *tetany.*

[1] A very valuable recent work is that of André Crotti on "Thyroid and Thymus."

Removal of the gland in an elderly person does not as often cause these conditions. Later knowledge indicates that removal of the thyroid with the parathyroids certainly produces myxedema or tetany unless aberrant thyroids exist and compensate. Removal of the thyroid without the parathyroids does not induce tetany, even when there are no aberrant thyroids. Besides colloid the thyroid perhaps furnishes an internal secretion which destroys certain toxic products of metabolism. It is thought that the parathyroids furnish an antitoxin to poisons formed during digestion.

Wounds cause violent hemorrhage which is difficult to arrest. Ligatures may cut out and forceps will not hold. The hemorrhage is arrested by suture-ligatures, purse-string sutures, the actual cautery, or removal of the bulk of the gland.

The thyroid gland may be absent at birth. **Congenital atrophy** or **congenital hypertrophy** may exist.

Acquired atrophy leads to *hypothyroidism* and *myxedema*. Hypothyroidism may arise during any process destructive of the cellular activity of the thyroid gland. It is seen not unusually in women of from twenty-five to forty who have borne children. It sometimes occurs in men. The patient usually grows fat, is sterile, and neurasthenic. The temperature is subnormal. Complaint is made of headache, backache, shortness of breath, and indigestion. In women amenorrhea is the rule. In severe cases there is myxedema. (See Robert L. Pitfield in "New York Med. Jour.," Aug. 27, 1910.) *Myxedema* is a condition characterized by the presence of a firm subcutaneous swelling in the face, neck, and limbs; slow speech; mental dulness, and subnormal temperature. The condition is identical with that produced by removal of the entire gland.

Cretinism was described by Paracelsus early in the sixteenth century. It is a result of hypothyroidism. It is a form of infantilism and idiocy due to absence of the gland or atrophy of glandular elements in the thyroid. When atrophy of the parenchyma alone exists the size of the gland may be actually increased. The body is dwarfed; bone development is very defective, the face, neck, and extremities resemble those parts in myxedema, and a low grade of idiocy exists. Myxedema and cretinism are treated by the internal administration of thyroid extract.

Thyroid Feeding and Grafting.—Hypothyroidism, with or without myxedema, is greatly benefited by thyroid feeding or the administration of thyroid extract. Some experimenters have transplanted thyroids into thyroidectomized animals. The results show striking but temporary improvement. Such transplanted material eventually disappears. Experiments have been made and are being made on thyroid grafting in the treatment of cretinism and myxedema. Grafts have been placed under the skin, in bone at the junction of the epiphysis with the diaphysis, in the spleen, and in other regions. Encouraging cases have been reported, but the results are temporary.

Congestion of the thyroid may be caused by violent exertion, prolonged effort, febrile maladies, and venous obstruction. It is treated by removing the cause and applying heat locally. Tracheotomy may be required.

Inflammation of the thyroid (*acute* or *inflammatory goiter*) may be induced by a septic or febrile malady, rheumatism, tonsillitis, muscular strain causing vascular rupture, a wound, or contusion of the thyroid. Cases due to typhoid bacilli have been reported. Usually but one lobe is affected. The ordinary symptoms of inflammation are present. In addition, there are dysphagia, dyspnea, venous congestion of the face, epistaxis, nausea and vomiting, and possibly delirium. It may terminate in resolution, suppuration, or fibrous induration.

Tuberculosis of the thyroid is usually a part of general miliary tuberculosis. It is very seldom that a local caseating focus occurs, but such cases have been reported.

Syphilis of the Thyroid.—Early in the secondary stage there is apt to be slight and painless thyroid enlargement. In the tertiary stage gummata may form.

Tumors of the thyroid are of various sorts. Among them are adenomata, cystic adenomata, sarcomata, and carcinomata. Eight cases of teratoma are on record (Isabella C. Herb, "Amer. Jour. Med. Sci.," June, 1906). Malignant disease is unusual. I have operated on but 2 cases: 1 of cystic carcinoma in which operation was rapidly fatal (Fig. 999), and 1 of round-celled sarcoma. The latter patient was living and apparently well four years after lobectomy (Fig. 998). Malignant disease may arise in the normal, but is more apt to arise in a goitrous thyroid. Carcinoma usually arises from an embryonal adenoma (Lewis B. Wilson in "Annals of Surgery," August, 1921. Also in "Collected Papers of the Mayo Clinic"). In over 50 per cent. of the reported cases there is a history of antecedent goiter. Malignant disease is

more common in women than in men and is very seldom met with before the age of thirty. It is most common between forty and sixty. One should always suspect malignant disease of the thyroid gland when the growth appears rather suddenly in a patient over forty years of age. If the growth is rapid, is irregular in outline, and is accompanied by pain and difficulty in swallowing the diagnosis becomes reasonably certain. Later in the case there are symptoms due to pressure upon and infiltration of the recurrent laryngeal and other nerves; the growth becomes firmly anchored and the lymph-glands adjacent to the thyroid become involved; there may be tracheal bleeding, and perhaps fever, and eventually cachexia develops. Sarcoma or carcinoma may occur and it is seldom possible to determine clinically with which we are dealing. The cancer may be a scirrhus or an epithelioma, but is usually an adenocarcinoma. A sarcoma may be either of the round-cell or spindle-cell type. In malignant disease of the thyroid metastasis occurs early in a great majority of cases, the lungs being first involved, and then the bones and other structures; though it has been stated that in adenocarcinoma the lungs are likely to escape and that solitary bone metastasis is not infrequently noted. Sarcoma (Fig. 998) may involve one lobe, but carcinoma (Fig. 999), even at an early stage, is apt to involve both lobes (Berry, "Diseases of the Thyroid Gland"). These growths soon penetrate the gland capsule, become anchored to surrounding parts, and involve the nerves, trachea, and even the great vessels of the neck. Malignant growths if not cystic are apt to be hard and nodular and they grow rapidly. At first the gland moves with deglutition, but later becomes anchored to surrounding parts. In malignant disease of the thyroid it is usual to find difficulty in swallowing and paralysis of the vocal cord on the side of the growth. Malignant disease is rapidly fatal. Many die within six months and few survive over eighteen months. Radical operation is proper only before the growth breaks through the capsule, although at any stage it may be necessary to operate in order to prevent suffocation.

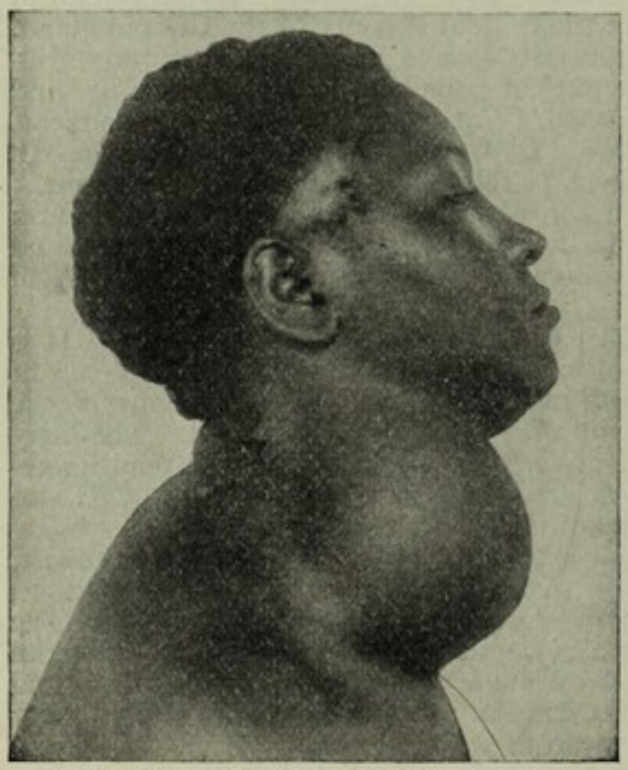


FIG. 998.—Sarcoma of thyroid gland.

A **goiter**[1] is an enlargement of the thyroid gland not due to a malignant tumor or to inflammation. Hippocrates makes no mention of goiter. Juvenal and Pliny refer to it. Juvenal speaks of its being common among Alpine mountaineers and Pliny states that certain wells seem to disseminate the disease. The enlargement may affect a small portion of the gland, one lobe, both lobes, or both lobes and the isthmus, and it may occur either sporadically or endemically. It is far more common in women than in men. It is very common in adolescent girls. It may exist in children. Adenomata may even be congenital.

There are a number of forms of ordinary goiter. Edema, formerly called hypertrophy, is not uncommon. It occurs particularly in girls near puberty. The gland is edematous and the colloid watery. In women it may occur during pregnancy or menstruation. It is small, symmetric, does not cause pressure symptoms, and usually disappears spontaneously, but may develop into parenchymatous goiter. Enlargement is in answer to a physiologic demand. The most common goiter is called *simple, colloidal,* or *parenchymatous* goiter (Fig. 1000). In this condition all portions of the gland enlarge, and the goiter is consequently bilateral. It does not appear first in one lobe and at a considerably later period in the other, but each lobe is enlarged equally or nearly equally.

The common goiter of adolescence is "an edematous condition of the gland due to watery colloid" (C. H. Mayo, "Illinois Med. Jour.," Feb., 1913).

[1] For a study of the "Pathological Anatomy of Goiter" see W. C. MacCarty in "New York State Jour. of Med.," Oct., 1912. This study is founded on 2500 cases from the Mayo Clinic.

Adenomatous goiter (Fig. 1001) is a condition due to the growth of encapsuled adenomata in the thyroid gland. There may be a single adenoma, but frequently there are multiple growths. One or both lobes may be involved. The goiter, however, usually seems to begin in one lobe; and if both lobes enlarge, one generally does so at a period distinctly subsequent to the enlargement of the other. In some cases

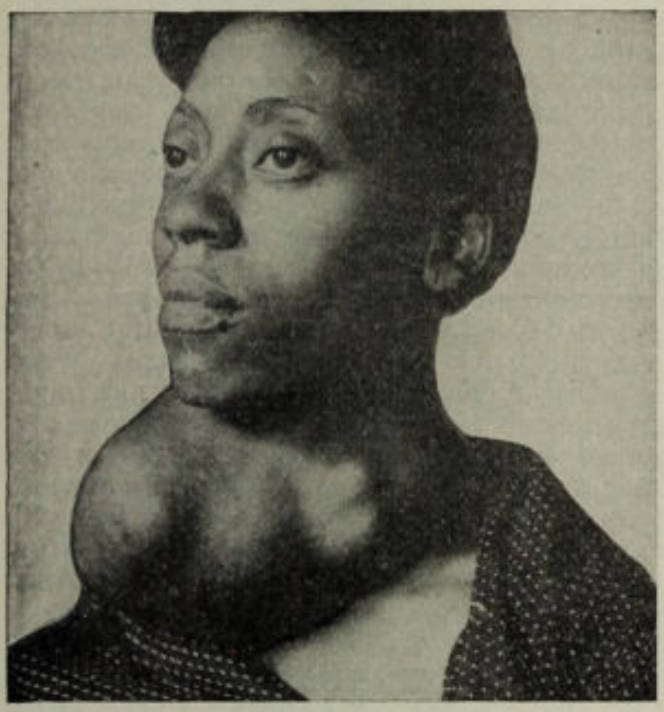


FIG. 999.—Cystic carcinoma of thyroid gland.

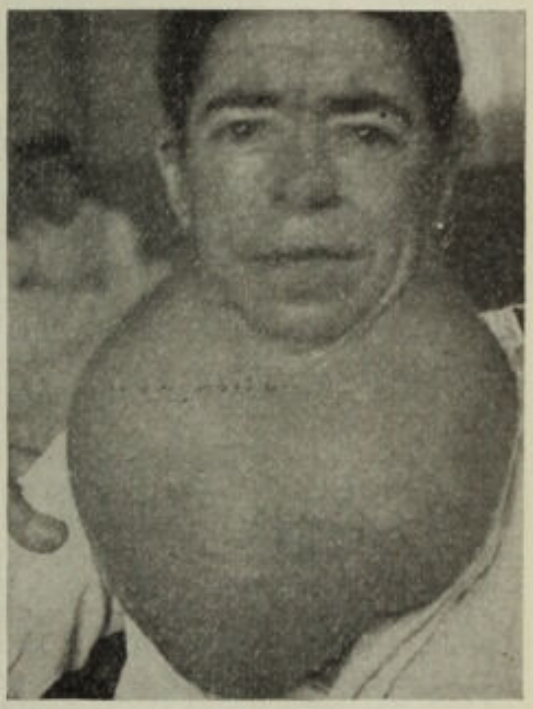


FIG. 999*a*.—Keen's case of huge cystic goiter.

growth seems to originate simultaneously in both lobes, but even then the growths seldom increase equally. Adenoma may develop in a healthy thyroid gland, but adenomatous growth is usually associated with some parenchymatous growth.

Cystic goiter, or *bronchocele*, is a condition in which the chief mass of the enlargement is composed of a cyst or of multiple cysts. When cysts form, the thyroid gland



FIG. 1000.—Parenchymatous goiter.



FIG. 1001.—Adenomatous goiter.

is usually hypertrophied or adenomatous; occasionally, however, cysts form in a non-hypertrophied thyroid. The great majority of cysts are due to cystic degeneration of adenomata; some are formed by the coalescence of overdistended thyroid vesicles, and some few follow blood-extravasation into the thyroid tissue. The lique-

faction is due to mucoid or colloid degeneration, and the fluid of the cyst is sometimes clear and thin, sometimes viscid, and often coffee ground in appearance (Fig. 999*a*).

A *fibrous goiter* is a fibrous induration. It is likely to arise in old bronchoceles, which may actually pass into a calcareous condition. By the term *malignant goiter* is meant malignant disease of the thyroid gland, either carcinoma or sarcoma. As stated above, such cases are not really goiters. When hemorrhage takes place into a goiter the condition is often spoken of as a *hemorrhagic goiter*. A *colloid goiter* is a form of parenchymatous goiter in which there is an extremely large amount of colloid material. *Exophthalmic goiter* is discussed on page 1240. Either a simple, or an adenomatous goiter, because of degenerative changes or overstimulation, may form toxic material or an excess of secretion and may cause symptoms of toxemia (*simple toxic goiter*). "These cases may have all the nervous symptoms and heart complications of a bad case of Basedow's disease without the protruding eyes" (C. H. Mayo, "Illinois Med. Jour.," Feb., 1913). This evolution gives rise to what we name a *toxic goiter* and the French call a *Basedowified goiter* (Morestin in "Rev. de Chir.," Nov. 10, 1899). A goiter that develops with great rapidity is sometimes called an *acute goiter*, and one that induces marked dyspnea is designated a *suffocating goiter*. Syphilitic, tuberculous, and amyloid enlargements are extremely rare, but occasionally occur. Such conditions are not classed with goiter. Further, a goiter may be back of the sternum, that is, *substernal* or *retrosternal*. A very movable goiter, which is now above and now below the sternal notch, is called a *wandering* or *diver goiter*. A goiter within the thorax is called *intrathoracic;* and such a goiter may be *retrosternal*, *retrotracheal*, or *retro-esophageal*. When a number of persons in the same region are attacked with goiter the condition is frequently referred to as *epidemic goiter*. When the condition is common in a certain district it is called *endemic goiter*. When a person living in a district in which the disease is rare develops goiter, we speak of the condition as *sporadic goiter*. It has long been known that *accessory* or *aberrant thyroids* exist. The term "aberrant" is better than "accessory" because in some reported cases the thyroid proper has been absent (V. L. Schrager in "Surg., Gynec., and Obstet.," Oct., 1906). Aberrant thyroids are masses of tissue composed of structure identical with the thyroid gland, and distinct and separate from the thyroid gland proper. Median aberrant thyroids are found about the hyoid bone and are formed from remnants of the thyroglossal duct. Lateral aberrant thyroids are found and develop from the remains of the lateral anlages of the thyroid (Ibid.). Aberrant thyroids vary in number: there may be none, one, several, or chains of them. An aberrant thyroid may enlarge with the thyroid, may not enlarge even though the thyroid does, or may enlarge when the thyroid proper remains normal. I recently saw a median tumor of the base of a man's tongue which on removal proved to be composed of thyroid tissue (*lingual goiter*). Nearly 100 cases of aberrant thyroid are on record, 90 per cent. of them in women. In some of the cases myxedema has followed removal. When cachexia strumipriva does not develop after complete thyroidectomy, the patient has been saved by enlargement and functionation of aberrant thyroids.

Causes of Goiter.—It is known that goiter is extremely common in the valleys at the foot of certain mountain ranges in Switzerland, southeastern France, northern Italy, the Austrian Tyrol, and in the Himalayas and the Andes. In a portion of England it is so common that it is referred to as the Derbyshire neck. There are goiter regions in Pennsylvania and in other parts of the United States. Endemic goiter has been known since the fourteenth century. Iodin is necessary to the formation of iodothyrin, the specific secretion of the thyroid gland. If iodin is furnished to the organism in insufficient quantity or is not furnished at all iodothyrin is produced in insufficient amounts or not at all and the gland undergoes enlargement (simple goiter), trying vainly to make the proper hormone without iodin. Starling calls this useless effort "a vain endeavor to make bricks without straw" ("Brit. Med. Jour.," Oct. 20, 1923). If the drinking water does not contain any iodin and if the vegetables consumed are free from it goiter is apt to arise. If this theory is true, we should be able to prevent goiter in known goiterous districts and we can do that very thing. It has been proved that goiter can be almost abolished in districts by giving children now and then small doses of iodin or the iodids. Thus the incidence of goiter among all the school children of the canton of St. Gallen has been reduced enormously (Starling, in "Brit. Med. Jour.," Oct. 20, 1923). Some writers maintain that individual liability is developed by habits of life; others think that susceptibility depends upon hygienic surroundings; and some attach great importance to hereditary influence. Some observers have blamed snow-water, some toxins from intestinal bacteria; many

have laid the cause of the trouble at the door of water impregnated with salts of lime; but the real cause is deficiency of iodin.

The ordinary parenchymatous goiter of adolescence seems to be a work hypertrophy. A number of years ago I suggested the view that the gland has undergone such an enlargement and has become distended with colloid material because the human body has demanded more of the secretion of the gland than the normal gland has been able to supply; as a consequence, the normal gland has enlarged its capacity and increased its output. Adenomata are tumors, and an adenoma may form in a normally secreting thyroid or may arise in a simple goiter.

Signs and Symptoms of Goiter.—One may determine that a growth is in the thyroid gland or is connected with it by studying a number of facts. A goiter, as a rule, follows the movements of the larynx and the trachea during deglutition, and this sign may be obtained in the great majority of instances. There are, however, rare conditions, such as hyoid cyst, in which a movement of the mass takes place during the act of swallowing, although the thyroid gland is not involved. Then, again, a malignant or an inflammatory growth of the thyroid usually becomes anchored to the surrounding tissues and does not show this mobility. Certainly, however, in the great number of cases an enlarged thyroid moves with the larynx and the trachea during swallowing.

Goiters vary greatly in size. Cases in which the goiter was as large as an adult's head, and some cases in which the goiter hung in front of the breast bone, and reached to below the level of the ensiform cartilage, have been described (Fig. 999*a*). A very large goiter may have a stalk.

When the entire gland, as well as the isthmus, is enlarged, or when the isthmus alone is involved, the swelling may appear to be in the median line of the neck. If the condition begins in one lobe, the growth will, for a time at least, be distinctly one sided; though when such a growth has attained a large size, it may displace the windpipe and come itself to the middle line of the neck.

A goiter of any considerable size pushes the sternocleidomastoid muscle externally and anteriorly, and the muscles that run from the sternum to the hyoid bone and to the thyroid cartilage overlie the front of the growth. The carotid artery is displaced externally and posteriorly. The relation of the jugular vein to the carotid artery is usually profoundly altered. The artery, as already stated, goes externally and posteriorly, while the vein is actually pulled anteriorly and is flattened out upon the side or the anterior surface of the goiter; hence the vein may lie to the inner side of the artery. This curious alteration in relationship is due to the fact that the common carotid artery has no branches, and therefore is pushed externally with ease; but the internal jugular vein receives branches that lie in the tumor, pull upon the vein, and prevent its displacement with the artery (Lücke).

Berry alludes to the fact that the tumor, unless it be very small, usually reaches the upper level of the sternum, and frequently passes below this level; and that only extremely large goiters hang in front of the sternum, but that it is not at all unusual for prolongations from a goiter to extend for quite a distance into the mediastinum. A substernal goiter is productive of very dangerous symptoms and offers many difficulties in diagnosis. A goiter will occasionally wander, now appearing in the neck and again disappearing behind the sternum.

Some goiters are said to pulsate. This takes place in exophthalmic goiter, the vessels of the goiter pulsating as do the other vessels of the body; but in the ordinary simple goiter what is called pulsation of the goiter is usually the transmitted pulsation from the carotid artery.

Some of the most important symptoms of goiter are due to pressure and to the displacement of anatomic structures. Pressure upon the veins at the root of the neck causes great enlargement of the veins above the goiter and in it. Pressure upon the recurrent laryngeal nerve may induce characteristic symptoms (spasm of the glottis or paralysis of a vocal cord), but the dyspnea of goiter is due to pressure upon the trachea and not to interference with the recurrent laryngeal. Paralysis of a vocal cord is most common in malignant goiter, but the records of the Mayo Clinic show that in almost one-fifth of all cases of goiter there is paresis or even paralysis of one or both vocal cords. The cords should always be studied before operation. Pressure upon the cervical sympathetic may cause contraction of the pupil and narrowing of the palpebral fissure (Berry). Pressure upon the cervical plexus causes parasthesia, anesthesia, or paralysis in the parts supplied by nerves from the compressed plexus. Pressure upon the larynx and the trachea may cause very great displacement, and

any such displacement is productive of marked dyspnea. This displacement is usually to the side; and it may cause such a flattening out of the tracheal rings that when the tumor is removed the trachea collapses and the patient perishes of suffocation.

A **simple, colloidal,** or **parenchymatous goiter** usually begins between the fifteenth and twenty-fifth years, never later than the thirty-fifth year. It usually begins insidiously and grows slowly. It is bilateral and symmetric. If adenomata arise, it may become asymmetric. It occasionally ceases to grow for a considerable period of time, and may even shrink. It frequently enlarges temporarily during menstruation or pregnancy. It may pass into the cystic form. Alterations in its consistency and outline may be due to the development of adenomatous masses. In simple goiter we may note rapid pulse and nervous symptoms, but never exophthalmus. There is no increase in basal metabolism, in fact it may be decreased (see Sistrunk in "Surg., Gynec., and Obstet.," 1921).

Adenomatous goiter begins probably in fetal rests. It starts in one lobe or the isthmus. The other lobe is apt to become involved. There may be a single growth, but usually the growths are multiple. There may be no symptoms except from pressure. Cyst formation is common and cysts may become enormous. Sistrunk (Ibid.) says that one-quarter of the cases are toxic (hyperthyroidism). In toxic adenoma the rate of basal metabolism is increased, but not nearly to the degree noted in Graves's disease. There is no exophthalmus. In toxic adenoma the cardiovascular system suffers particularly (tachycardia, palpitation, arythmia). Myocardial degeneration may be early. Tremor and loss of flesh are noted. In toxic adenoma the secretion of the gland is altered in quantity and contains an excess of iodin. Some goiters become toxic. Some believe that toxicity means perverted function, others that it means increased secretion. Perhaps both conditions exist. Disease of a ductless gland may overthrow the endocrine balance maintained normally between the glands. A gland may be antagonistic to another gland. When the thyroid is overactive it inhibits the islands of Langerhans in the pancreas; hence, in hyperthyroidism glycosuria may develop, fatty stools may perhaps be noted, and organic disease of the pancreas may arise. These conditions constitute the "*thyro-Langerhans syndrome*" (Garrod in "Lancet," July 2, 1923).

In making a diagnosis between the different forms of goiter, one should remember that an adenomatous goiter is asymmetric and often lobulated, that a fairly symmetric, bilateral growth is probably parenchymatous; if it has been symmetric from the start the probability of its being parenchymatous is enhanced; that sudden enlargements are produced by hemorrhage; that cyst formation may lead to very great enlargement, and possibly to fluctuation; that if a non-malignant goiter induces dyspnea, it almost invariably does so by pressing upon the larynx and the trachea, whereas a malignant goiter may do so by interfering with the nerves of the part or by infiltration of the trachea; that a non-malignant goiter very rarely produces difficulty in swallowing, but that a malignant goiter frequently does so; and that cough often exists if there be pressure upon the larynx or the trachea, such a cough being metallic in nature and unassociated with impairment of the voice.

Adenomata may become calcareous. Hemorrhage may occur, and if it does, it rapidly increases swelling. The swelling is irregular, often nodular, asymmetric, firm in some areas, soft in others. In some cases there is one enlargement, but usually there are several. It is not toxic in the beginning, but one-quarter of the cases become so.

In any goiter there may be cerebral symptoms, such as anemia, syncope, or even convulsions. Rapidly growing goiters are often fatal, and slowly growing goiters are very rarely so. A malignant goiter grows with great rapidity, becomes adherent, infiltrates, and quickly produces metastases, and both sarcoma and carcinoma produce metastases by way of the venous system. A goiter may grow slowly or rapidly during pregnancy. At the end of pregnancy it may disappear.

Toxic Goiter.—Toxic adenoma is a condition in which there is increased absorption of iodothyrin soon made manifest by various symptoms resembling those of exophthalmic goiter, although there is no exophthalmus. In toxic adenoma the rate of basal metabolism is increased. The increase in metabolism gives us an estimate of the activity of the thyroid, but does not tell us anything as to the renal or cardiovascular condition. Normal is −15 to +15.

In colloidal goiter, even though nervous symptoms arise, there is never an increase in basal metabolism. In some cases the metabolic rate is lowered. In recent cases of encapsuled adenomata the metabolic rate is normal or slightly lowered. After

years toxicity may develop, but the metabolic rate never becomes so high as in exophthalmic goiter. In the latter disease it may, in a severe case, reach or exceed +75.

It is not only in toxic goiter that basal metabolism is increased. There may be an increase in cardiorenal disease with dyspnea, in typhoid fever, in leukemia or from chills, sweats, fever, exercise, food, menstruation, violent emotion, worry, fear, etc. The rate is lowered in obesity, in tuberculosis without fever, in diabetes, in cretinism, in myxedema and in some other conditions. (See Mohler in "Therapeutic Gaz.," Oct. 15, 1921; Mohler in Paper before the Congress of Int. Med. Phila., April 6, 1923; Sistrunk in "Surg., Gynec., and Obstet.," 1921, vol. 33.)

Metastasis of Non-malignant Goiter.—An ordinary goiter which presents no sign of being malignant may suddenly be disseminated. The deposits are apt to take place in the bones and in the lungs. Tumors haye been removed without any thought of thyroid trouble being responsible, and examination has shown thyroid structure. Patel collected 18 cases of thyroid metastasis ("Tumeurs bénignes du corps thyroide donnant des métastases," "Rev. de Chir.," No. 29, 1904). The bones most apt to receive metastases are the bones of the cranium, the lower jaw, the vertebræ, the pelvis, and the long bones. In 4 of these 18 cases the spine was affected. Dercum has reported a case of thyroid metastasis to the spine ("Jour. of Nervous and Mental Dis.," March, 1906). Colloid goiters are particularly prone to metastasis. Some surgeons maintain that if a metastatic deposit grows and destroys bone, the primary tumor should be regarded as malignant, no matter what histologic studies indicate.

Treatment of Goiter.—The goiters of adolescents usually disappear spontaneously. If not treat as a colloidal goiter. The administration of thyroid extract may do much good in a case of parenchymatous goiter, but it is useless in adenoma. Lugol's solution is valuable in parenchymatous goiter. Iodin and thyroid extract are most serviceable in the goiters of adolescent girls. Large doses of iodin are unsafe. Kocher pointed out years ago that too much of the drug might cause an adenomatous goiter to become toxic. Iodin should never be given for adenomatous goiter. It cannot remove adenomata and it may cause toxicity. McCarrison ("Proceedings of the Royal Society of Medicine," Feb., 1912) grew cultures from the feces of individuals with goiter. He prepared a mixed vaccine. He also isolated certain bacteria and prepared vaccines from them. Cases of goiter were treated with the vaccines. It is claimed that the vaccines, especially the mixed vaccine, will cure recent parenchymatous goiter. The vaccine is said to act more promptly than thyroid extract. In times past it was customary to treat cystic goiters by aspiration and injection with a solution of iodin. Electrolysis has been used for soft goiter, the negative pole being pushed into the growth, the positive pole being applied to its surface. In many cases the *x*-rays prove of benefit, but must be used by an expert, because, otherwise, myxedema and hypothyroidism may result. In considering the propriety of operation remember that a goiter which begins at puberty may pass away. We should operate on every non-malignant goiter which is increasing in size steadily or rapidly, which is making injurious pressure, which is causing pain, which is interfering with important nerves, or which is actively toxic. Operation is justifiable even if there is no pressure because the mortality is very small, and it saves the patient from the possibility of malignant change, of hemorrhage, and of inflammation. Pregnancy increases greatly the risk of operation. Abortion is apt to follow. In some cases of colloidal goiter operation is necessary. After operation give iodin internally, otherwise there may be recurrence. The custom of the Mayo Clinic as to adenomatous goiter is as follows (Sistrunk in "Surg., Gynec., and Obstet.," vol. 33, 1921): Do not operate on persons under thirty years of age. In an older person, if there are lumps over 3 or 4 c.c. in diameter, perform partial thyroidectomy. Toxicity makes the case surgical unless there is serious damage to the heart. The rate of the basal metabolism is a measure of the activity of the thyroid, but not of the amount of myocardial damage. If metabolic rate is high, prepare for the operation by rest in bed and the administration of digitalis. I used to operate under local anesthesia. There is less bleeding under local anesthesia than under ether. It is a great advantage to have the patient conscious, because by asking him to speak from time to time during the operation the surgeon can tell by the change in the voice if the recurrent laryngeal nerve is being approached or touched. Two cases of violent hemorrhage in conscious patients taught me a lesson. Each patient was conscious that something was wrong, became terrified and uncontrollable, and greatly increased the danger and difficulty. I now give ether (by intratracheal insufflation) unless there be very high blood-pressure, serious tracheal obstruction, or disease of the heart, lungs, or kidneys (C. H. Mayo,

"Illinois Med. Jour.," Feb., 1913). When ether is to be given I precede its administration twenty or thirty minutes by $\frac{1}{6}$ gr. of morphin and 1/120 gr. of atropin, given hypodermically. In some cases I follow Charles H. Mayo's plan and combine local anesthesia with light general anesthesia. In some cases intraglandular *enucleation* is performed, in other cases *extirpation*. Occasionally these two methods are combined (Bergeat). Simple division of the isthmus was formerly advocated. Ligation of the thyroid arteries has been recommended. *Exothyropexy* is the operation of exposing the thyroid gland, dislocating it through the wound, and leaving it in this situation. Exothyropexy is now almost never performed, on account of the safety of the operation of thyroidectomy. Atrophy of the gland follows exothyropexy. Enucleation, if possible, is the desirable operation. It may easily be employed for the removal of a single adenomatous, colloidal, or cystic area. *Thyroidectomy* (extirpation) is employed when enucleation is impossible. The entire thyroid is not removed for an innocent growth; at least a portion of a lobe is left behind, otherwise operative myxedema will probably arise. Unilateral extirpation (*lobectomy*) is the method usually chosen. In cancer and in some cases of sarcoma complete extirpation may be attempted if the growth be movable. If it be immovable operation is useless. The operation in malignant disease will occasionally prolong life, but it will rarely effect a cure except in very early cases. (See Lewis B. Wilson in "Annals of Surgery," Aug., 1921.) In malignant disease tracheotomy may be rendered necessary by urgent dyspnea. The operation is often very difficult in goiter because the growth may cover the trachea, the trachea may be deviated a considerable distance from its proper position, and the veins may be very large. After the performance of tracheotomy it is usually impossible to use an ordinary tube, and in such a case König's long, flexible tube (Fig. 1002) is employed.

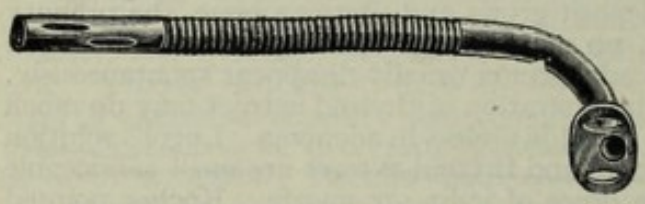


FIG. 1002.—König's long tracheotomy tube.

Intrathoracic Goiter.—Goiter in this situation causes great pressure on the veins and on the trachea and distention of the veins of the neck, dyspnea, and cyanosis. It may be reached by dividing the manubrium longitudinally or dividing the entire sternum. Endotracheal anesthesia is used.

Endotracheal Goiter.—Such a goiter may be due to misplaced thyroid tissue or may be a prolongation from the thyroid gland. Occasionally the growth is situated in front, but, as a rule, it is attached to the posterior surface of the larynx or trachea. The first symptom is dyspnea, which increases and becomes very severe. An examination with a laryngoscope makes the condition evident. Endotracheal goiter is much more common in the female than in the male. It is believed to begin usually at about the age of puberty, though it may exist for a long time unnoticed. In some reported cases the patients were forty years of age before having been seen. The proper treatment for an endotracheal goiter is the performance of a preliminary tracheotomy and then extirpation.

Exophthalmic Goiter (*Graves's Disease: Basedow's Disease: Pulsating Goiter*).—This condition was first described by Graves, of Dublin, in 1835. It is a condition of chronic overactivity of the gland (hyperthyroidism) in which the secreting structure of the gland is increased in amount by hyperplasia. The increase of parenchyma may perhaps be general, may perhaps be in separated areas (C. H. Mayo, "Illinois Med. Jour.," Feb., 1913). The gland cells are packed with epithelium. The absorption of incompletely iodized thyroxin is rapid. The secretion is rapidly absorbed when it is in an immature state. It is like moonshine whisky, dangerous when new, but free from serious danger when a bit matured. The symptoms may arise suddenly or gradually. In some cases rapid loss of weight and rapid pulse antedate enlargement of the thyroid. The symptoms are very variable, depending upon the amount and nature of the thyroid secretion and also upon the nervous tendencies of the victim. It is ten times more common in women than in men, and is most common between the ages of twenty and forty. It may arise at puberty, but is very rare in children under ten years of age. The Mayos operated on only 5 such cases in eight years ("St. Paul Med. Jour.," 1914, xvi). It has been stated that child-bearing has little influence in its causation, but I have seen the development of it in a woman three times in three different pregnancies. There is no proof of heredity, but it is not unusual to find

more than one member of a family with it. It is not particularly prone to appear in ordinary goitrous families, although a person with an ordinary goiter sometimes develops all the nervous symptoms and heart symptoms of Graves's disease (see Basedowified Goiter, page 1238). It may arise after emotional excitement or depression, fright, shock, hemorrhage, or an acute illness. It may develop during the existence of locomotor ataxia, paresis, epilepsy, neurasthenia, hysteria and other nervous troubles, and abdominal and pelvic diseases. A shock or fright does not cause hypersecretion. That existed before, but there were no symptoms because the body had been neutralizing the poison. Shock develops symptoms by abolishing neutralization (C. H. Mayo, "Illinois Med. Jour.," Feb., 1913). Crile ("Amer. Jour. Med. Sci.," Jan., 1913) believes that "Graves's disease is not a disease of a single organ or the result of some fleeting cause," that it originates in fear, and is excited by "some stimulating emotion intensely or repeatedly given, or some lowering of the threshold of the nerve receptors, thus establishing a pathologic interaction between the brain and thyroid." Digestive toxemia is thought by many to be the underlying cause. It is frequently associated with marked anemia the result of excessive vomiting. The disease is a toxemia and the real cause of the symptoms is hypertrophy of the thyroid and excessive secretion of the gland (*hyperthyroidism*). This view is rendered more probable when we recall that a condition known as myxedema possesses many symptoms directly opposite to those of Graves's disease and that myxedema is due to deterioration, great diminution or absence of thyroid secretion, and the unopposed action of adrenal secretion. The administration of thyroid extract to an individual may produce some symptoms observed in exophthalmic goiter. Notthaft (Garrod in "Lancet," July 2, 1923) tells of a man who took thyroid extract to reduce his weight and developed signs of exophthalmic goiter. The secretion during hyperthyroidism contains little or no iodin. The poisonous element is probably thyroxin. When the thyroid is stimulated the hormone thyroxin is incompletely iodized and raises the metabolic rate (Plummer, quoted in "Jour. Amer. Med. Assoc.," June 30, 1923).



FIG. 1003.—Exophthalmic goiter and total blindness from protrusion of eyes (Hansell).

An apparent objection to this view is that Graves's disease may exist without detectable thyroid enlargement, but this objection loses force when we recall that the thyroid may be somewhat enlarged, though we cannot detect the increase, and that a gland may be diseased even when not enlarged. It is probable in exophthalmic goiter that whether or not there be an excess of thyroid products passing into the circulation, toxic materials of some sort are formed in the gland and are taken into the lymph and blood. The real cause of exophthalmic goiter is not positively proved, but it seems probable that the disease is due to the action on the sympathetic system of large amounts of imperfectly iodized thyroid material, and of some poisonous product of thyroid activity, or of some toxin the thyroid fails to destroy. The basal metabolism is increased and in severe cases is very high (+50 to +75). The estimation of the basal metabolism is valuable diagnostically (is much higher than in toxic adenoma), but gives no clue as to the damage which has been done to the cardiovascular and renal systems. The disease tends to cause myocardial degeneration and cardiac dilatation. After a year of the disease there is certain to be cardiac damage.

In exophthalmic goiter the vessels of the gland are not dilated, in fact, they are

"usually smaller and less numerous than in a parenchymatous goiter of the corresponding size" (Berry on "Diseases of the Thyroid Gland"), but the vessels of the capsule are dilated. The surface of the gland is smooth. On section, the cut surfaces seem solid and very little colloid is visible. The enlargement is due to growth of the glandular epithelium, either general or in localized areas, and this epithelial proliferation may be induced by different exciting causes.

In many cases of Graves's disease the thymus is enlarged by hyperplasia. This is most apt to be the case in young subjects. Status lymphaticus (page 158) may exist and if it does the danger of operation is much enhanced.

In exophthalmic goiter the lymphatics within the lobules are usually obliterated, but the lymphatics around the lobules are present in increased number and are of exaggerated size. Sometimes the thyroid becomes fibrous, and in such cases myxedema is apt to arise. In a typical case there are rapid pulse, or *tachycardia*, and protrusion of the eyeballs, or *exophthalmus*. Some suppose that the exophthalmus is due to a collection of fat back of each eye, but the variability in the degree of protrusion and the rapidity with which protrusion may occur, seem to contradict this view. It is almost certainly due to involvement of the sympathetic system, and enlargement of the thyroid gland or *goiter*. Either thyroid enlargement or exophthalmus may be absent, in fact, in some rare cases both are absent. The pulse-rate in most cases is from 90 to 140. Exophthalmus is present in at least 80 per cent. of cases. The enlargement of the thyroid is solid, smooth, and bilateral. Unilateral enlargements probably are instances of Basedowified goiter; that is, are cases in which toxemia arises in the course of an ordinary goiter (see page 1238). A systolic bruit is usually audible over the thyroid region, and the large vessels at the root of the neck pulsate strongly because of arterial dilatation. The cardiac symptoms are of great importance. Acute cardiac dilatation occurs during tachycardia, and for a time, at least, disappears as tachycardia abates. Even trivial fatigue brings on temporary dilatation. Dilatation may become permanent (and does after one year), valvular insufficiency may arise, or cardiac hypertrophy may occur (Grocco in "R. Crit. di Clin. Med.," Jan. 2, 1904). *Von Graefe's sign* may be present; this is inability of the upper lids to follow, or slowness and jerkiness in following the eyes in looking down. *Stellwag's sign* is retraction of the upper lids. The lids in some cases cannot be completely closed, and when the eyeball is suddenly turned up, the lid and brow may fail to act together. *Moebius's sign* is inability to maintain the eyes in convergence. In some cases ocular palsies exist, in others there is photophobia or nystagmus. Patients may suffer from neuralgia, colic, choreic movements, tremor, flushes of heat, and gastric crises. Tremor is practically always present when the arms and forearms are extended, the palms of the hands are turned down, and the fingers are spread apart. Wide-spread tremor is apt to arise from any excitement, shock, or surprise. Dyspnea often exists and albuminuria and polyuria are not uncommon. Hemoptysis, hematemesis, or mental disturbance is sometimes noted. Dermatography is a condition in which linear wheals are produced by drawing a finger or lead pencil over the skin. Words or figures may be written. This peculiar condition may be observed in Graves's disease. The patient is usually greatly depressed mentally, sometimes is excited, and may have outbreaks of violent hysteric excitement, delirium, or even of mania. The usual expression is one of fright. There may be insomnia, elevated temperature, excessive sweating, or sudden attacks of diarrhea. Fatty stools may be noted (page 1238). All symptoms are increased by fear or fright. Sugar may be found in the urine. The development of intermittent glycosuria or of diabetes means that hyperthyroidism has inhibited the secretion of the islands of Langerhans in the pancreas. Now and then a patient with diabetes develops exophthalmic goiter. "Some diabetics exhibit an incomplete thyroidal syndrome usually limited to the ocular signs" (Garrod in "Lancet," July 2, 1923). In hypothyroidism the organism becomes very tolerant of glucose. It is very tolerant in myxedema. Exophthalmic goiter is sometimes associated with osteomalacia. This fact is important in connection with MacCallum's observations on the action of the parathyroids in controlling calcium metabolism. Kocher emphasized the importance of the blood-picture. In nearly all cases there is lymphocytosis. Halsted ("Annals of Surgery," Aug., 1913) says of his cases: "Almost invariably the proportion of lymphocytes was increased, once being as high as 65 per cent. But in 1 case, the most serious of all, the total percentage of lymphocytes was only 9." Halsted regards enlargement of the thymus as probably responsible for the lymphocytosis, and the thymus is enlarged in at least 75 per cent. of

marked cases. After operation lymphocytosis gradually diminishes (Halsted, Ibid.). My colleague, Professor Hansell, writes me that he has noticed in practically all of the cases of Graves's disease which he has examined, dilatation and tortuosity of the retinal veins. Dr. Francis Ashley Faught writes me in answer to an inquiry, that the systolic pressure is usually from 140 to 160 and that he has no records of subnormal pressure in toxic goiter. Diastolic pressure is usually from 100 to 120. The duration of a case is entirely uncertain. It is usually very chronic, with remissions or actual intermissions. Sometimes the patient gets entirely well, but this result is rare. There is often a partial cure, lasting perhaps for several years, but which may at any time be followed by a renewed outbreak. Sometimes the condition passes away rapidly, but abatement is usually gradual. Some cases get progressively worse and die. Certain cases are acute and these are apt to result fatally. A man in the Jefferson Hospital died in five weeks after the first symptoms were noted. He was delirious for several weeks. Another case died in four weeks in spite of ligation of the two superior thyroids. Very grave cases of exophthalmic goiter are probably often associated with disease of the thymus (Rehn). C. H. Mayo ("Illinois Med. Jour.," Feb., 1913) says: "While the large majority of cases can be easily diagnosed from the nervous symptoms, tachycardia, goiter, and eye symptoms, there are a few cases in which it is difficult to diagnose true hyperthyroidism from pure neurasthenia, myocarditis, or Bright's disease, as well as a few cases in which there may be a complication by affection of the hypophysis, thymus, or adrenals." Children seem to suffer less when hyperthyroidism exists than do adults. In exophthalmic goiter even a trivial operation may be followed by elevated temperature and rapid death. In hyperthyroidism, due either to exophthalmic goiter or overfunctionating adenoma, there is increase of basal metabolism though the increase is much greater in the former than in the latter. The degree of basal metabolism shows the activity of the thyroid, but gives no information as to the organic damage done by the disease.

Treatment.—Medical treatment in a severe case should comprise rest in bed, the use of an ice-bag over the heart, and the administration of digitalis and Lugol's solution. When the patient gets about again he must avoid alcohol and all forms of excitement. Gentle exercise is desirable, but never violent exercise. Diet is to be nutritious, but non-stimulating. Electricity is said to be of benefit. Experiments in organotherapy are being tried in this disease. Thymus extract has been used. Ballet and Enriquez assumed that the thyroid gland furnished an antitoxin to certain body poisons, that an excess of thyroid secretion over the amount required to neutralize toxin caused the condition known as Graves's disease, and that the symptoms of Graves's disease would disappear if sufficient toxin were administered to antidote the excess of thyroid secretion (Hubert Richardson in "Amer. Medicine," Aug., 1906). The two observers mentioned above obtained blood-serum from thyroidectomized dogs and injected it into individuals suffering from Graves's disease and claim that they noted improvement. In 2 of their patients, however, tetany developed. Lanz has used the milk of thyroidectomized goats instead of the serum of thyroidectomized dogs. The serum of thyroidectomized sheep, powder made from the dried goiter of a cretin, and the powdered flesh of the thyroidectomized sheep have been used (Hubert Richardson, Ibid.). What is known as *thyroidectin* is the dried serum of an animal from which the thyroid gland has been removed. John W. Rogers and S. P. Beebe have made some extremely interesting studies on the production and application of a serum. Rogers makes two sera, using one or the other, according to the needs of the case. One serum, called the normal serum, is obtained from sheep or rabbits after injecting them with the combined nucleoproteins and thyroglobulin of healthy thyroids; the other, called the pathologic serum, is obtained from the animals after having injected them with combined nucleoproteins and thyroglobulin obtained from the thyroids of Graves's disease. In 1 severe case I have seen rapid improvement and apparent cure follow the use of Rogers's serum. The value of serum treatment is as yet undetermined. It is certainly not free from danger and some deaths have followed its use. One cause of diverse results after the use of goat-serum may be found in the fact that some of the animals were probably incompletely thyroidectomized. The goat possesses aberrant thyroids and these must be removed as well as the gland proper. Beebe and Beveridge ("New York Med. Jour.," Dec. 25, 1915) state that 50 per cent. of more than 3000 treated were cured "in the sense that they are strong and able to meet all the demands made upon them."

There are upon the market three preparations to combat hyperthyroidism:

1. Thyroidectin (or thyreoidectin) is a powder made from the dried blood-serum

of thyroidectomized animals. It is given in 5-gr. capsules. The dose is one or two capsules three times a day.

2. Beebe's serum is the serum of thyroidectomized animals.

3. The antithyroidin of Moebius is the serum of sheep's blood, the animal having had its thyroid gland removed at least six weeks before the serum was obtained.

Jaboulay of Lyons suggested cutting the cervical sympathetic nerve on each side. Jonnesco of Bucharest suggested bilateral extirpation of the cervical ganglia. Bilateral extirpation of the cervical ganglia of the sympathetic and division of each nerve below the ganglion has been employed, it is alleged, with benefit. I have not employed the operation for this disease. It benefits exophthalmus, perhaps, more than does thyroidectomy. Ligation of the thyroid arteries may do good. Its chief use is preliminary to thyroidectomy, but it will cure exophthalmic goiter in a child. Partial thyroidectomy is the operation commonly employed in severe cases; it cures within six months from 50 to 75 per cent. of the cases operated upon. One lobe, the isthmus, and a portion of the other lobe are removed. Some cases do not improve; others improve slowly and relief is only partial. It is the operation which I prefer. The Mayos have obtained a splendid series of results from this operation. It is advisable to apply the *x*-rays daily for several weeks and then to operate. The rays produce decided but temporary improvement. The operation is intracapsular extirpation of one lobe. Ether is given to most cases (by intratracheal insufflation). In some cases thyroid intoxication follows operation. In other cases very rapid growth follows incomplete removal, and the operation seems actually to have done harm. Sudden death occasionally follows the operation. Before operation lessen symptoms by rest in bed, the administration of digitalis and Lugol's solution, and perhaps the application of the *x*-rays. In toxic adenoma Lugol's solution is not to be given. It could do no good and might do harm.

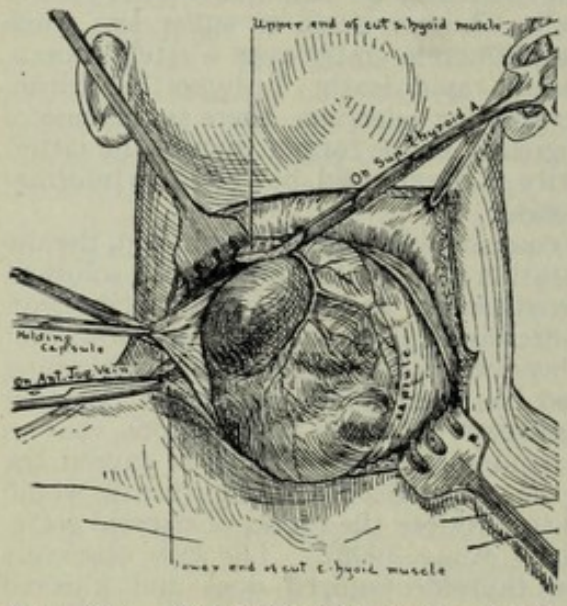


FIG. 1004.—Enucleation of cystic goiter; capsule opened (C. H. Mayo).

Operations on the Thyroid Gland.—The removal of a goiter is a major operation and one beset with difficulties and dangers. Nevertheless it is a very successful operation. I lost a case of supposed adenomatous goiter which turned out to be a metastatic hypernephroma. The patient died from secondary hemorrhage. I lost a case of carcinoma of the thyroid and a case of simple adenoma. My mortality in ordinary goiter has been under 2 per cent. In 1200 cases of ordinary goiter the Mayos had a mortality of 1 per cent. following extirpation. In the Mayo Clinic from Jan. 1, 1907, to Jan. 1, 1918, there were 6668 thyroidectomies for simple goiter with a mortality of 0.7 per cent. Kocher's mortality is 0.4 per cent. Certain anatomic points are to be borne in mind. The internal jugular vein is frequently found to the inner side of the carotid artery and lying on the goiter (because the vein has branches which run from the goiter and hold the vessel against the thyroid). The recurrent laryngeal nerve ascends along the side of the trachea back of the gland, and is in contact with the esophagus before it passes through the cricothyroid membrane. On the right side the nerve is very close to the inferior thyroid artery, sometimes passing over it, sometimes under it. On the left side it is deeper and not so near the artery. The parathyroids are behind the thyroid and usually behind the capsule.

In view of the fact that one or both recurrent laryngeal nerves may be paretic from pressure, all cases should be examined with the laryngeal mirror before the operation to determine this point. If the paresis is on one side only, the sound vocal cord may possibly compensate by advancing across the midline. In such conditions the paresis may be first observed following operation, leading the operator to think that he has injured a nerve (C. H. Mayo in "Surg., Gyn., and Obst.," July, 1907).

Intraglandular Enucleation (Socin's Operation—Fig. 1004).—By this operation an adenoma, a colloidal area, or a cyst of the thyroid gland can be removed, the encompassing glandular tissue being left in place. The capsule of such a growth is

glandular tissue. The operation of enucleation is not suited to the removal of multiple tumors and it cannot be performed for wide-spread parenchymatous goiter or exophthalmic goiter. Intraglandular enucleation is performed as follows: The thyroid is exposed by an oblique or by a transverse incision. An incision is made through the capsule of the thyroid gland and through the glandular tissue until the cyst or solid tumor is reached. As a rule, the tumor can be recognized by the fact that its color differs from the color of the thyroid tissue. The tumor is turned out by the fingers, a special scoop, the knife handle, or a dry dissector. In some cases a cyst can be most easily removed if, after exposure, it be incised and emptied and its wall then grasped by strong forceps. A solid tumor should, if possible, be removed intact. The wound is packed temporarily with gauze, the edges of the cavity are grasped by forceps, the gauze is removed, and every bleeding point is carefully ligated. The wound is closed by three layers of sutures: "one in the gland, one in the muscles, and a third in the skin" (James Berry on "Diseases of the Thyroid Gland"). If the tumor is large, drain for twenty-four hours; otherwise, do not drain.

Enucleation is a very successful operation if performed upon properly selected cases, and can be performed rapidly, but the arrest of bleeding is often tedious and troublesome.

Extracapsular Extirpation.—This term means removal of the entire gland (*complete thyroidectomy*) or a portion of the gland (*partial thyroidectomy*) with the glandular

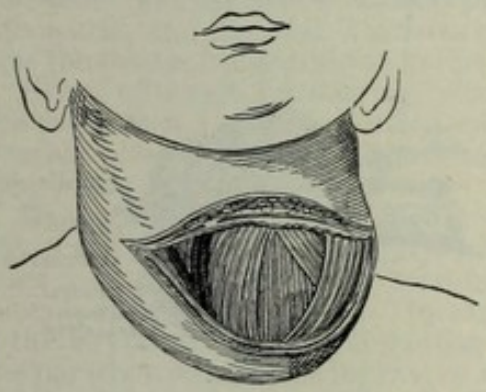


FIG. 1005.—Kocher's transverse incision exposing the muscles and median veins of the neck (Kocher).

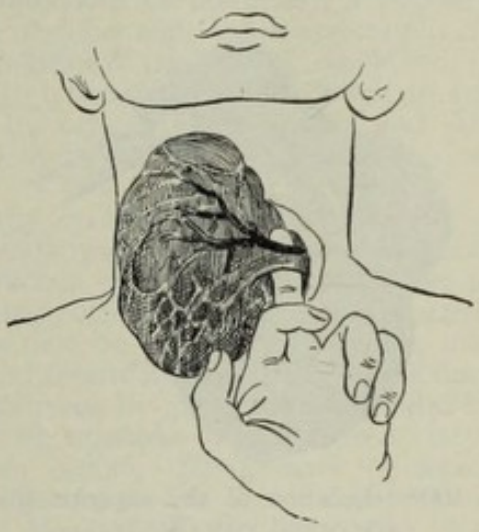


FIG. 1006.—Isolating the accessory veins (Kocher).

capsule, the operation being an extracapsular procedure. Usually but one lobe is extirpated (*lobectomy*), or one lobe, the isthmus, and a portion of the other lobe. This method enables the operator to tie the chief vessels before he cuts them; as his vision is not obscured by bleeding, he can avoid cutting the glandular capsule (which would provoke copious bleeding), and he keeps a safe distance away from the recurrent laryngeal nerve.

If the patient suffers from grave respiratory trouble with myocardial disease, a general anesthetic is contraindicated. If ether is used, after unconsciousness is obtained the ether is continued by intratracheal insufflation. The patient is placed recumbent, with the shoulders a little raised and the neck laid upon a sand-pillow so as to throw the head back as far as is consistent with comfortable respiration.

An oblique incision, a horseshoe-shaped incision, or a transverse collar incision (Fig. 1005) may be made. I usually employ an incision shaped like an incomplete horseshoe, the convexity being downward. Layer by layer the tissues are divided. Vessels are carefully tied as divided or before division. The muscles which run from the sternum to the hyoid bone may in some cases be separated, but the extirpation of a large goiter requires transverse division of the muscles high up. The capsule of the lobe is exposed and is separated from external parts (Figs. 1006–1008). The upper portion of the gland is cleared. The superior thyroid vessels are found, tied with two ligatures each, and divided between the ligatures (Fig. 1009). The clearing of the gland is carried on toward the median line and some rather large veins are

encountered and tied (Fig. 1011). The lower portion of the lobe is cleared and the inferior thyroid vessels are found (Fig. 1010). Near this point the recurrent laryngeal

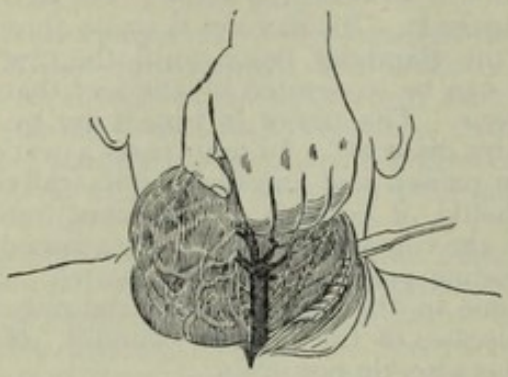


FIG. 1007.—Exposure of veins of lower end before ligation (Kocher).

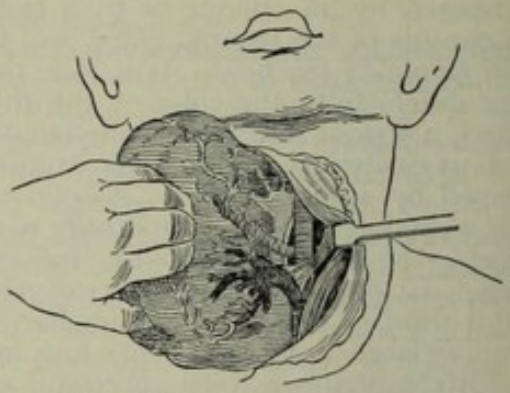


FIG. 1008.—Dislocation of the goiter toward the right (Kocher).

nerve lies and may be located. If the operation is being done under a local anesthetic, adjacency to the nerve is readily determined, because if the nerve is pulled upon or if

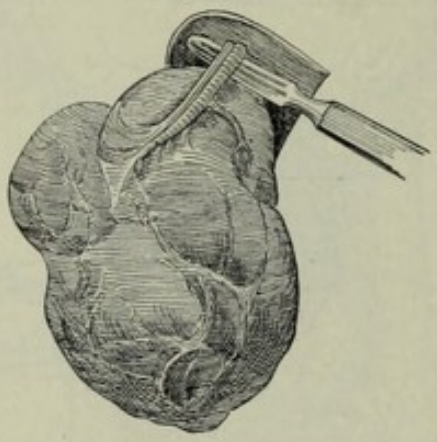


FIG. 1009.—Isolation of the superior thyroid artery and vein (Kocher).

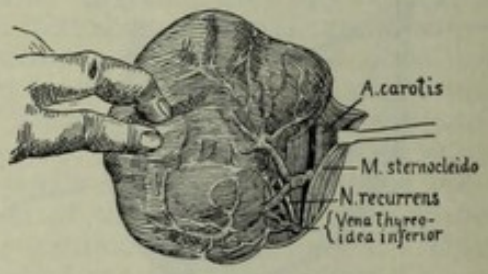


FIG. 1010.—Ligation of the inferior thyroid artery (Kocher).

it is pressed upon or touched by a blunt instrument, the patient's voice becomes metallic. A deliberate attempt is made to locate the nerve, and the patient is engaged

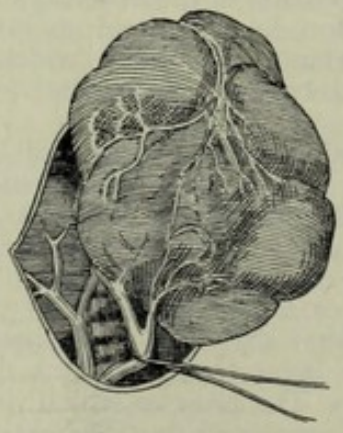


FIG. 1011.—Isolation of the venæ thyreoideæ imæ (Kocher).

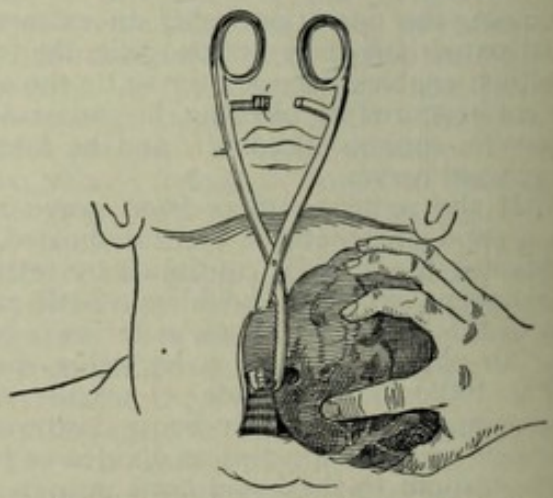


FIG. 1012.—Isolation and clamping of the isthmus (Kocher).

in a conversation requiring answers while the surgeon is investigating. The lobe is lifted from its bed and dislocated from the wound and the inferior thyroid vessels

are tied close to the border of the gland in order to avoid the recurrent laryngeal nerve (Fig. 1010). The vessels are tied and cut across as were the superior thyroid vessels. The isthmus is next exposed, clamped, ligated, and cut across, every care being taken to prevent colloid from being squeezed into the wound (Fig. 1012). After dividing the isthmus, any bleeding point is ligated and the stump is cauterized. The divided muscles are sutured with catgut, a drainage-tube is inserted, and the superficial wound is closed with sutures of silkworm-gut or fine silk.

Intracapsular Extirpation.—This operation is warmly advocated by the Mayos. I practice it habitually. The preservation of the posterior portion of the capsule protects the recurrent laryngeal nerve and greatly lessens the risk of injuring the parathyroids. Ether is given unless there is grave respiratory difficulty with myocardial degeneration, and half an hour before administering the ether the patient is given a hypodermic injection of $\frac{1}{4}$ gr. of morphin and 1/100 gr. of atropin. The ether is continued by intratracheal insufflation. When anesthetized, the patient is placed in the reversed Trendelenburg position and the shoulders are elevated (C. H. Mayo in "Surg., Gyn., and Obst.," June, 1907). Kocher's transverse collar incision is made. Muscles are separated or divided as in ordinary extraglandular extirpation. If the ribbon muscles are divided the cut is made near their upper insertion to save their nerve supply and prevent the muscle scar from being in line with the skin scar. The gland is elevated. The vessels entering and leaving the raised lobe are double clamped and tied. The capsule is incised along the outer side of the gland, is pushed back with gauze, and the lobe is drawn toward the midline, and vessels are caught by forceps, the tissues being grasped in line with the midline of the body (C. H. Mayo, Ibid.).

Every structure bearing any resemblance to a parathyroid is allowed to remain. The isthmus is clamped, divided, and closed by suture. The muscles and skin are sutured. Drainage is required after removal of large growths, a separate incision being made to permit of it.

Dangers in Goiter Operations.—During any operation for goiter sudden death may occur. In some cases a general anesthetic is responsible. In others suffocation arises from pressure upon or bending of the trachea or collapse of the trachea as the goiter is lifted from its bed. In rare cases dangerous dyspnea arises from irritation of the laryngeal nerves, and cardiac inhibition may be induced in the same manner. The parathyroids may be injured or removed and tetany may result. Rough handling and flooding the wound with colloid may be followed by great and even fatal hyperthyroidism. The trachea or esophagus may be opened. The recurrent laryngeal nerve may be injured. Air embolism seldom occurs. Reactionary or secondary hemorrhage is usually due to slipping of the ligature on the superior thyroid artery "caused by including a piece of muscle" (C. H. Mayo in "Surg., Gyn., and Obstet.," June, 1907).

Acute Postoperative Thyroidism (Hyperthyroidism).—When colloid from the thyroid is squeezed into the wound during the operation or leaks into it later, it is absorbed and may produce serious symptoms or even death. This is most apt to happen in exophthalmic goiter. The symptoms always appear within forty-eight hours and usually within twenty-four. Sometimes they arise quickly after operation. In some cases in which this happens the patient never reacts from the operative shock, but develops a very rapid pulse and intense dyspnea, and dies in a few hours. In less severe cases there is a period of circulatory excitement, dyspnea, and elevated temperature (*thyroid fever*). The surgeon seeks to prevent acute thyroidism by limiting leaking of colloid by cauterizing the stump, by suturing the capsule over the raw stump of the gland, and by inserting drainage. If this condition arises wash out the stomach several times a day with a hot solution of bicarbonate of soda, administer advancing doses of digitalis, put an ice-bag over the heart, and cut a stitch or two to secure free drainage.

The Operation for Exophthalmic Goiter.—The removal of an exophthalmic goiter requires great delicacy. The capsule and capsular vessels are easily torn. Occasionally sudden death occurs. Nevertheless the operation is very successful. Status lymphaticus adds greatly to operative danger, although enlargement of the thymus without status lymphaticus does not add greatly to danger. If the thymus is much enlarged precede operation by the administration of thymus tablets and exposure to the *x*-rays. The operation of thyroidectomy is not to be performed during an acute exacerbation. (See Judd and Pemberton in "Surg., Gynec., and Obst.," March, 1916.) To do it then will very probably cause death. Delirium is a contraindication. So are gastric crises. The operation is very dangerous when there is great cardiac dilatation.

After the disease has existed one year it is highly probable that marked dilatation exists.[1] Hence, early operations are much safer than late ones. If a case is seen early, and if the *x*-rays (and perhaps serums) fail to cure, operation should be recommended. Roentgen rays often have a very favorable effect on exophthalmic goiter, probably by destroying some of the glandular epithelium and thus lessening the amount and the toxicity of the secretion. They also induce fibroid changes. About 80 per cent. of cases are relieved. Some are even cured. In one of my cases the *x*-rays caused such atrophy that myxedema developed and it was necessary to administer thyroid extract. Mackenzie reported a similar case ("Lancet," 1916). High basal metabolism should be allayed before operation. In any case with serious symptoms of overactivity of the gland the surgeon seeks to modify those symptoms before thyroidectomy by means of rest in bed, the ice-bag over the heart, digitalis, the *x*-rays, Lugol's solution, and perhaps serums. Lugol's solution of iodin is of great value to lessen the metabolic rate. Often it will reduce a rapid pulse to a nearly normal pulse. Increased metabolism means increased glandular activity, and an increase in secretion of poorly iodized thyroxin. The *x*-rays used before operation lessen the amount and toxicity of the thyroid secretion, diminish the vascularity of the capsule, and modify the symptoms. It is true that resulting fibroid changes may add somewhat to the difficulties of the operation. If under this treatment the dangerous symptoms disappear or greatly abate, thyroidectomy may be performed.

If the dangerous symptoms are little modified or not modified at all by medical treatment, preliminary ligation of one of the thyroid arteries is indicated. Ligation of an artery will not cure a case, but will probably greatly improve it. The operation is strictly palliative and preliminary. Tie the right superior thyroid. Wait one week. If the symptoms are not greatly improved, tie the left superior thyroid and wait a while. In severe cases tie both superior thyroids at one operation. The operation is done under infiltration anesthesia. It is not entirely free from danger and may cause death. There is nearly always at least a definite reaction (vomiting, rapid pulse, elevated temperature, restlessness, etc.), but it should begin to abate after twenty-four to thirty-six hours. Halsted ("Annals of Surgery," Aug., 1913) ties one inferior thyroid or both inferior thyroids. He says that by the inferior operation we obtain a better cosmetic effect, leave a scar largely beyond the incision which will subsequently be used for lobectomy, and tie vessels which are larger than the superior arteries. Not more than three arteries should be tied before lobectomy. C. H. Mayo[2] points out that the ligature of the superior thyroid should be applied very close to the pole or should actually include some of the thyroid tissue, "so that a reversed circulation in anastomotic branches with the inferior thyroid artery may not occur."

When it is esteemed safe the surgeon prepares to perform partial thyroidectomy. In most cases ether is given, preceded by a hypodermic injection of morphin and atropin. After the patient is anesthetized by ether the tracheal tube should be introduced and the unconsciousness maintained by insufflation anesthesia. If there is grave cardiac dilatation and we determine to operate, infiltration anesthesia is relied upon.

At the operation an entire lobe (except a thin slice), the isthmus, and a portion of the other lobe should be removed. The more of the gland removed, the better the prospect of cure (Halsted, "Annals of Surgery," Aug., 1913). At least one-half of one lobe should be left in order to prevent myxedema with certainty. The parathyroids are protected by leaving a small slice of the posterior portion of each lobe (Halsted, Ibid.). After the removal of one lobe the other usually undergoes considerable atrophy. After thyroidectomy, lymphocytosis gradually decreases, and an enlarged thymus generally disappears (Ibid.). Thyroidectomy may cure the case; it may greatly improve it; may fail or nearly fail, or may cause death. Cure is gradual and may be attained after several months only. From 50 to 75 per cent. of patients are cured by the operation. Many others are vastly and permanently improved. Some are improved, but are subject to temporary relapses. In Halsted's 39 cases there was not a death from operation.

In the first 16 cases operated upon by the Mayos the mortality was 25 per cent. At present the factors which forbid operation are recognized. In 3709 operations for exophthalmic goiter their mortality was only 3 per cent. (Personal communication

[1] C. H. Mayo in "Collected Papers by the Staff of St. Mary's Hospital," Mayo Clinic, 1912; Halsted, "Annals of Surgery," August, 1913.

[2] "Collected Papers by the Staff of St. Mary's Hospital," Mayo Clinic, August, 1912.

to the author.) They have had 278 consecutive cases without a death, a truly wonderful record.[1] Crile's mortality in 500 cases was 1 per cent.

The elder Kocher ("Jour. Amer. Med. Assoc.," April, 1910) reports upon 535 partial thyroidectomies for exophthalmic goiter. The mortality was 3.1 per cent.; 3 died from the anesthetic, and now his clinic uses local anesthesia preceded by Crile's plan of psychic narcosis; 3 others died from kidney disease which existed at the time of operation. Now no operation is recommended in his clinic if kidney disease exists. There were 3 thymus deaths; 4 with status lymphaticus died suddenly while being prepared for operation. Such patients should not be operated upon before they have been greatly improved by medical treatment. Kocher, like Halsted, says that the degree of improvement depends upon the amount of gland removed. In such cases use medical treatment and the *x*-rays first. If this plan fails, tie one or more of the thyroid arteries before doing thyroidectomy.

My personal experience in exophthalmic goiter is small. I have performed thyroidectomy for exophthalmic goiter 18 times, with 2 deaths.

The Parathyroid Glands and Tetany.—(See collective review in "Internat. Abstract of Surgery," May, 1915, by Eugene H. Pool, and Dercum's "Biology of the Internal Secretions," W. B. Saunders Co., 1924.) These glands were discovered by Sandström in 1880, and their vital functions were pointed out by Gley. He showed that removal of the parathyroids causes tetany. The glands arise from the entoderm of the third and fourth branchial clefts. They contain epithelial cells and tissue resembling that of the thymus.

The parathyroids are brownish red and are larger in adults than in infants. They are constant in man, never being congenitally absent.

They are usually four in number and are ordinarily placed external to the thyroid capsule. In some cases, however, one or more of them may be found embedded in the thyroid gland, but even when they appear to lie within the thyroid they are always separated from it by a capsule of connective tissue.

While there are usually four parathyroids, there may be only three, or there may be five, six, seven, or eight. Accessory parathyroids may be found over wide areas, but are most common near the thymus. One was discovered by Rogers and Ferguson in the middle of the posterior portion of the pharynx; and there was found in the thorax by Ogle a gland that was partly parathyroid.

From their usual situation the parathyroids are divided into superior and inferior, or external and internal. Walsh describes these glands in adults as being each from 6 to 7 mm. in length, 3 to 4 mm. in breadth, and 1 to 1½ mm. in thickness. Each of these glands is supplied by a terminal artery, and the supply is very largely obtained from the inferior thyroid artery or from the branch of anastomosis between the superior and inferior thyroid vessels.

If the parathyroid glands be extirpated from an animal, tetany usually develops (*experimental tetany*). This is positively the case in dogs. These glands certainly have most important functions in the metabolism of the body. They are essential for normal metabolism (Mayo and McGrath in "Annals of Surgery," Feb., 1912). MacCallum and Voegtlin ("Johns Hopkins Hosp. Bull.," March, 1908) believe that damage to or removal of them causes great changes in calcium metabolism. Other observers believe that the glands destroy certain toxins, especially amines, which are formed in the intestine by bacteria acting on proteins. Extirpation of the parathyroids lowers sugar metabolism; in other words, functionating parathyroids inhibit the elimination of sugar and reinforce the action of the pancreas (Dercum, Ibid.). The parathyroids, like the pancreas, are antagonistic to the chromaffin system and to the thyroid.

Very little is known of diseases of the parathyroid glands. A few cases of tumor have been reported, each being an example of either work-hypertrophy or adenoma. One of these cases was reported by the author in "Surg., Gyn., and Obst.," Jan., 1909. In this case the tumor was removed under the impression that it was an adenoma of the right lobe of the thyroid gland. The pathologic report, however, showed it to be a parathyroid. No trouble of any kind followed the operation, though at a later period enlargement of the opposite side of the neck occurred. This has been let alone through fear that it may be a left parathyroid. In spontaneous tetany histologic changes have been found in the parathyroids and there is some evidence that traumatism may produce functional insufficiency.

Some persons have maintained that deficiency of parathyroid secretion is the cause

[1] C. H. Mayo in "Collected Papers by the Staff of St. Mary's Hospital," Mayo Clinic, 1912.

of paralysis agitans, but this idea has been warmly combated and lacks evidence. Some observers believe that there is a deficiency of parathyroid secretion in exophthalmic goiter.

In view of the well-known fact that removal of or damage to the parathyroids may result in tetany (*hypoparathyroidism*), provided that several of these glands or all of them are damaged or removed, it becomes the duty of the surgeon, when operating for goiter, to exercise the utmost care that he does not remove any of these bodies. The safest way to avoid them is to retain the posterior portion of the capsule of the thyroid gland. If, during operation, any small body that resembles a parathyroid be detected, it should be let alone; or if such a body has been accidentally removed, it should immediately be implanted into the capsule of the lobe of the thyroid gland that has been left undisturbed. It is highly improbable that the removal of even both parathyroids on one side will cause tetany if there are two normal parathyroids on the opposite side.

On account of the possibility of the development of tetany the question of the transplantation of parathyroids from animals becomes extremely important. Halsted has made some very valuable experiments upon the auto- and isotransplantation of the parathyroid glands in dogs ("Annals of Surgery," Oct., 1907; "Jour. of Experimental Med.," vol. xi, No. 1, 1909). He has shown that if the parathyroid be transplanted into an animal with normal parathyroids failure will follow, and the transplanted glandule will disappear. If, however, there be parathyroid deficiency in the animal into which the transplantation is made, the glandule will attach itself and grow. He obtained the best results by placing the parathyroid beneath the posterior sheath of the rectus muscle of the abdomen. Some observers have placed it in the spleen; others, within the peritoneum and in various other regions.

One of the dogs experimented upon by Halsted and reported upon in "Jour. of Exper. Med.," vol. xi, No. 1, 1909, lived in perfect health "for fifteen months and was in good health until the performance of the final operation, at which a parathyroid autograft" was removed. The dog died in three months from hypoparathyroidism (Ibid., No. 3, 1912). It has been shown by Lester that a dog from which the parathyroids have been removed may be kept alive for a year at least provided that liberal amounts of lactose are added to the diet (quoted from the "Amer. Jour. of Physiology" by the "Brit. Med. Jour.," Dec. 1, 1923).

If tetany follows thyroidectomy, it may be treated by the intravenous, rectal, or stomach administration of a 5 per cent. solution of lactate of calcium (MacCallum and Voegtlin, Loc. cit.). Von Iselsberg gives parathyroid tablets and, if these fail, practices parathyroid transplantation. Beebe and Berkley have prepared a parathyroid serum which they claim to be efficient. Charles H. Mayo maintains that in tetany either the serum or the calcium lactate should be used, in the hope of tiding the patient over until parathyroid glands can be secured and implanted ("Annals of Surgery," July, 1909). Human parathyroids are preferable. They should be obtained from infants which died during delivery or from adults killed by accident. The calcium salt may be given intravenously, subcutaneously, by the stomach, or by the rectum. Joseph H. Branham ("Annals of Surgery," Aug., 1908) has reported tetany following thyroidectomy cured by the subcutaneous injection of parathyroid emulsion. The emulsion was made by grinding up fresh glands of beeves in a mortar, and then pouring 400 c.c. of sterile salt solution into the mortar. The preparation was filtered through sterile gauze and was administered beneath the patient's breast.

J. Clarke in 1815 and S. L. Steinheim in 1830 described tetany. The name was coined by Corvisart. The condition has been described in association with many very different conditions (pregnancy, gastric dilatation, childhood). It is assumed that in all forms of tetany there is impaired secretion of the parathyroids because of damage by toxins or traumatism. The form we are considering here is due to removal of or injury to the parathyroids (Erdheims designates it *tetany parathyreopriva*). Cases of tetany in the newborn have been reported.

When tetany begins to develop in a patient there are usually headache, dizziness, and pain in the extremities. The muscles in one or both forearms and hands are liable to be affected. The hand flexes at the wrist, while the fingers are extended, and in some cases the forearm flexes at the elbow. Now and then the fingers will flex at the metacarpophalangeal joints, but the distal phalanges will remain extended. These spasms are painful. Similar spasms may occur in the feet and toes. In most severe cases the trunk muscles and those of the chest, throat, and eye may be involved.

Trousseau, years ago, showed that a spasm may be brought on in the affected

limb by pressing upon the nerve-trunks and blood-vessels; this is called the *Trousseau sign*. Pressure upon the facial nerve may induce the spasms, and it is called *Chvostek's sign*. *Erb's sign* is a great increase in the galvanic irritability of the motor nerves. *Hoffmann's sign* is excessive sensitiveness of the sensory nerves. *Schultze's tongue sign* ("Münch. Med. Woch.," Oct. 31, 1911) is said to be invariably present in adults with tetany. If the side of the tongue be tapped the organ responds by grooving itself on that side. If the tongue be lifted by a spatula and the dorsum be tapped a constriction like a waist forms.

Tetany due to absence of the parathyroids will inevitably prove fatal if not treated actively.

Before we understood the necessity of guarding the parathyroids tetany after goiter operations was not uncommon. The preservation of the posterior portion of the capsule has almost abolished this peril. In 3203 operations on the thyroid performed at the Mayo Clinic in St. Mary's Hospital, Rochester (up to Dec. 1, 1911), there was but 1 case of tetany and the symptoms in that were slight and transitory.

XXXI. THE CAROTID GLAND; THE THYMUS GLAND

The Carotid Body or Gland.—This structure was discovered by Haller in 1743. It is a part of the chromaffin system and contains epithelial cells. It is about the size of a grain of rice and lies in or very near the carotid bifurcation, being adherent usually to the common carotid, occasionally to the external or internal carotid by the ligament of Mayer. Tumors may form in this little body. The type found is the perithelioma. They are most common in those between twenty and thirty years of age. Such a tumor grows slowly, is hard, is movable from side to side, but not up and down, and is lifted with each beat of the carotid artery. In the long run it tends to become malignant. As the tumor grows it eventually surrounds the common carotid artery. Dr. Wagner, of Wilkesbarre, Pa., referred to me a patient with rapidly growing bilateral tumors of the carotid bodies. No operation was performed. The tumors were removed postmortem and proved to be sarcomatous.

Treatment of Tumor of the Carotid Gland.—Callison and MacKenty ("Annals of Surgery," 1913, lviii) collected 54 operations. Of these, 32 recovered and 22 died. Of the cases which survived, 3 had hemiplegia with aphasia, 4 dysphagia, 1 constant cough, 5 deviation of the tongue, 4 eye symptoms, and 4 facial palsy. Winslow has collected 10 more cases ("Annals of Surgery," 1916, lxiv). Operation on an advanced case is very difficult, will probably require ligation of the common carotid, and will cause grave injury to important nerves. In one of the author's patients the common carotid was tied and the patient developed laryngeal palsy and hemiplegia. Early operation may permit of removal of the tumor without tying the common carotid artery. In his second and third cases the author was able to accomplish this. My first case led me to agree with Reclus that these tumors should be let alone unless they are productive of dangerous symptoms. I have come to the conclusion that the time to operate is early, long before there are dangerous symptoms, and when we may perhaps get off without tying the common carotid. To wait for obvious malignancy is to court failure or disaster (see the author in "New York Med. Jour.," Feb. 7, 1914; also Callison and MacKenty in "Annals of Surgery," Dec., 1913).

Suprarenal Capsules.—The Adrenals.—The adrenal cortex and the adrenal medulla are definite and distinct structures. The cortex is epithelial in origin. The medulla arises "in close connection with, if not in common with, the cells of the sympathetic nervous system" (Dercum, "The Biology of the Internal Secretions"). The cortex takes origin from the anterior portion of the Wolffian body, that is to say, from the same blastodermic layer as the sex organs.

We know that when the thymus gland persists and hence when its function is excessive, the medulla of the adrenal shows high development, or perhaps has been injured by tuberculosis, as has been noted in Addison's disease. It becomes evident that the medullary portion and the cortical portion are two separate and distinct organs which are not related, but are adjacent, as the medullary portion is stained yellow by the cells of chromin and is called the chromaffin portion. Chromaffin material is not limited to the medulla of the adrenals, but exists in the sympathetic ganglia, in the carotid body, and in the coccygeal glands. All of the tissues that contain chromaffin material are considered together as the chromaffin system. The cells of the medulla, of the adrenals, and all of the chromaffin system produce a hormone—adrenalin

(epinephrin). It has been claimed that enlargement of the thymus is the result of partial development of the chromaffin system. There is a strange association between the adrenals and the sexual organs. Cases of adrenal disease have been reported in which the external genitals of the female approach the male type (enlarged clitoris, perhaps a male urethra or labia which suggests a scrotum). In these cases there is disease or notable enlargement of the cortex of the adrenals. Some children which appear normal at birth, and perhaps for several years after birth, accumulate an undue amount of fat, especially in the buttocks, the belly, the hips, and the mons veneris. In such cases the child develops prematurely. It is stronger than befits its age and there is premature sexual development. Even in a young child hair may appear on the pubes and in the armpits, and in boys a growth of hair may be noticed upon the face. The voice and the external genital organs may resemble strongly those of the adult. In fact, in boys even at a very early age there may be sexual capacity. In girls decided enlargement of the clitoris may be observed as well as enlargement of the mammary glands and menstruation may appear. In these cases there is no pituitary enlargement, but an adrenal tumor usually exists. Sooner or later these cases waste and emaciate and perish from exhaustion. An older woman, the victim of adrenal disease, is apt to suffer from menstrual disorder, and finally from a premature menopause. She takes on a great amount of fat and shows a definite change in disposition and the assumption of masculine characteristics. Of course, if an adult, the external genital organs are not affected. Sooner or later, as we noticed in younger people, the patient becomes weak and emaciated and decidedly depressed.

The adrenals may be the seat of enlargement, of atrophy, of tumor, or of cysts. In 1908 Doran reported a cyst of the adrenal capsule in a patient sixty-two years of age, which he removed by operation. There are two similar specimens in the Royal College of Surgeons (Sir Hamilton A. Ballance, "Brit. Med. Jour.," June 2, 1923).

The common condition calling for operation is an adrenal cyst. As a rule hemorrhage occurs in these cysts, hence the fluid is generally of a brownish color. It is not necessary that a cyst should exist to have a hemorrhage into the adrenal, as we know hemorrhage may occur in recently born children and in the inmates of hospitals for the insane. Suprarenal cysts may attain a very large size without causing any general symptoms, although in a child there are apt to be symptoms of perverted development as previously cited. In some of the cases there has been severe pain. Tumors cannot be detected until large enough to be palpated. Of course the kidney is pushed downward. As Ballance points out (Ibid.) a right-sided cyst displaces the liver toward the left side and a left-sided cyst displaces the spleen and the tail of the pancreas. The usual routine of surgery has been to make an abdominal exploration to determine the diagnosis. It seems to be better to make a lumbar incision, the ordinary kidney incision, as Ballance points out (Ibid.). Such an incision can be extended forward as much as is necessary and we are able if we desire to remove the last rib. The fluid should be evacuated and an attempt should be made to completely enucleate the cyst. If it is impossible to remove all of the cyst wall, and we are compelled to leave the deepest part, we can drain through the lumbar incision. See the report of a successful case of removal of a cyst of the suprarenal body by Sir Hamilton A. Ballance in the "Brit. Med. Jour.," June 2, 1923.

A microscopic examination of the specimen showed cells of the adrenal cortex embedded in the outer half and that many of the glandular elements in the wall of the cyst had degenerated.

The Thymus Gland.—This bilobed ductless gland is present in all vertebrates. It becomes fully developed toward the end of the second year of life. From that period it remains stationary for a time and then undergoes retrogression. At puberty retrogression becomes rapid. Finally, the gland almost entirely disappears, although a small vestige of it usually remains through life. Studied in the very young child, it is found to consist of a thoracic portion and a cervical portion. The chief part of the gland lies directly back of the sternum and upper four costal cartilages of each side in the superior and anterior mediastinal spaces. On each side are the pleura and lung. Posteriorly it lies upon the pericardium, superior vena cava, innominate vein, and pulmonary artery. The two lobes from the gland rise into the neck in front of the trachea. The left lobe overlaps the common carotid; the right lobe, the innominate artery. A strand of fibrous tissue usually passes from the lobe which ascends highest to the corresponding lobe of the thyroid gland. The lobes of the thymus receive

numerous veins from the thyroids. The inferior thyroid artery is the chief source of arterial blood. The thymus is composed of many lobules separated by septa. The undegenerated thymus contains both lymphoid and epithelial structures.

The cells of the reticulum are epithelial. In the medulla of the lobules are the concentric corpuscles of Hassall which are derived from the epithelium of the reticulum. The small thymic cells are probably lymphocytes. In Hammar's words: "The thymus is an epithelial organ which is permeated with lymphocytes" (quoted by Charles H. Mayo and Bernard F. McGrath in their thorough and impressive study of "The Surgical Importance of the Thymus"). (See "Collected Papers by the Staff of St. Mary's Hospital," Mayo Clinic, 1912.)

The function of the thymus is as yet undetermined. Some believe it is merely a lymphatic structure and furnishes no internal secretion. Others believe that it furnishes an internal secretion of great, perhaps of essential, importance in the development of the skeleton and other structures. Some observers believe that the thymus destroys toxins, and that deficiency of thymus permits the accumulation of toxic matter in the system. These studies of hypothymization were made on thymectomized animals. We do know that when the thymus persists or enlarges this process is but a part of general lymphatic enlargement or lymphatism. (See Dercum's "The Biology of Internal Secretions," W. B. Saunders Co., 1924.)

Speaking in general the gland is composed of a lymphoid cortex and an epithelial medulla.

Experiments to determine the result of excessive thymus function (hyperthymization) are peculiarly contradictory, unsatisfactory, and inconclusive. In these experiments thymus glands have been implanted, thymus juice has been injected, and thymus feeding has been practised.

Mayo and McGrath (Ibid.) conclude "that the thymic function is concerned in the general process of nutrition, particularly with the ossification of bone"; further, it is probable "that the thymus and the chromaffin portion of the adrenals act antagonistically on the sympathetic."

Although the thymus should have practically disappeared between the twelfth and twentieth year, there are cases in which it fails to disappear at all. There may never have been any symptoms to suggest persistence and the gland may be discovered at a necropsy. It is known that the thymus persists in castrated animals (Renton in "Glasgow Med. Jour.," 1916, lxxxvi).

The thymus gland may enlarge. The enlargement is most usual in childhood, but if the thymus be persistent, may occur much later in life. The condition is hypertrophy or hyperplasia. Enlargement of the gland may be met with in exophthalmic goiter, leukemia, Hodgkin's disease, and status lymphaticus. It may produce no symptoms whatever. It has been held responsible for asthma and for sudden death (*thymic asthma* and *thymic death*).

Thymic asthma may be noted in cases of status lymphaticus (status thymolymphaticus). It occurs especially in children and youths. There is laryngeal spasm and the larynx is usually incompletely developed. These patients may die suddenly from heart failure or may develop evidences of dementia præcox or psychasthenia. Sudden death in children or adults may occur if there is enlargement of the thymus. In such a case there is sudden heart failure due to a toxic agent secreted by the thymus epithelium. Any shock, physical or mental, may precipitate it. Enlargement may sometimes be recognized by the *x*-rays—by no means always.

Infectious and wasting diseases in children may cause atrophy of the thymus. The gland may be the seat of hemorrhages, inflammation, tuberculosis, calculi formation, and necrosis (in diphtheria). In congenital syphilis the thymus may be the seat of gummatous change or fibrosis.

DuBois's abscesses occur in syphilis of the thymus. Many spaces form and the spaces are full of a fluid resembling or actually pus.

Enlargement by cysts or tumors may occur. Innocent tumors (fibroma, myxoma, and adenoma) are rare. Malignant tumors (carcinoma and sarcoma) are more common. The most common tumor is lymphosarcoma (*thymoma*). Spindle-cell sarcoma and endothelioma may arise (see James Ewing on "The Thymus and its Tumors" in "Surg., Gynec., and Obst.," April, 1916).

Tumors of the thymus cause the symptoms of mediastinal tumor (cyanosis, dyspnea, exophthalmus, cough, alterations in voice, circulatory disturbance). Metastases are often early. Such a tumor may be rapidly fatal by asphyxia. With not a few cases of thymus tumor myasthenia gravis has been associated. No symptoms are

reported to suggest sympathetic disturbance of the chromaffine system (Ewing, Ibid.).

Status Lymphaticus (*Status Thymicus; Lymphatism*).—This condition is associated with enlargement of the thymus. (See page 158.)

Operations for Thymus Enlargement or Tumor.—(See Oliver in "Archiv. gén. d. Chir.," vi, 138, 1912.) Operators have removed the thymus in goiter operations and also when the thymus alone has been enlarged.

To perform *exothymopexy* expose the thymus by an incision above the sternum, catch the gland and capsule with forceps, draw them up as far as possible, and suture to the fascia. This operation is without much value. A decompression operation can be done by resecting the manubrium. It does not cure, but may give relief.

Thymectomy has been performed a number of times. It may be extracapsular or intracapsular, partial or complete. In 42 reported cases there were 15 deaths. I have had 2 successful cases of intracapsular thymectomy.

XXXII. DISEASES AND INJURIES OF THE LYMPHATICS

Wounds, Ruptures, and Occlusions of the Left Thoracic Duct.—It was long believed that wounds of any part of the thoracic duct were almost certainly fatal. It is now known that wounds of the duct at the root of the neck are rarely very dangerous unless the duct be divided close to the vein. A wound of the duct, as the result of an accident, is rarely diagnosed because the adjacent vital structures are apt to be injured at the same time and death rapidly ensues. Wounds of the duct or of its large branches occasionally, but very rarely, are inflicted during surgical operations. Benetau speaks of 12 cases thus inflicted; in 8 cases the operation was for tuberculous glands, in 3 for malignant glands, and in 1 for ligation of the subclavian artery. One alleged danger of wound of the duct is entrance of air into the adjacent vein. This is said to have happened in 1 case. As a rule, the short end of the cut duct does not bleed, the duct valves preventing hemorrhage. In Fullerton's case, when a grooved director was passed along the stump of the duct by way of a terminal into the vein, blood at once appeared. In most cases the injury is not recognized at the time, but is later, when white fluid escapes from the wound. The discharge may continue or may cease spontaneously. If it continues, there is rapid loss of flesh and strength. I assisted Dr. Keen in the case in which he did recognize the wound at the time it was inflicted. A thin fluid was observed flowing rhythmically from a tear in the duct. It is to be remembered that the course of the cervical part of the duct is very variable and sometimes the duct lies very high above the clavicle. There was 1 death in 17 recorded cases (Dudley P. Allen and C. E. Briggs in "Amer. Med.," Sept. 21, 1901).

The discharge from a cut duct may continue to leak—perhaps a pint or more flowing out during twenty-four hours. In Wilms's case of division of the duct 2 quarts of fluid escaped in the first twenty hours, but in six days the duct had healed ("Semaine Med.," March 23, 1910). If leakage continues long, constitutional effects will sooner or later become evident. In Schoff's case ("Wien. klin. Woch.," Nov. 28, 1901) it was not known that the duct had been injured until the stitches were removed from the wound in the neck. The wound was found distended with chyle and Schoff packed it with iodoform gauze. Fifteen days later the patient died from chylothorax and pulmonary compression.

Rupture of the thoracic duct or of the receptaculum chyli may occur from traumatism or be a secondary consequence of tuberculosis or carcinoma. Rupture may lead to death by starvation, or to fatal compression by the exuded fluid (Harvey W. Cushing in "Annals of Surgery," June, 1898). Occlusion of the main duct may be followed by rupture of the receptaculum chili. Gradual occlusion by a tuberculous or inflammatory growth may not produce any serious symptoms. Cushing assumes that in such a case the lymph-current is reversed and is taken up by the right thoracic duct. In gradual obstruction masses of dilated lymph-vessels may be found, particularly in the thorax and abdomen. If lymph-vessels rupture, chyle flows out and, according to the situation, there arises "chylous ascites, chylothorax, chyluria, or chylous diarrhea" (Ibid.).

Treatment of Wounds.—If the wound in the neck does not completely divide the duct, and if the duct wound is discovered at the time of operation, suture the duct. Allen sutured the duct and had no further leakage. Keen sutured the duct and recovery followed. If the duct be completely divided, ligate both ends or follow

Cushing's advice: "It would seem advisable to place a provisional ligature about the duct on the proximal side of the wound, and to control the leakage, if possible, by a gauze tampon. This would act as a safety-valve, and allow chyle to escape, if the pressure in the duct became too great and there was difficulty in establishing a collateral lymphatic circulation. The patient meanwhile should be given a meager diet. If the leakage should become uncontrollable and threaten starvation, the provisional ligature should be tied, with the hope of a final readjustment of collateral circulation or trusting in the presence of some anomalous anastomotic branch which might suffice to carry the lymph into the venous circulation" (Ibid.). Fullerton tied both ends of a divided duct and the patient recovered ("Brit. Med. Jour.," June 16, 1906). Deanesley ("Lancet," Dec. 26, 1903) inserted the divided duct into the internal jugular vein and sutured it in place. There was some leakage, but recovery ensued. After ligation the duct on the proximal side of the ligature may distend greatly and may actually rupture. When a wounded duct is leaking the patient should be fed exclusively on proteins. The diet should be scanty and the patient must be kept absolutely quiet in order to keep pressure in the duct at as low a level as possible during the establishment of a collateral lymphatic circulation (Fullerton, Loc. cit.). Nasaroff (Abstract in "Surg., Gynec., and Obst.," Jan., 1914) reported a case of injury to the duct during a surgical operation, and collected 62 others from literature. Most cases heal after more or less prolonged chylorrhea. Tamponade and ligation must be considered in the treatment. Frederick Lee has shown experimentally that a collateral lymph circulation is quickly re-established after ligation and that a duct wound heals rapidly ("Bull. Johns Hopkins Hosp.," Jan., 1922).

W. A. Costain has deliberately tied the duct near the vein, opened it, and drained. He has done so to prevent the absorption of bacteria and toxins in cases of peritonitis. In his reported case the discharge ceased on the seventh day. He calls the operation *lymphaticostomy* ("Surg., Gynec., and Obst., March, 1923).

Lymphangitis is inflammation of lymphatic vessels. *Reticular* or *capillary* lymphangitis (erysipeloid), which is inflammation of lymphatic radicles, is seen in some circumscribed inflammations of the skin. It is apt to attack the hands, causing redness and swelling, fading at the point of initial trouble while it spreads at the periphery; it is caused by micro-organisms derived from decomposing animal matter (see page 131). Erysipelas also causes it (see page 131). *Tubular* lymphangitis, which is due to the entry into the lymphatic ducts of virulent micro-organisms or toxic materials, is seen after the infliction of dissecting wounds, septic wounds, snake-bites, etc. It is announced by edema and by definite, hard, red streaks running from the wound up the extremity. Suppuration may occur.

Septic or **infective lymphadenitis,** or inflammation of the lymph-glands, may follow lymphangitis or may be due to the deposition of infective material, the lymph-vessels not being inflamed. In this form of lymphadenitis there are pain, tenderness, and swelling; in severe cases there are a chill and a septic fever. Suppuration may arise.

The **treatment** is to drain and asepticize the wound, to apply iodin, blue ointment, or ichthyol over the glands and vessels, and to employ rest, heat, and compression. Internally milk-punch, quinin, and nourishing diet are required. If the glands do not rapidly diminish in size after disinfection of a wound, and if they are in an accessible region, extirpate them. If suppuration of the glands occurs, incise and drain.

Acute lymphadenitis, or acute inflammation of the lymphatic glands, may be due to tubercle, syphilis, toxins, cold, traumatism, or bacteria. Suppuration may or may not occur. In inflammatory lymphadenitis there are pain, heat, and nodular swelling. In severe cases there is fever.

The *treatment* is to asepticize any area of infection, place the parts at rest, apply heat and ichthyol ointment, or inject into the gland every day 5 minims of a 3 per cent. solution of carbolic acid to prevent suppuration. If the glands do not rapidly shrink, extirpate them. If pus forms, evacuate it, drain, and asepticize.

Chronic lymphadenitis is almost invariably syphilitic or tuberculous. It requires constitutional treatment and the local use of ichthyol, iodin, or blue ointment. If these remedies are not rapidly successful, tuberculous glands should be removed, but syphilitic glands rarely require such radical treatment.

Lymphangiectasis (*varicose lymphatics*), or dilatation of the lymphatic vessels, is due to obstruction. It may be congenital (macroglossia; lymphatic nevus, see page 313). It may be acquired. Many external causes may produce obstruction; for instance, the removal or suppurative annihilation of a considerable group of

lymphatics; pressure of a scar or of a new growth upon lymph-vessels; tuberculosis or neoplasm of a group of glands. In many cases of external pressure upon lymphatics there is no lymphangiectasis because the lymph finds other channels. In fact, it has been proved that ligation of a large lymphatic trunk is not of necessity followed by lymphangiectasis. Even when the condition arises from external pressure, it is usually temporary, although, particularly if glandular tumors exist, it may be permanent.

The persistent cases are usually due to obstruction within the ducts, for instance, endothelial proliferation as a result of chronic lymphangitis, or recurrent attacks of acute capillary lymphangitis (erysipelas) or ordinary acute lymphangitis; or tuberculosis and other chronic infections. There may be such a condition as primary intralymphatic endothelial proliferation ("Med. Record," Sept. 6, 1902). Blocking with *filarial worms* may occur, and if it does, the lymphangiectasis is usually situated in the pubic, the inguinal, or the scrotal region, or on the inner side of the thigh. There are two forms of lymphangiectasis: the *varicose*, in which the vessels have a tortuous outline, like varicose veins, but are covered only with surface epithelium; and *lymphatic warts* (*lymphangioma circumscriptum*), in which wart-like masses spring up, these masses being covered with epithelium and filled with lymph. In most cases of lymphangiectasis there is considerable hard edema (*lymphedema*). Lymphangiectasis sometimes develops in the upper extremity after removing the axillary glands, and in the lower extremity after removing the inguinal glands. Periodic attacks of pain and redness occur in the area of lymphangiectasis, and usually at such times fever develops. Rupture of the dilated vessels causes a flow of lymph (*lymphorrhea*). Infection and erysipelas are apt to occur, perhaps again and again. It is uncertain whether these repeated attacks of erysipelas cause and maintain lymphangiectasis or are predisposed to by it.

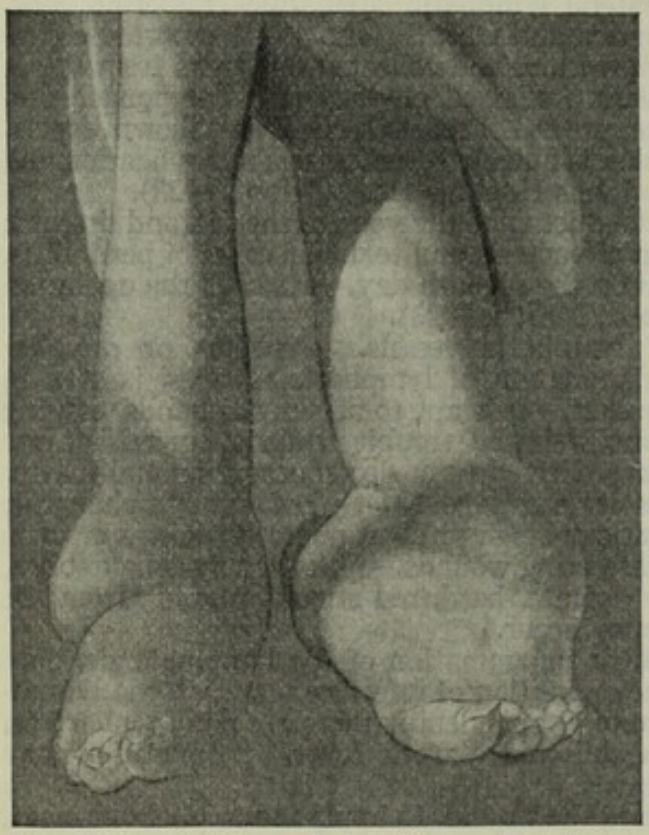


FIG. 1013.—Spurious elephantiasis. No filariæ found. Born and lived in Philadelphia.

Treatment.—If the entire area can be removed, it should be extirpated. Maitland ("Brit. Med. Jour.," Jan. 25, 1902) shows that many varices are local and can be removed. If the varices are only partially removed, lymphorrhea will probably develop.

Lymphangioma is an advanced stage of lymphangiectasis (see page 313).

The **treatment** in mild cases is to pierce each vesicle with the negative pole of a galvanic battery and to pass a current. In severe cases destroy the mass with the Paquelin cautery or excise it with a knife or with scissors.

Elephantiasis is due to lymphatic and perhaps also to venous obstruction brought about by nocturnal filaria (tropical form of the disease) or by streptococci. *True* elephantiasis (elephantiasis Arabum) is chronic hypertrophy of the skin and subcutaneous tissues following a lymphangiectasis produced by a nematode worm (the Filaria sanguinis hominis). The disease is encountered in the tropics only. Elephantiasis of the scrotum is called *lymph-scrotum*. Elephantiasis of the leg is called *Barbadoes leg*.

Spurious or *pseudo*-elephantiasis (Fig. 1013) is hypertrophy of the skin and subcutaneous tissue due to chronic inflammation (for instance, in a leg which possesses an ancient ulcer, or in the scrotum of a man with urinary fistula).

The **treatment** of true elephantiasis is massage and bandaging, excision (as in the scrotum), excision of a strip of the deep fascia (*Kondoléon operation*), ligation of the artery of supply, extirpation, or amputation. Hadley passed silk threads from the involved region to a sound region so as to create new lymph routes. The best opera-

tion for spurious elephantiasis is that of Kondoléon, of Athens. He excises a long strip of deep fascia and sutures the fascial edges to the muscle. New veins and lymphatics form.

Tuberculous Glands.—(See page 180.)

Lymphadenoma (*Malignant Lymphoma; Hodgkin's Disease; Pseudoleukemia*).—Malpighi in 1665 gave an outline of the condition which Thomas Hodgkin described in 1832. In 1865 Sir Samuel Wilks gave it the name of Hodgkin's disease. The term "lymphoma" is used loosely to designate any persistent swelling of a lymphatic gland or glands. Lymphadenoma means a swelling of lymph-glands or lymphadenoid tissue due to endothelial proliferation, is progressive in character, involves group after group of glands, is associated with anemia, and often accompanied by secondary growths in the abdominal viscera.

This disease can attack persons of any age, but is most common in those under forty, and affects males far more frequently than females. Hereditary influence is not apparent. It may start in a seemingly robust person. In many cases the disease arises slowly in apparently healthy glands, and exists for some time before it takes on signs of malignancy and invades distant glands. In some cases the disease comes on acutely and has a tendency to generalization from the start; in others it appears to remain localized for many months. Some regard the condition as neoplastic, others as inflammatory. A gland enlarged from irritation or from tuberculous disease may become lymphadenomatous, and tubercle bacilli can sometimes be found in lymphadenomatous glands. Lazarus asserts that the disease is lymphosarcoma and the tuberculosis accidental. Musser, Sternberg, and others believe that tuberculosis is the disease and that lymphadenoma is really tuberculosis, but this view seems to have been definitely disproved. Late in a case miliary tuberculosis is rather apt to arise. There is a form of tuberculosis strongly resembling Hodgkin's disease, but I do not believe that the two processes are identical. A diphtheroidal bacillus is regarded by some as causal (Yates and Bunting, "Jour. Amer. Med. Assoc.," June 12, 1915, also Cunningham in "Amer. Jour. Med. Sci.," March, 1917). Those who assert that the condition is a granuloma due to infection believe the point of entry of the bacilli may be the tonsil, the sinuses, the teeth, the middle ear, the intestine, or the skin.

That the disease is at least similar to sarcoma is held by many. That it is a variety of sarcoma is asserted by some. In Hodgkin's disease Coley's fluid (the mixed toxins of erysipelas and Bacillus prodigiosus) causes a reaction as in sarcoma. The glandular and splenic enlargements are neoplastic and not hyperplastic. The new tissue formed is called lymphadenoid tissue and, according to Banti, it is often atypical, tends to invade glandular trabeculæ and capsules, sometimes adjacent tissue, and gives origin to metastases.

Leukemia and pseudoleukemia are closely related, and both, according to Banti, are sarcoma. In leukemia the influence that stimulates proliferation acts chiefly upon the bone-marrow; in Hodgkin's disease, upon the lymph-nodes (Neumann, quoted by Coley, in a forceful article maintaining that Hodgkin's disease is a type of sarcoma, "Trans. Amer. Surg. Assoc.," 1908).

Symptoms.—The glands in the neck are usually involved first, especially the glands of the subclavian triangle, but the disease may begin in the cervical glands of the anterior triangle, the axillary glands, the inguinal glands, the thoracic glands, or the intra-abdominal glands.

Two or more regions are sometimes involved simultaneously or almost simultaneously.

When the disease begins in the neck it affects at first one side, and after many weeks or months the other side becomes involved. The glands are at first hard, painless, isolated, not tender, movable, the skin moves freely over them, and they may remain in this condition of freedom from periglandular involvement. Very late the large glands may weld together and form great masses upon both sides of the neck and in the axillæ, obstructing respiration. In contradiction of the general view it is certain that, in acute cases or during acute exacerbations, periglandular structures may be invaded. Great subcutaneous induration may occur.

After a time a very large mass may break through its capsule and infiltrate adjacent structures, and in very rare cases the skin becomes adherent and finally breaks. Intrathoracic symptoms point to involvement of the thoracic glands. It may be possible to palpate enlarged abdominal glands.

Lemon and Doyle ("Int. Abstract of Surg.," Jan. to June, 1922, vol. xxxiv) reviewed

26 cases of Hodgkin's disease with involvement of the mediastinum, studied in the clinic of the Mayos. They say that 23 of these were proved absolutely by the microscope. It has been the general opinion that children are attacked more frequently than adults, but in this series of cases the ages ranged from twenty to sixty-four. There was apparently no connection between the mediastinal involvement and antecedent involvement of the throat. In only 3 cases were cyanosis and swelling of the face and neck noted, and these cases were the only 3 in which there were dilated veins. In all of the cases there were palpable glands of the neck.

It is usually held that there is no distinctive blood-picture. Yates and Bunting (Ibid.) insist that there is, and set it forth as follows:

"There are two distinct types, an early and a late, showing a constant characteristic increase in the number of platelets (unless exhaustion of the bone-marrow occurs) with abnormally large forms and either a relative or absolute increase in the so-called transitional cells. In the early type the leukocytes are usually less than 10,000. Very early there is a moderate increase in the basophils, and when the disease is well established the eosinophils are slightly increased. The polymorphonuclear neutrophils remain within the usual limits, the lymphocytes at or slightly above the normal. The late type shows a leukocytosis which may reach 100,000, the neutrophils are relatively increased to a percentage of from 75 to 92, and the lymphocytes are reduced to 5 per cent., frequently even less. The transitionals, the only other cells found in any numbers, are usually above 8 per cent. unless the leukocytosis is very high, when they may be relatively fewer, but still exceed the lymphocytes in number. This late picture is a result of the intensity of the disease rather than the extent of involvement, and is usually largely dependent on duration for its development."

The spleen and liver are enlarged; the thyroid may be enlarged. When anemia becomes marked there are the ordinary symptoms which go with it, viz., palpitation, breathlessness, indigestion, vertigo, headache, pallor, and sometimes epistaxis. Without obvious reason the glands may suddenly increase in size or rapidly undergo a notable but temporary diminution. In fact, a characteristic feature of the disease is fluctuation in the size, consistency, and movability of the glands (Yates and Bunting in "Jour. Amer. Med. Assoc.," June 12, 1915). I have never seen secondary pyogenic infection.

Distinct attacks of fever arise at times in many cases, and ague-like paroxysms may occur. During the existence of fever the glands usually increase rapidly in size.

Diagnosis.—In a wide-spread case the diagnosis is easy; in a localized case it is difficult. True tuberculous glands are most apt to appear first in the submaxillary triangle or some other part of the anterior triangle; lymphadenomatous glands, in the root of the neck or in the occipital triangle. Tuberculous adenitis is most common in children. As a rule, tuberculous glands caseate, but they may remain localized for years if caseation does not occur. The tuberculous glands usually soon become adherent and immovable. Lymphadenoma is most common after twenty, rarely remains localized for more than a few months, rarely softens unless very large, and the glands are separated and movable until a huge mass forms. The fluctuations in the size, consistency, and movability of the glands and the blood-picture are important diagnostically. Early softening, prolonged limitation to one region, and absence of pronounced anemia in a person under twenty point to tubercle. In doubtful cases a gland should be removed for microscopic and bacteriologic study.

In wide-spread tuberculous lymphatic involvement, simulating Hodgkin's disease, fever is far more likely to be present than in Hodgkin's disease. LaRoy ("Archives Internat. de Chir.," 1907, vol. iii) says that tuberculous glands are but little improved by the *x*-rays (a statement I do not altogether endorse), whereas, enlargements in Hodgkin's disease may be greatly benefited, and that in tuberculous conditions there is no particular tendency to hemorrhage and there often is in Hodgkin's disease. Coley ("Trans. Amer. Surg. Assoc.," 1908) shows that the patients with Hodgkin's disease react strongly to the toxins of erysipelas.

Prognosis.—The disease is almost always, if not invariably, fatal. Most cases die within three years, some die within two months, some few live four or five years or more. Acute cases die, as a rule, in from two to four months. In 1901 Fischer could not find a single authenticated cure on record. Yates and Bunting ("Jour. Amer. Med. Assoc.," June 12, 1915) have seen two recoveries, regarding as a cure five years' freedom from evidence of the disease.

Treatment.—If the glands are localized to one side of the neck, or even to both sides of the neck, remove the tonsils, put the teeth in order, and treat any disease

of the nasopharynx. In any other region, seek for any possible portal of bacillary entry and apply suitable treatment. Glandular enlargements localized to certain regions should be extirpated (see Yates and Bunting in "Jour. Amer. Med. Assoc.," March 10, 1917). Early removal before dissemination has occurred may possibly save the patient. If early or radical removal is not possible, do not operate, but treat the patient with nutritious food, tonics, courses of arsenic, the mixed toxins of erysipelas and the Bacillus prodigiosus, and applications of the *x*-rays. The *x*-rays are thought to kill causal bacteria and do cause fibrous changes. Coley treated 2 cases by the mixed toxins. In both cases the lymphatic, hepatic, and splenic enlargements entirely disappeared ("Surg., Gynec., and Obst.," Aug., 1911). Efforts are now being made to obtain a curative serum. Beck makes nucleoprotein serum from the glands of cases of Hodgkin's disease. Yates and Bunting employ a vaccine (Ibid.). My experience leads me to agree with Holding and Brown ("Jour. Amer. Med. Assoc.," March 3, 1917), who say that the only results to be expected from treatment are "temporary ameliorations," that the *x*-rays and radium should be used after operation, and that "a Roentgen examination of the chest is indicated in all cases before an extensive surgical removal is considered. This will save many patients from a needless operation."

Climatic Bubo.—(Captain C. S. Butler, M. C., U. S. N., did me the honor to write this article.)—**Definition.**—An adenitis affecting the lymph-nodes of the groin and characterized by prolonged course, slight fever, and a tendency to necrosis on the part of the nodes involved.

Synonyms.—Tropical bubo; non-venereal bubo; adenitis tropicalis; klimatische bubonen (Ger.); les bubons climatériques (Fr.); buboné climatica (Ital.); bubo climatica (Span.).

Geographic Distribution.—The disease is common throughout all tropical countries. It is prevalent in all the islands of the Caribbean, in Central America, and the tropical portions of South America; the east and west coasts of equatorial Africa, the Straits of Malacca, Indo-China, China, Hong Kong, Japan, the Philippines, and the Dutch East Indies.

Etiology.—Though natives may be affected, the condition is much more common among white people, and it occurs much more frequently among men than among women—in fact, it is rarely seen in the latter. This prevalence of climatic bubo among white men and its absence among white women in the tropics lends support to the prevailing idea that the disease is venereal in origin. In nearly all cases of climatic bubo there is a history of a recent immoral contact, and generally this has taken place with a native woman. When we eliminate the usual causes of inguinal bubo, such as gonorrhea, chancroid, syphilis, and sepsis, not to mention plague, septic absorption from sores on the feet, from wounds and from mycotic affections of the feet and crotch, from filarial disease and from trypanosomiasis, there still remains a group of inguinal buboes for which physicians practising in the tropics are unable to assign a distinct cause, though it is evident that the condition is due to a living germ of some sort. We are unable to say, then, whether tropical bubo is a distinct disease or whether it is one of the usual agencies acting in an unusual way.

The disease has its greatest incidence among white soldiers and sailors serving in the hot, humid conditions which prevail in many parts of the tropical world. It is not, however, confined to the tropics, as is shown by Inspector General Godding's figures for the British Navy and by Scheube for Kioto, Japan (35° N.). In the United States Navy there are cases of apparently non-venereal inguinal bubo which occur in northern climates. These cases are increased in incidence for ships stationed in the tropics and for the personnel of many tropical shore stations. Heiner ("Nav. Med. Bulletin," 1913, p. 126) published 18 cases of climatic bubo in all of which a sexual exposure had occurred (usually about three weeks previously). In 13 of these cases smears from the excised glands showed the presence of organisms resembling gonococci. In this connection it may be stated as immunologically conceivable that, with a urethra locally immune from a former gonorrhea, a gonorrheal lymphangitis eventuating in an inguinal adenitis, might occur from inoculation with a new strain of gonococcus which would produce little or no urethritis. Again the bacillus of Ducrey might conceivably gain entrance to the lymphatics and cause adenitis, the portal of entry having healed without being noticed. In each of these hypothetic cases culture of the material from the bubo upon the *ordinary* culture-media of the laboratory would give negative results. Nearly all investigators have reported the primary culture of tropical bubo material as negative. The majority of Naval Medical Officers who have

seen this so-called climatic bubo are firm in the belief that it is usually venereal in origin, though they are unable to explain how the virus gets to the inguinal lymph-nodes without leaving some local evidence of its point of entry. We know, however, that adenitis, other than inguinal adenitis, *does* occur, and that it is often impossible to find the point of entry of the infecting germ. Thus, in plague, the first evidence of infection may be the bubo and there may be no lymphangitis in the area drained by the node involved, nor any papule or vesicle indicating the probable point of entry of the bacillus. It may be well to mention here that Bacillus pestis has been thought to be the cause of climatic bubo. Cantlie was formerly of this opinion. Other authorities have attributed climatic bubo to malaria. Each of these views is erroneous and it may be positively stated that neither plague nor malaria has anything to do with the cause of the condition we are speaking about. Twenty years ago Scheube wrote: "The question of the cause of climatic buboes, according to the material at present obtainable, is impossible to answer, and its explanation must be left for reply to future investigation. Only this much may be said that the affection is caused by some still unknown factor that has undoubtedly some connection with climate." At present the status of the etiology of climatic bubo is substantially as he gave it for the year 1903.

Pathology.—The inguinal or the femoral glands on one or both sides may be involved. Usually the glands above Poupart's ligament are the ones affected, unilaterally as a rule, but occasionally on both sides. One or several nodes may be enlarged, and, in the latter case, one of the series may become much larger than the others. After subsidence of the adenitis there may be relapse on the same side or the process may occur on the other side, leaving the nodes first involved alone. The size of the inflamed nodes varies from that of a filbert to that of a hen's egg. The nodes are congested, edematous, and may soften and give a sense of fluctuation. Often the reaction extends to the capsule and causes a periadenitis. Culture of material taken by gland puncture is usually negative, as stated above, when ordinary culture materials are used. We are not aware of any special methods or media having been employed in the study of this condition. If cultures in the early cases are positive the organisms usually recovered are staphylococci. When the buboes have suppurated, as occurs in about 40 per cent. of the cases, or when the glands have been dissected out, of course we get the ordinary pus organisms in our cultures. Letulle and Nattan-Larrier ("Bull. de la Soc. de Path.," exot. v. 3, 1910, p. 758) describe the histologic changes in climatic bubo as:

1. Dislocation of the glandular tissue,
2. Plasma-cell infiltration, diffuse and patchy,
3. Insular necrosis of the reticular tissue of the gland. They were unable to stain any bacteria in the single node which they studied.

As regards the leukocyte reaction in climatic bubo it seems that in the early stage of the condition there is a moderate leukocytosis. Not all cases, however, give this. Counts vary from normal to 25,000 and over per cubic millimeter. As a general thing the leukocytosis is between 10,000 and 20,000. Certain authors, as, for instance, Clayton ("Jour. Trop. Med.," Jan. 2, 1905) and Phillips ("Nav. Med. Bul.," 1912), have called attention to what would seem to be a rather constant eosinophilia in climatic bubo. In their cases apparently they excluded the things which ordinarily give an eosinophilia, such as intestinal parasites. One of Clayton's cases showed as high as 22 per cent. of eosinophils. Another case showed 8 per cent. of eosinophils, while in both of Phillips's cases the percentage of eosinophils was around 8. Phillips, on account of the eosinophilia, suggested that climatic bubo might be due to some protozoan. Eosinophilia probably has no etiologic significance. It may, however, be of some diagnostic significance, as plague, with which climatic bubo may be confused, has no eosinophilia. In the case of plague, however, the leukocyte counts are very much greater. Climatic bubo, if the gland suppurates, gives a polyneucleosis as does any other abscess. One of Clayton's cases gave the following white counts on different days of the disease: November 24th, 11,200; December 12th, 18,200; January 4th, 10,000, and February 15th, 45,000. On the whole there isn't much that we can say about blood-counts in climatic bubo except that there seems to be primarily in most cases a slight leukocytosis.

Symptomatology.—The period of incubation of climatic bubo is approximately three weeks. As regards its symptomatology, fever (slight), usually remittent in type, occurs in the majority of cases. Malaise and some pain in the region of the affected gland is almost constantly noted. Glands vary in size from a filbert to a hen's egg and often give the impression of fluctuation. If the disease lasts for four to six weeks there is usually some anemia developed. At times the disease runs its course without

fever. At other times the febrile reaction seems to precede the enlargement of the lymph-nodes. The course of the disease is from ten days to four or five months. Chilly sensations and pain in the back and legs are occasionally complained of when the disease begins. Some authors have described a general adenopathy accompanying the inguinal enlargement. In the writer's experience this is unusual.

Diagnosis.—Conditions from which climatic bubo are to be differentiated are mild forms of plague in regions where plague occurs; venereal buboes where the venereal evidence is slight; and Hodgkin's disease showing primary inguinal involvement. Usually the diagnosis is easily made. In case of plague, while about 70 per cent. of plague buboes are inguinal the other symptoms are more marked and graver than in the case of climatic bubo. The leukocytosis, the greater tenderness of the glands, and the mental condition of the patient with climatic bubo should serve to differentiate. Gland puncture and laboratory study will demonstrate Bacillus pestis. As regards the differentiation from Hodgkin's disease it is not usual for the primary enlargement of the lymph-nodes in Hodgkin's disease to be inguinal. The blood-picture is different, and though there may be periods of fever in Hodgkin's disease, the course of this disease is quite different from that of climatic bubo and there is no tendency on the part of the glands to undergo necrosis in pseudoleukemia.

Prognosis.—Thirty-six cases of climatic bubo published by Ruge showed 60.5 per cent. of the swellings absorbed, notwithstanding their size, without operation, while 39.5 per cent. had to be operated upon. Climatic bubo appears not to be primarily dangerous to life. Secondary infections, however, may cause the death of the patient.

Treatment.—The treatment of climatic bubo deserves considerable study. From the figures published above, that is, that 60 per cent. of these swellings may be absorbed without operation, it is evident that the expectant treatment has considerable to be said in its favor. The shortening of the course of the disease and the getting of the patient off the sick list are not necessarily the main considerations. If by the expectant treatment we can obtain the cure of more than half the cases and at the same time leave the lymphatic structures intact it would certainly seem worth while to try this treatment out. Once the glands have been dissected out they cannot be replaced, but nature's repair to the nodes, as is often effected if she is given a chance, probably leaves a large part of the gland structure and gland connections in as good condition as before. To this end the patient should be put to bed and ichthyol spread on gauze, put over the bubo, and a firm bandage applied. If the glands suppurate it is probable that the next best treatment is to open up only those nodes that are broken down. The radical treatment consists in dissecting out of all of the diseased glands and closing the wound thus made in the hope that it will heal with the least possible loss of tissue. There is little doubt that this radical operation shortens the course of the disease considerably. There is grave doubt, however, as intimated above, that it is best in the long run.

Internal medication by salicylates, quinin, and the usual array of "specifics" is useless. Rest, laxatives, and tonics are the general measures indicated.

XXXIII. PLASTIC SURGERY

Plastic surgery includes operations for the repair of deficiencies, for the replacement of lost parts, for the restoration of function in parts tied down by scars, and for the correction of disfiguring projections. Many reparative operations have been devised. Among them are: cheiloplasty, or the construction of a new lip; the closure of a cleft in the palate, the lip, or the penis; the making of a new nose; skin-grafting; fascia transplantation; fat transplantation; bone-grafting; tendon-grafting; grafting of blood-vessel, nerve, cartilage, joint, muscle, or tendon; the introduction of celluloid or metal into the tissues to act as a support; the injection of paraffin into the tissues to amend a depression; the division of shortened tendons and contracted fascia; the diminution in the size of a lip or a nose; the amendment of protuberant ears; the correction of distortion due to cicatrices; excision of scars; closure of congenital sinuses and of fistulæ; and removal of disfiguring growths.

Carrel has proved that autoplastic transplantation of organs can be accomplished successfully; that homoplastic transplantations succeed temporarily only and that heteroplastic transplantations always fail. The rapid destruction of the heteroplastic transplant as well as the destruction of the homoplastic transplant is due to the invincible tendency of the organism to destroy foreign tissue. Transplantation of organs is useless in human surgery because a homoplastic transplant, though an anatomic

success, does not functionate (Carrel in "Med. Press and Circular," 1914, xcvii). Lydston has apparently proved that a transplanted testicle may give out an internal secretion for a sufficient length of time to place an individual in the masculine groove and to remove him from the road to perversion. Fingers and toes can be transplanted. For a most able discussion on the transplantation of organs see Harold Neuhof on "The Transplantation of Tissues," D. Appleton & Co., 1923.

The subject of plastic surgery is very extensive, and a treatise upon it should be consulted if one wishes to obtain detailed and comprehensive information.

A plastic operation can only be successful after lupus when the disease has been cured. It is useless to do a plastic operation during active syphilis, and a plastic operation for a syphilitic loss of substance is to be performed only after the patient has been thoroughly treated and the disease has been apparently cured. The first step of a plastic operation consists in making the surfaces which are to be brought together raw; the second step is the complete arrest of bleeding; the third step is the approximation of the surfaces without tension; the fourth step is to close any gap from which tissue may have been transplanted; and the final step is the application of the dressings.[1] The following are the methods used[2]:

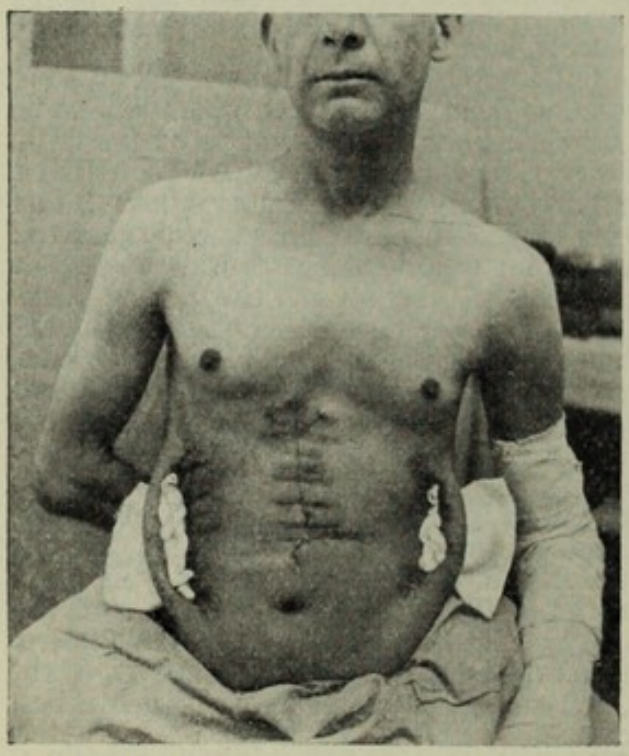


FIG. 1014.—Showing tubular pedicle previous to lifting skin flap from abdomen to cover raw area of left forearm, the result of avulsion of the skin (Dr. C. F. Nassau).

Displacement is the method of stretching or of sliding: (1) Approximation after freshening the edges (as in harelip); (2) sliding into position after transferring tensi on to other localities (linear incisions to allow of stretching of the skin over large wounds). *Interpolation* is the method of borrowing material from an adjacent or a distant region or from another person: (1) *Transferring a flap with a pedicle*, in which the flap is put in place at once or gradually by a series of partial operations (as in rhinoplasty, when a flap is taken from the forehead); (2) *transplanting without a pedicle*, which is performed by placing in position and by fixing portions of tissue recently removed from the part, from another part of the same individual, or from a lower animal (as replacement of the button of bone after trephining, transplanting a piece of bone from a lower animal to remedy a bone defect in a human being, transplantation of fat or fascia, or the grafting of a piece of nerve from a lower animal or from an amputated human limb to remedy a loss of nerve in a human being). (See "Free Tissue Transplantations," by D. B. Phemister in a Collective Review in "Internat. Abstract of Surgery," Jan., 1914.) *Retrenchment* is the removal of redundant material and the production of cicatricial contraction.

Skin-grafting.—As long ago as 1854 Dr. Frank Hamilton partly covered an ulcer with a pediculated flap, and trusted that the uncovered portion would be healed by new skin from the flap. Beck's "Adhesive plaster method for the rapid regeneration of skin over granulating wounds" will undoubtedly supersede some of the skin transplant operations. Beck applies "strips of plain or zinc oxid adhesive plaster along the edges of the granulating wound" and leaves these strips in place for twenty-four hours, when he finds, along the skin margin, a bluish-gray border of epithelial cells. He now dresses the wound with dry gauze for twenty-four hours and then makes another application of adhesive plaster. This routine is followed until the whole granulating surface is covered with an epithelial growth which "serves practically the same purpose as a skin transplant" (Emil G. Beck, "Annals of Surgery," March, 1919). We may graft small pieces of epithelium taken from the patient, another person, or one of the lower animals, or may graft large pieces of epithelium. The grafts should, if possible,

[1] "American Text-book of Surgery." [2] Ibid.

come from the person to be grafted. The epidermic scales may be scraped off the sound skin and grafted. Lusk has blistered the skin with cantharides and grafted portions of the epidermis. The shavings of a corn and fragments of hair roots have been used. The best plan is to cut off and transplant small bits of epidermis.

Grafts may come from another person or from a lower animal, but such grafts are not so apt to grow as those obtained from the individual, and even when they do grow, fail to furnish a secure cicatrix. The organism always strives to eliminate foreign matter. If a graft must be obtained from another person, the closer blood relation that person is, the better the chance of the graft growing. Before taking a graft from another person be certain that the donor is free from syphilis. Frog-skin furnishes unsatisfactory grafts. Some surgeons have used bits of sponge; others, the skin of rabbits, guinea-pigs, or pups. Arnot has employed the lining membrane of a hen's egg, cut in strips and applied upon the wound with the shell surface uppermost. Small bits of epidermis taken from a recently amputated foreskin or limb have been used. Grafts of fetal membranes and of ovarian cysts have been used. Autoplastic grafts (grafts from the person himself) should be used whenever possible. Homoplastic grafts (grafts from one of the same species) from stern necessity only. Heteroplastic grafts (grafts from one of another species) never. When we transfuse blood we use blood from a donor which is suited to the blood of the recipient. When we make a homoplastic graft it should be from a donor whose blood is of the type suited to the blood of the recipient.



FIG. 1015.—Injury caused by crush and burn. Healed by granulation in eight months. Showing condition after removal of scar of the palm, which has been repaired by stitching in an autoplastic graft (free flap) from the thigh (George S. Brown).

Reverdin's Method.—This operation was devised by Reverdin in 1869. Small bits of epithelium are used, and they are taken, preferably, from the person himself. Each bit is about the size of a mustard seed. The surface to be grafted should possess healthy granulations level with the skin. Cleanse the skin from which the grafts are to come, the ulcer, and the skin about it with a stream of warm normal salt solution. Thrust a sewing-needle under the epidermis to raise it into a cone and cut off the graft below the needle by a pair of scissors. The graft includes some of the true skin. Place the raw surface of the graft upon the ulcer. After applying a number of grafts, place thin pieces of gutta-percha tissue over them and extending beyond each side of the ulcer. These pieces of gutta-percha should be so arranged as to have distinct intervals between them, the gaps permitting drainage. The rubber tissue must be aseptic and moist with warm normal salt solution. Dress with a pad of aseptic gauze moistened with salt solution; place over this gauze a rubber-dam, and over the latter absorbent cotton and a bandage. In the case of a child apply a light silicate bandage. If the grafted area be very extensive or if it be in the lower extremity, put the patient in bed. In forty-eight hours remove all the dressings except the gutta-percha tissue, irrigate with normal salt solution, and reapply the dressings. All signs of the grafts will often have disappeared. In a day or two more, at the site of grafting, there should appear

bluish-white spots, which are islands of epidermis. Each graft is capable of forming about ½ inch of cicatrix. Grafting also stimulates the edges of the ulcer to cicatrize and contract. At the end of seven days the special dressings can be dispensed with. The spot from which the grafts have been taken is dressed aseptically. Reverdin's method does not limit cicatricial contraction to any great degree, and the new skin is apt to break down.

The Ollier-Thiersch Method.—Ollier, of Lyons, in 1872 succeeded in transferring large pieces of epidermis. In 1886 Thiersch, of Leipzig, set forth the technic practically as it is employed today. The Ollier-Thiersch method is performed as follows: Thoroughly asepticize the ulcer, the surrounding skin, and the site from which the graft is to come (the inner side of the arm or the thigh), and wash away an irritant antiseptic with normal salt solution. Apply dressings wet with salt solution. On bringing the patient into the operating room remove the dressings from the ulcer, scrape the ulcer and its edges, irrigate with salt solution, and compress to arrest hemorrhage. Grafts are then obtained by putting the prepared skin upon the stretch and cutting strips with a razor held flat. While the razor is being used the part is constantly irrigated with salt solution. Mixter's apparatus enables one to perform this operation with great neatness and speed. This apparatus consists of a knife and an open metal square with sharp points on the under surface. The square is forced down upon the front of the thigh, the skin mounts up in the opening to above the level of the metal sides and the grafts may be cut with ease. The graft contains the epidermis, the rete, and part of the true skin. In Halsted's Clinic the skin of the thigh is made tense by pressing and drawing upon it with a piece of asepticized wood, the wood is drawn slowly along, and is followed closely by the sharp catlin, by which the surgeon cuts long grafts. The grafts are pressed into place upon the raw surface, and each graft overlaps a little the edges of the wound and the adjacent grafts. The skin wound is dressed



FIG. 1016.—Claw-hand from burn. A flap with a pedicle was taken from the chest. The pedicle was cut on ninth day.

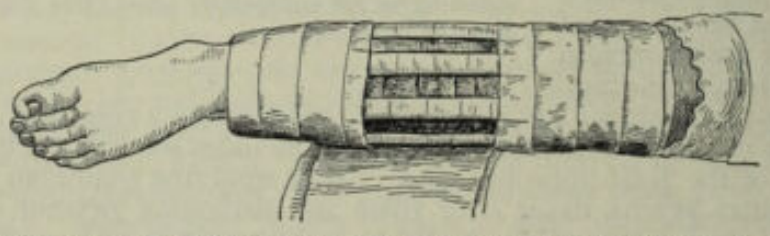


FIG. 1017.—Mayer's dressing for Thiersch's method of skin-grafting ("Amer. Text-book of Surg.").

antiseptically, and the grafted area may be dressed as in Reverdin's method. If a ring of aseptic gauze be made to encircle the limb below the grafted area, and another ring above the grafted area, and if on these pads little strips of wood wrapped in aseptic gauze be laid, a cage is made, and around this cage the dressings may be applied (moist chamber plan—Fig. 1017). Some surgeons dress with paraffin net gauze, others with only a cage.

Wolfe-Krause Method.—It was pointed out by Wolfe that a piece of skin, comprising the entire thickness of that structure, can be successfully transplanted without a pedicle. The ulcer is extirpated and asepticized and bleeding is arrested. The flap is cut one-sixth larger than the surface to be covered. Fat is kept out of the graft. This bit of tissue is laid upon the wound, the edges of the graft being brought against the edges of the raw area. It is not necessary to employ sutures. The part is dressed in a moist chamber (Fig. 1017). If the graft perishes, remove it. For full details of these methods see Harold Neuhof's book on "The Transplantation of Tissues," D. Appleton & Co., 1923.

Transplantation of Free Grafts of Mucous Membrane.—Even if the transplant holds it may not remain mucous membrane, but will probably become fibrous. Nevertheless a mucous membrane flap from another part of the mouth is the method of choice when there is membrane to spare and there is no danger of harmful contraction of the area which furnished the flap.

Free Skin-grafts to *Replace Oral Mucous Membrane.*—An unfortunate thing is that the flap may bear hair. If it does, destroy hair bulbs before operating by means of the *x*-rays. Esser's plan is to incise the skin over the contracture, going down to, but not into, the mouth, take an impression of the cavity in modeling compound, place a Thiersch graft on the impression with the raw surface out, introduce it into the cavity, and suture the skin over it. In ten days incise the scar within the mouth, remove the compound, leaving the adherent graft, which will be found continuous with the oral cavity (Dorrance in "Annals of Surgery," March, 1920). The method has since been variously modified and improved (Dorrance, Ibid.).

Subcutaneous Injection of Paraffin for Prosthetic Purposes.—The principle of injecting solidifying oils into tissues to obtain mechanical effects was first laid down by J. Leonard Corning in 1891. The use of paraffin was introduced by Gersuny to amend the deformity of a saddle-nose. It has been used to limit incontinence of feces, incontinence of urine in women, to prevent reunion of nerves after division, as a counterfeit testicle, to obliterate smallpox marks, to narrow a hernial ring, to correct sinking of the cheek after removal of the upper jaw, and for other purposes (Moszkowicz in "Wien. klin. Woch.," June 20, 1901). Paraffin is not toxic. Its injection may produce some swelling and redness, but applications of cold usually control inflammation. In two or three months the paraffin becomes hard like cartilage and encapsuled. It is questionable whether or not it is subsequently destroyed and replaced by granulation tissue. Sometimes sloughing takes place in the skin above it.

Prepare the paraffin as follows: In Gersuny's Clinic solid paraffin is mixed with liquid paraffin. The melting-point of the mixture should be about 104° F. It is rendered sterile by boiling, is injected by a warm syringe, and as a semisolid, the skin having been first warmed by a hot sponge. After injection it is molded into proper shape. It sets in half a minute. It is not wise to use a mixture with a much higher melting-point, because it would possibly cause thrombosis in veins. There are difficulties and even dangers in the use of paraffin for saddle-nose. It should only be used when the skin is loose and elastic. It should never be used if there be great deformity, because then the amount required would surely cause dangerous tension. It is difficult to prevent the injected material from passing down the sides of the nose and up into the forehead. Cases of embolism causing blindness have been reported. The skin may slough if the injection be too hot or if it produce much tension.

Paraffinoma.—This term, suggested by Delangre, means an inflammatory new formation which may arise in the submucous or subcutaneous tissues about a depot of injected paraffin. It may or may not ulcerate. It is particularly apt to form in a tuberculous person. The swelling is marked and the disfigurement great. The possibility of the formation of a paraffinoma is particularly great if paraffin be used in the subcutaneous tissue.

The only treatment is excision.

Correction of Saddle-nose by the Insertion of a Plate.—Saddle-nose is a condition in which the bones and cartilages have been destroyed by ulceration or collapsed by injury. It is useless to attempt correction by skin-flaps alone. Paraffin injections (see above) may be used in the less severe cases. In a bad case we must transplant bone-flaps or insert a plate for support. The bone-flap operation is seldom satisfactory and, of necessity, creates a hideous scar. The insertion of a plate may give an excellent result, although the future is always uncertain. In 2 cases I have seen sloughing occur over the plate months after the operation. In 1 of these cases the sloughing was due to a blow from a cow's tail.

The plate used may be of silver, gold, or celluloid. An incision is made to permit the insertion of the plate. I agree with Leonard Freeman ("Annals of Surgery," August, 1907) that the incision along the bridge and the incision in the septum below the tip are both objectionable. The first leaves an unsightly scar and does not allow for stretching of the skin. The incision at the tip gives unsatisfactory access to the tissues requiring separation and is liable to infection from the nostril.

The best incision is Freeman's. This is a short incision across the root of the nose between the eyes. The skin is undermined along the bridge to the tip and along the sides. The undermined skin can be stretched if necessary.

Rhinoplasty.—The complete operation may be performed by transferring a flap from the forehead. This is known as the Indian operation. It was employed for centuries in India, and interest in it was awakened in England about 1820 by Mr. Carpue. The edges of the defect are made raw. A model of the desired nose, made out of guttapercha, has its outlines marked upon the forehead, and the cut is made $\frac{1}{4}$ inch outside of the outline, so as to allow room for retraction. The flap is turned down and sutured in place (Fig. 1022), care being taken not to cut off the blood-supply from the pedicle. Plugs of gauze or tubes are inserted to support the flap.

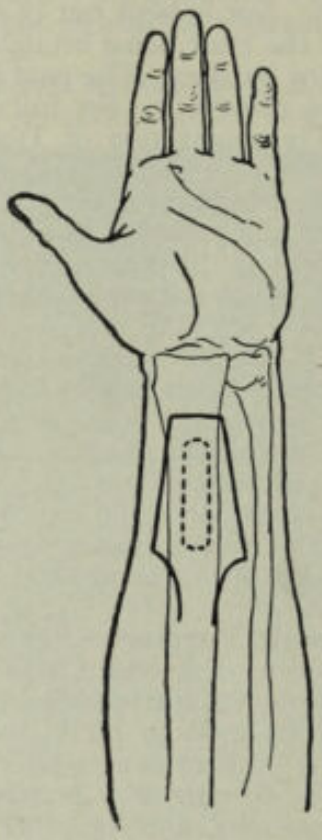


FIG. 1018.—Flap from forearm containing bone (Warbasse).

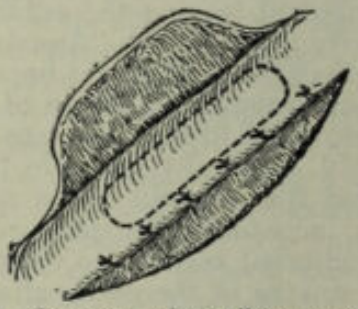


FIG. 1019.—Segment of cartilage covered with wrapping of skin (Warbasse).

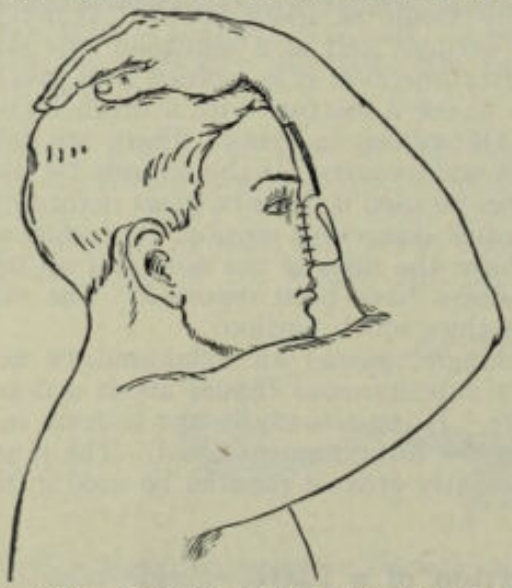


FIG. 1020.—Osteoplastic flap from forearm fixed to nose (Warbasse).

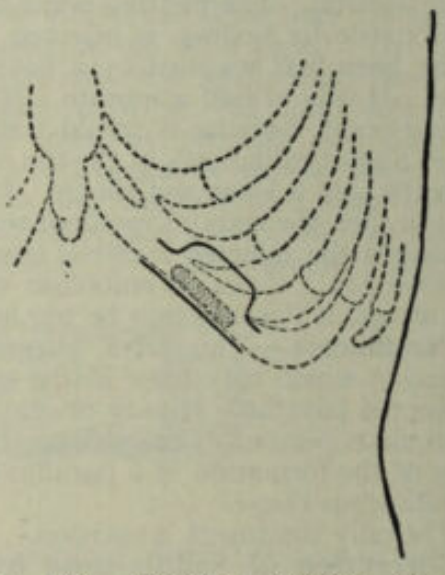


FIG. 1021.—Covering segment of costal cartilage with a wrapping of skin. Showing skin incisions. The cartilage is cut free, but is not detached from the skin (Warbasse).

The complete operation can be performed by the Italian method (Tagliacotian method). The method was first described in Tagliacozzi's book, which was published in 1597. In this operation the flap is marked out on the arm, is made twice the size of the desired nose, and is left attached by a broad pedicle. The nasal surface is rendered raw at proper regions, and the flap is sutured in place, the hand being held upon the head by a special apparatus (Figs. 1020, 1023). The raw surface upon the arm is dressed. In about three weeks the flap is cut loose from the arm, and is pared and corrected as may be necessary. Keegan and others have done much in recent years to perfect rhinoplasty (see special treatises). Warbasse says that rhinoplasty with a soft flap is scarcely worth doing. The new nose is without support, flattens promptly, and becomes distorted ("Surgical Treatment," by Jas. P. Warbasse, W. B. Saunders Co., 1919). He thinks that prosthetic supports of soft flaps are of little value and that even a nose made from double skin-flaps ultimately becomes flattened if the septum is gone. A double flap may give a fairly good result. A bony or cartilaginous support adds greatly to the value of soft flap operations (Figs. 1018, 1019).

The method approved by many is that of Koenig, who did what is called osteoplastic rhinoplasty, taking a flap of skin and bone from the middle line of the forehead. Nealton advocated transplanting a piece of costal cartilage under the periosteum of the frontal bone, waiting until union was firm and then making a flap containing the

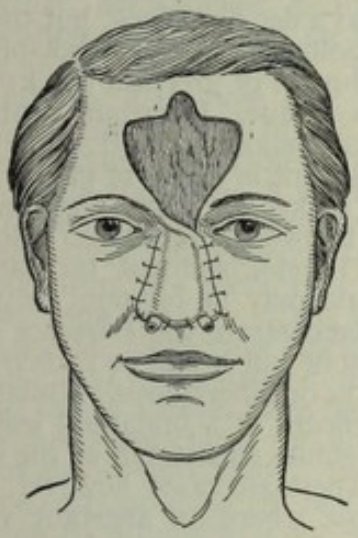


FIG. 1022.—Indian method of rhinoplasty.



FIG. 1023.—Italian method of rhinoplasty.

cartilage. A flap containing bone may be taken from the radial side of the forearm (Fig. 1018). Israel made one from the inner side of the forearm which contained a piece of ulna. Warbasse says that the transplantation of distant structures has great possibilities (Warbasse, Ibid.):

"In carrying bone and cartilage flaps from remote parts of the body, using the forearm or hand as a vehicle, bone may be taken from the crest of the ilium, from the ribs, or the sternum. The bone or cartilage to be transplanted may be first involved in skin as shown above (Fig. 1019) or it may be transferred lying on the free surface. It does better when first involved in the skin covering. A toe may be grafted upon the hand and thence successfully transferred to the nose."

The little finger may be used to great advantage in reconstructing a nose, the terminal phalanx becoming the nasal septum and the proximal phalanx becoming the body of the nose.

The operations for harelip and cleft-palate, and plastic operations on muscles, nerves, tendons, and bones are considered in other portions of this work.

XXXIV. DISEASES AND INJURIES OF THE GENITO-URINARY ORGANS

(Dr. Thomas C. Stellwagen, Associate Professor of Genito-urinary Surgery in Jefferson Medical College, kindly aided me in revising this section.)

Hematuria.—By this term is meant the voiding of bloody urine or of pure blood, the blood arising from any portion of the urinary apparatus, and the condition being a symptom and not a disease. In hematuria the urine contains more than blood coloring-matter; it also contains blood-corpuscles. The condition in which there is coloring-matter only is called *hemoglobinuria*. Hemoglobinuria may arise after burns, etherization, and after taking urotropin, and during various fevers, especially in malaria. Hematuria may be a symptom of disease or of injury of some part of the urinary system (calculus, acute nephritis, pyelitis, renal tuberculosis, prostatic enlargement, morbid growth, wounds or contusions of the genito-urinary tract), of blood disorganizations (purpura, scurvy, variola, leukemia, or anemia), or of metallic poisoning (mercury, lead, or arsenic). It may arise during typhoid fever, in the beginning of an acute fever (especially variola), in hemophilia, in nephralgia, in malarial fever, and in kidney infarction resulting from endocarditis. It may be caused by parasites (Filaria sanguinis hominis and Bilharzia hæmatobia). Some drugs are renal irritants and may cause hematuria (cantharides, oil of turpentine). Oxaluria is an occasional cause. The most usual cause of renal hematuria is stone. The color of the urine in hematuria may be anything between a light pink and a decided black, but these colors may be produced by agents other than blood. (See Sollmann's "Text-Book of Pharmacology.") Carbolic and salicylic acids make urine brown or greenish black; beet-root and sorrel, the color of blood; methylene-blue, green or blue. In melanosis and splenic fever the urine becomes brown. Senna and rhubarb make an acid urine yellowish brown and an alkaline urine purple. In jaundice the urine is yellow or green. Coal-tar products may make it blackish brown. Picric acid makes it yellow. Santonin makes an acid urine yellow and an alkaline urine pink. Logwood imparts no color to acid urine, but colors alkaline urine violet or reddish. Trional, sulfonal, tar, tannic acid, and gallic acid make urine brown. Renal hematuria may be bilateral or unilateral. The cystoscope and ureteral catheterization will demonstrate the existence of either. The commonest cause of unilateral hemorrhage is stone but it can be caused by pyelitis, infarction, a neoplasm, injury, parasites, nephritis, or tuberculosis. Unilateral pain associated with unilateral hematuria is very significant of a unilateral lesion. The so-called symptomless or idiopathic hematuria is a definite entity, but as the science of renal diagnosis progresses it becomes more rare. There are cases, however, where no definite lesion can be demonstrated, and again those where an aberrant vessel has been found in the kidney.

Tests for Blood.—Spectroscopic Test.—Bloody urine, if fresh and diluted with water, shows the two absorption bands of oxyhemoglobin. The addition of ammonium sulphid causes the two bands to give place to the band of reduced hemoglobin. If bloody urine stands for some time the four bands of methemoglobin are discovered (von Jaksch).

Heller's Test.—Add potassium hydrate to the urine and boil; a red precipitate of earthy phosphates and hematin forms. Throw the precipitate upon a filter and treat it with acetic acid; a red solution is produced, which soon fades.

Rosenthal's Test.—Take the precipitate from caustic potash, dry it, and test it for hematin; put some of the dry sediment on a slide, add a crystal of common salt, apply a cover-glass, and cause a few drops of glacial acetic acid to flow under the glass; warm, but do not boil. Teichmann's crystals will appear on cooling.

Struve's Test.—Test the urine with hydrate of potassium and add acetic acid in excess; a dark precipitate forms, which will yield crystals of hematin when treated with sal ammoniac and glacial acetic acid.

Almen's Test (Guaiac Test).—Take 10 c.c. of urine and pour upon its surface a mixture of equal parts of tincture of guaiac and old oil of turpentine; at the point of junction of this fluid with the urine there forms a white ring which turns to a striking blue. If a man is taking iodid of potash his urine shows blue in the guaiac test.

The Benzidin Test.—This is very delicate. If this reaction cannot be obtained the urine is certainly free of blood. Add 1 c.c. of glacial acetic acid to 10 c.c. of urine. Add to the mixture one-third of its volume of ether containing a few drops of alcohol, shake, and allow to stand. The ether rises to the top, is taken off by a pipet, and is put in a test-tube in which is the benzidin mixture (0.5 c.c. of a solution of benzidin in 2 c.c. of glacial acetic acid and 2 c.c. of hydrogen dioxid). Blood turns the reagent

green or blue within two minutes. Later the color changes to purple. (See Holland's "Medical Chemistry and Toxicology.")

Microscopic Test.—The microscope shows numerous corpuscles except in a very alkaline urine, when but few corpuscles may be found.

In hemoglobinuria—a condition sometimes occurring after burns, as a result of large doses of urotropin, and during malaria, acute febrile maladies, metallic poisoning, acute alcoholism, poisoning by mushrooms, chlorate of potash, coal-tar products, pyrogallic acid, and naphthol—there is present blood coloring-matter which is shown by Heller's test and by Almen's test. The spectroscope shows methemoglobin. The microscope shows no corpuscles or only a few, but discloses masses of pigment. Hemoglobinuria does not occur in diseases limited to the genito-urinary tract.

Determination of the Source of the Blood.—In a woman be sure that the bloody urine is not due to a mixture with menstrual blood. If menstruation does exist, obtain the urine for examination by a catheter. The three-glass test may be of service. Blood may be thoroughly mixed with urine. Renal blood is sure to be mixed. Bladder blood may or may not be. Blood from the urethra comes out with the first urine. The source of blood may be determined certainly only by the urethroscope, cystoscope, or ureteral catheter.

Bleeding from the Kidney Substance.—Bleeding from the *pelvis* of the kidney and from the *ureter* may be due to inflammation, congestion, contusion, stone, vicarious menstruation, hemorrhagic diathesis, powerful diuretics, fevers, purpura, tumors, catheterization of the ureter, etc. Blood is thoroughly mixed with the urine and no sediment forms (smoky urine). The corpuscles are profoundly altered, are devoid of coloring-matter, and show pale yellow rings. The severity of the hemorrhage is measured by the number of the corpuscles. Von Jaksch states that the diagnosis between renal and ureteral hemorrhage rests on the nature of the casts and epithelium present. From the pelvis of the kidney and from the ureter comes small epithelium, the cells from the superficial layers being polygonal or elliptical, those from the deeper layers being oval or irregular. In hemorrhage from the ureter the cells are few; in hemorrhage from the pelvis they are plentiful and rest upon one another like "tiles on a roof" (von Jaksch). Cells from the tubules of the kidney are small, granular, and polyhedral, have large nuclei, and are often so arranged as to form cylinders (epithelial casts). The urine during and immediately after a renal hemorrhage is apt to be acid unless alkalies have been administered, unless the bleeding has been severe, or unless pus is present in the urine. A very large renal hemorrhage may cause the passage of almost pure blood. In *renal* hematuria there are aching in the loin, numbness of the corresponding leg, and often renal colic. The use of the cystoscope enables the surgeon to determine if the hemorrhage is vesical or renal, and if it comes from one or both kidneys. If the bladder fluid is kept clear, the blood can be seen flowing out of the ureter of the damaged organ, or if both ureters are catheterized a sample of urine can be obtained from each kidney. Even when skilfully used the ureteral catheter is apt to cause slight hemorrhage. Hence, after catheterization, microscopic hemorrhage does not count in diagnosis.

Spontaneous Hemorrhage into the Kidney.—This may or may not cause hematuria. It may arise during nephritis or may depend on arterial disease. No lesion may be discoverable. If accompanied by hematuria it is classed as essential hematuria (see below). The bleeding may take place beneath the capsule or through a tear in the capsule into the perirenal tissue. In some cases bleeding begins in the perirenal tissue. A possible cause is aneurysm of the renal artery. There are 26 cases of this condition on record ("Lancet," Jan. 27, 1912). Spontaneous hemorrhage comes on suddenly with shock and pain in the loin. There may or may not be hematuria. A mass can be palpated. In some cases the skin becomes discolored. Always operate. If hemorrhage comes from perirenal tissue, excise the bleeding tissue. If blood comes from the kidney it is usually necessary to perform nephrectomy. In spontaneous hemorrhage blood may tear its way into the peritoneal cavity. (See Article by Russell S. Fowler in "Annals of Surgery," Dec., 1911.)

Essential Hematuria.—In this condition the ureteral catheter reveals blood from one kidney only, there being no demonstrable lesion to account for the condition. Randall, in a very comprehensive article, draws the following conclusions regarding this condition ("Jour. Amer. Med. Assoc.," Jan. 4, 1913).

He divides essential hematurias into three groups: (1) Nephritis with congestion playing the leading rôle. (2) Varicosities of vessels of renal pelvis resulting from some extrinsic condition affecting the kidney circulation. (3) Hemorrhage due to rupture

of capillaries or to diapedesis of red blood-corpuscles. In each of these conditions congestion probably exists.

I believe that some cases are due to unrecognized papilloma. Essential hematuria is sometimes called *unilateral hematuria*, an unfortunate name, as many cases of hematuria which do not belong to this group are unilateral.

Urethral Hemorrhage.—In urethral bleeding blood appears independently of micturition, or blood comes out first and is followed by clear urine. Urethral hemorrhage may arise from acute urethritis, from an inflamed stricture, from the passage of an instrument, or from some other traumatism. It may be due to a polypus, to a stone in the prostatic urethra, to violent or prolonged sexual effort.

The source of urethral hemorrhage can be ascertained by the use of the endoscope or, better, by means of the cysto-urethroscope.

Vesical hemorrhage, including hemorrhage from the prostate, may follow the relief of retention of urine (hence do not draw off all the urine at once when a bladder is distended), may be due to stone, inflammation, tumors, etc., or may arise from traumatisms, instrumental or otherwise. The color of the urine is usually bright red, but if long retained in the bladder it becomes black and often tarry. The reaction is alkaline. The clots, when floated out, are large and without definite shape. In micturition the urine is clear or only a little colored at the beginning, but becomes darker and darker as micturition continues, and as it ends the flow may consist of almost pure blood. In very small vesical hemorrhages the urine may be smoky. Crystals of triple phosphate indicate bladder disorder. The microscope shows colorless and swollen corpuscles and many polygonal cells. Symptoms of bladder mischief usually exist, but cystoscopic examination or exploratory suprapubic cystotomy may be required for the diagnosis.

Pain in Genito-urinary Diseases.—Pain as a symptom of genito-urinary disease may be found at some point distant from the seat of lesion. A stone in the bladder causes pain in the head of the penis just back of the meatus; stone in the kidney induces pain in the loin, the groin, the thigh, and the testicle; inflammation of the testicle causes pain in the line of the cord in the groin. In other cases of genito-urinary disease pain is felt at the seat of lesion, as in urethritis and prostatitis. Pain felt before micturition, and being relieved by the act, is found in cystitis and in retention of urine. Pain is felt during micturition in inflammation of the bladder, prostate, and urethra, and in the passage of gravel or stone. Pain which is acute at the end of micturition is noted in stone in the bladder, in trigonitis or urethrocystitis (inflammation of the neck of the bladder), and in inflammation of the prostate gland. The pain caused by stone in the bladder, it may be observed, is ameliorated by rest and is aggravated by exercise unless the stone be encysted. The pain caused by acute prostatitis is intensified by defecation and the act is accompanied by the appearance at the meatus of a few drops of starch-like mucus.

Frequency of Micturition.—Frequent micturition arises from irritation of the sensory nerves, from phimosis, contracted meatus, inflammations, very acid urine, strongly alkaline urine, calculi, urethral stricture, and hyperesthesia of the urethra. Frequency of micturition may be due to spinal irritability from concussion or from sexual excess, from contraction of the bladder rendering the viscus unable to hold much, from worry, anxiety, fear, or from excessive urinary secretion, as in diabetes or in the first stage of contracted kidney. Frequent micturition exists in obstruction by enlarged prostate and in atony of the bladder walls. Hypersecretion of urine plus bladder intolerance is known as "nervousness of the bladder," and is found in hysteria. Frequency of micturition increased by *movement* is observed in stone and tumor of the bladder. Nocturnal frequency of micturition is present in cases of enlarged prostate and atony of the muscular walls of the bladder. Frequency of micturition with diminution of the diameter of the stream suggests a constriction of the urethral canal; frequency of micturition with diminished projectile force suggests a posterior stricture, enlarged prostate, or bladder atony. Slowness of micturition hints at enlarged prostate, atony, or urethral stricture.

Sir Henry Thompson's diagnostic questions are as follows:

"1. Have you any, and, if so, what, frequency in passing water? Is frequency more manifest during the night or the day? Is frequency more manifest during motion or rest? Does any other circumstance affect it?

"2. Is there pain on passing urine, and, if so, is it before, during, or after the act? What is its character—acute, smarting, dull, transitory, or continuous? What is its seat? Is it felt at other times, and is it produced or intensified by sudden movements?

"3. What is the character of the stream? Is it small or large; twisted or irregular; strong or weak; continuous, remitting, or intermitting? Does it come through the meatus, or partly or entirely through fistulæ?

"4. Is the character of the urine altered? What is its appearance, color, odor, reaction, and specific gravity? Is it clear or turbid, and, if turbid, is it so at the time of passing? Does it vary in quantity? Are the normal consituents increased or diminished? Does it contain abnormal elements, as albumin or sugar? What organic deposits are found? What organic materials are met with?

"5. Has the urine ever contained blood? If so, was the color brown or bright red; were the blood and urine thoroughly mixed; was the blood passed at the end or at the beginning of micturition, or did it come only with the last drops of urine; or was it passed independently of micturition?

"6. Inquire as to pain in the back, loins, and hips, permanent or transitory, and for the occurrence of severe paroxysms of pain in these regions."

The Determination of the Excretory Capacity of the Kidneys in Health and in Disease.—As a rule marked diminution in the excretory power of a kidney means anatomic changes, but this inference is not always correct. Even a great diminution in excretion may be functional. Hence the surgeon must always gage and weigh the functional findings in the light of clinical evidence. There are two types of cases in which the surgeon finds renal functional tests of the greatest value: (1) in cases in which kidney disease is secondary to disease of the lower genito-urinary tract and (2) in cases in which such tests are applied with ureteral catheterization in unilateral and bilateral surgical maladies (J. T. Geraghty in "Bull. Johns Hopkins Hospital," 1915, xxvi).

The Methylene-blue Test (*The Method of Achard and Castaign*).—When methylene-blue is injected hypodermically it normally is changed into a chromogen, appears in the urine within half an hour, and disappears in from thirty-six to forty-eight hours. If the blue color is not manifest in the urine for an hour or more, there is impairment of renal permeability. Only 50 per cent. of the amount ingested is removed by the kidneys. Accuracy in the test is not possible unless the amount of the methylene-blue actually passing into the urine in a given time be determined. The dose given hypodermically is 0.05 gm. in 1 c.c. of sterile water. The test is unreliable and the blue color may appear in the urine in half an hour in some cases of marked kidney disease. At its best the test only indicates the freedom of mechanical renal permeability.

The Indigocarmin Test.—This drug should be largely excreted in a few minutes. It colors the urine. It will show functional failure, but there may be no functional failure even in organic disease.

This method enables us to recognize functional incapacity. By it we may forecast uremia. If the urine be collected from each ureter separately we can tell the capacity of each kidney. In this test, if color does not appear until after twenty-five minutes, and if during the first hour less than 30 per cent. of the amount introduced is excreted, a contemplated surgical operation should be postponed or abandoned.

The Phenolsulphonephthalein Test.—This is the most reliable one. It shows the working capacity of each kidney. The drug is not toxic. It is given in an alkaline solution. A hypodermic injection of 6 mg. is administered. It appears in the urine when the kidneys are normal in from six to twelve minutes, and from 40 to 60 per cent. of the amount given is excreted during the first hour. It colors urine red and a quantitative estimation can be made by means of a colorimeter. When the color first appears, and how much of the drug is excreted in the first hour, must be noted. (For details see Keen's "Surgery" and Warbasse's "Surgical Treatment.")

The most reliable method of judging the renal capacity is by a study of the blood chemistry and its interpretation. This requires an expert chemist, but should be done if possible previous to surgical operation upon the genito-urinary tract. Cryoscopy and the phloridzin test have had their day and have been superseded by indigocarmin, phenolsulphonephthalein, and blood chemistry studies.

Diseases and Injuries of the Kidney and Ureter

Infantile Kidney.—This is a rare anomaly, but a very dangerous one if a surgeon operates upon the other kidney. Even when ureteral catheterization is practised a clear and normal urine may be obtained from the ureter of the small kidney. The amount of urine is small, the percentage of urea is decreased, and functional activity

is impaired (Geraghty and Plaggemeyer in "Jour. Amer. Med. Assoc.," 1913, lxi). In some few persons who are thin the *x*-rays will demonstrate the kidney to be very small. Geraghty and Plaggemeyer point out that pyelography is of no help, as the size of the renal pelvis is no certain index of the size of the kidney (Ibid.).

Cysts and Tumors of the Kidney.—Cysts are not uncommon. In a case of *congenital cystic kidney* both kidneys are usually involved. The condition is due to failure of fusion between the excretory and collecting tubes. The cysts are numerous and are separated by bands of atrophic renal structure. The cyst fluid is usually clear and yellow and contains urinary salts. In some cases it is colored by blood. The congenital cystic kidney may attain a great size. It is a strange fact that these kidneys are functionally active and that a person who has them may live well into adult life, although they are prone to strike work suddenly, a cessation which causes death (see Staehlin in "Annals of Surg.," 1916, xxx). The bilateral nature of the condition forbids nephrectomy. Cysts, single or multiple, bilateral or unilateral, may arise after birth. Obstruction of the renal tubules may result from acute parenchymatous nephritis or interstitial fibrosis, and obstruction may produce a retention cyst or retention cysts. The large solitary, serous retention cyst is an uncommon disease, most often encountered in males and in adult life (Cunningham, "Surg., Gynec., and Obst.," 1916, xxiii; Staehlin, Ibid.). Hydatid cysts may form in the kidney. Tumors, innocent or malignant, may arise in the kidney. Among the innocent tumors are fibroma, lipoma, angioma, and adenoma. Hypernephroma of the kidney arises from fragments of adrenal tissue included in the kidney. Hypernephromata were thought to be renal lipomata until 1883, when Grawitz showed they contained adrenal elements ("Virchow's Archiv.," xciii). The name "hypernephroma" was suggested by Birch-Hirschfeld in 1896. A hypernephroma may arise directly from the suprarenal gland or it may arise from an adrenal "rest" or aberrant gland. Such rests may be met with in the substance of the kidney, under the renal capsule, in the perirenal tissue, in the testicle, the ovary, the liver, the inguinal canal, the mesentery, among the spermatic vessels, in the broad ligament, in the renal plexus, or in the solar plexus (W. W. Keen). The term "hypernephroma" is applied to any growth which arises from adrenal cells "whether the growth be adenoma, carcinoma, or sarcoma in type" (Duffield in "New York Med. Jour.," May 1, 1909). The tissue of a hypernephroma is identical with the adrenal gland, and it contains fat and glycogen. The tumor may arise at any period of life from childhood to old age. The commonest decade is from fifty to sixty years. The exact nature of such a tumor is unsettled. It is probably an adenoma, but some consider it to be a sarcoma and others a carcinoma. Some tumors give no evidence of malignancy; some are very malignant. A malignant hypernephroma grows rather rapidly, eventually attains a large size, and is sometimes painful. A patient in the Philadelphia Hospital from whom I removed a hypernephroma complained of tenderness in the left side and occasional attacks like renal colic during which he passed bloody urine. The tumor could be easily palpated in the left loin. The kidney was removed and resembled a huge kidney of nearly normal shape, but nodular in outline. Dr. Coplin found it to be hypernephroma. In this case there was no increase of arterial tension. The patient died. Another case was a woman of forty-five who was brought to the Jefferson Hospital. She had suffered from pain in the loin for months. It was paroxysmal, but lacked the radiation of renal colic. Hematuria appeared long after the pain had begun. It was persistent, but small in amount. Palpation detected a tumor and the *x*-rays showed enlarged kidney. There was no increase of arterial tension. Recovery followed nephrectomy. In a man aged thirty-four in the Philadelphia Hospital there were attacks of severe pain referred to the groin, testicle, and loin. The bleeding was profuse. A mass was palpable in the right upper abdomen and loin. Examination of blood showed hemolysis, but there was no hypertension. The growth was exposed in the loin. Hemorrhage was so violent that it became necessary to open the abdomen and ligate the renal pedicle. The kidney was removed and the patient recovered.

Very malignant cases have proved fatal within six weeks after symptoms were first observed. Some patients have lived three years. A hypernephroma of malignant nature involves adjacent structures, and gives rise, after a time, to metastases, particularly by way of the blood. The bones are most liable to metastatic deposit, but such deposits may occur in the lungs, liver, and other regions. In a case upon which I operated for a supposed adenomatous goiter the condition was really metastatic hypernephroma. Hypernephromata are infinitely more common in the kidney than anywhere else. The treatment is nephrectomy. The operative mortality of hyper-

nephroma of the kidney is from 7 to 15 per cent. The earlier the operation, the better the prospect of cure. One-third of the cases will pass the three-year limit after nephrectomy. Sarcoma or carcinoma may arise in the kidney. They may be primary or secondary. Primary sarcoma is far more common than primary carcinoma. Primary sarcoma is most common in the young, and may reach an enormous size (Fig. 1024). A malignant tumor of the kidney produces hematuria, the urine often containing blood-casts of the ureter, kidney, and pelvis, and sometimes, though rarely, characteristic cells. Pain is often present in the loin and thigh, and there may be colic-like attacks when clots are passing through the ureter. A tumor can usually be palpated. Emaciation is decided and rapid. Sarcoma of the kidney is a rapid growth, and in this, as in all rapidly growing sarcomata, fever is not uncommon (Longhnane in "Brit. Jour. Surgery," 1914, ii). In some few cases the growth is bilateral. Pyelography with a solution of sodium iodid may aid in the diagnosis (see page 1307). The only possible treatment for a malignant growth is early nephrectomy. In some few cases an innocent tumor can be removed by a partial nephrectomy. A malig-

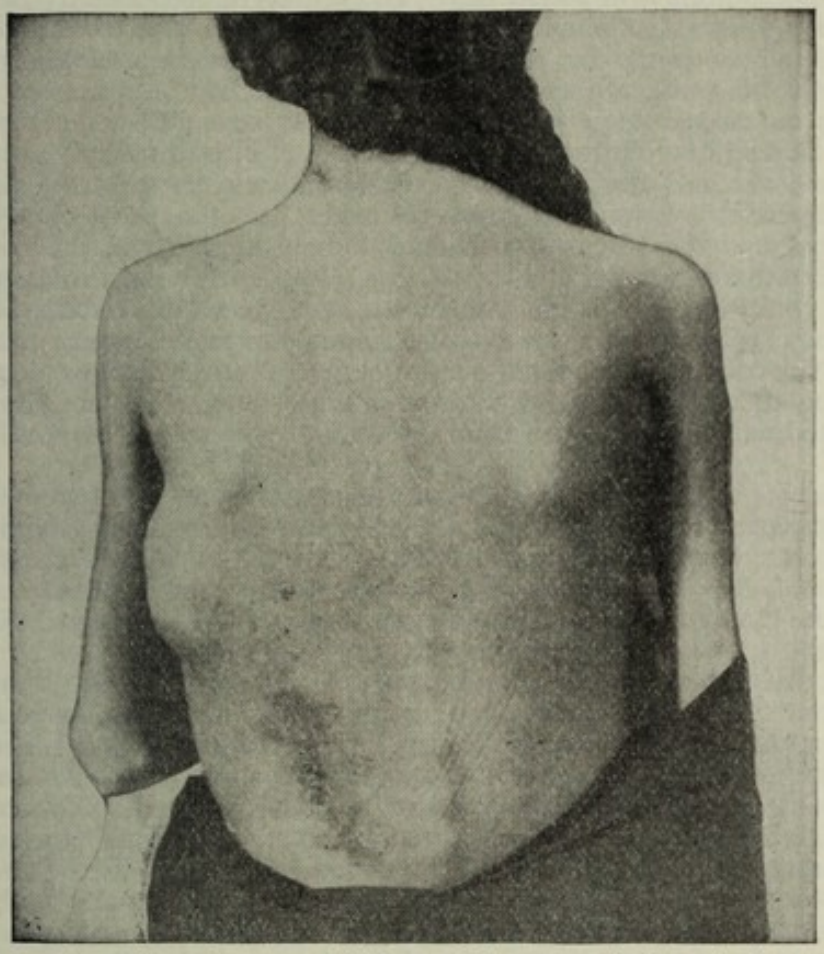


FIG. 1024.—Sarcoma of kidney with metastasis (Horwitz).

nant tumor requires a complete nephrectomy. The mortality is considerable (7 to 15 per cent.) and rapid recurrence is to be expected in 80 per cent. of the cases. A very few pass the three-year limit. In making a diagnosis of renal tumor use the cystoscope. If blood is coming from above the bladder, note if it is from one or from both ureters. Blood from both would contraindicate nephrectomy. Before removing a kidney it is necessary to be sure that the patient is possessed of two kidneys. Note if urine flows from each ureter, and, if uncertain, catheterize the ureters.

Nephroptosis, Prolapse of the Kidney, or Mobile Kidney.—There are two forms of this condition: (1) *Movable kidney*, which is an organ freely moving back of the peritoneum, either within the cavity of its fibrofatty capsule or entirely without its capsule (this condition is acquired); and (2) *floating* or *wandering kidney*, an organ having a mesonephron and lying within the peritoneal cavity (this rare condition is always congenital). Keen states that there may be drawn a clear theoretic distinction between movable and floating kidney, but practically there is no rigid line of demarcation, as a movable kidney may have as large a range of movement as a

floating kidney. The kidney is normally somewhat mobile, and nephroptosis is considered to exist only when the range of movement exceeds distinctly what is normal. Normally on inspiration the kidney descends about ½ inch. It is seldom that a normal kidney can be palpated in men, but in most women the right kidney can be palpated, and in some women the left organ can also be felt. Harris ("Jour. Amer. Med. Assoc.," June 1, 1901) describes three degrees of movable kidney. In cases of the first degree one-half of the organ can be distinctly grasped and the kidney can be made to recede. In cases of the second degree both hands can be brought together above the kidney. In cases of the third degree the kidney has descended as low as the pelvic brim or has moved to or beyond the umbilicus. The organ may drop below the brim of the pelvis, may cross the vertebral column, or may reach the anterior abdominal wall. When a movable kidney becomes fixed in an abnormal situation, the organ is spoken of as *dislocated*.

Women suffer from movable kidney more often than men. Küster estimates that 4.41 per cent. of women examined in general surgical practice have movable kidney. Edebohls finds it in 20 per cent., and Harris in 56 per cent., of cases in gynecologic practice. In about one-half of the cases it gives rise to little or no trouble. A movable kidney is found in the great majority of cases upon the right side. In many cases it is bilateral, the right kidney being usually the most mobile. Splanchnoptosis may be associated with acquired nephroptosis. Floating kidney is always congenital. Movability of the kidney is occasionally, but rarely, found in children, though congenital cases occur. In a congenital case there is no splanchnoptosis. Tuffier has reported 3 cases in children six, nine, and ten years of age respectively, and J. Cromby reported 18 cases of floating kidney in children, the youngest patient being three months of age (quoted by Harris, Ibid.). Among the assigned causes of the movable condition are to be named traumatism; strains; abdominal wall laxity from pregnancy, removal of a tumor, or tapping for ascites; absorption of perirenal fat from wasting disease (Edebohls); tight lacing; uterine displacements; and enteroptosis leading to traction on the transverse mesocolon. The condition is certainly often associated with ptosis of the other abdominal viscera (enteroptosis, gastroptosis, etc.).

Traumatism is rarely the immediate and essential cause of a true movable kidney. In some cases patients assert that pain began immediately after a blow, an attack of coughing, violent vomiting, lifting, straining at stool, a fall, or in parturition. In such cases the kidney may have been mobile before the accident. Again, pain is not proof of the inauguration of movability. It is probable, however, that traumatism may loosen the kidney and that mobility may subsequently develop. Gutterbock says that a kidney in normal relations cannot be rendered mobile by a simple fall or a trivial force. Loosening can be induced only by rupturing surrounding tissues; and if this happens, symptoms of a distinct nature will indicate the seat of injury. Becher and Lennhoff claimed that there is a connection between movability of the kidney and the length and breadth of the body. They have laid down a formula, viz.: Measure the distance from the suprasternal notch to the crest of the pubes. Divide this by the smallest circumference of the abdomen. Multiply the product by 100. The result is the abdominal index. If the index is greater than 75 there is a tendency to movable kidney. If it is less than 75 there is no such tendency. Harris makes out a strong case for the view that the condition is due to the relation existing between the location of the kidney and the body form. He divides the body into three zones: The upper zone contains the lungs and heart. The middle contains the liver, stomach, spleen, pancreas, and the greater part of each kidney. The lower contains the intestinal canal and the lesser part of each kidney. When there is a naturally small or a diminished capacity of the middle zone, the kidney is displaced downward. The right kidney is pressed upon by the heavy liver, which drives it down; the left kidney is pressed upon by the comparatively small spleen. Hence movable kidney is more common on the right side than on the left. The upper pole of the kidney is first pushed forward and then the entire organ descends (M. L. Harris in "Jour. Amer. Med. Assoc.," June 1, 1901). Harris maintains that the amount of mobility depends upon the degree of contraction of the middle zone and upon internal traumatisms (lifting, straining, coughing, etc.).

Symptoms of Both Forms.—There may be no discomfort whatever, or the patient may be a confirmed invalid. The usual symptoms are epigastric pain (just to the left of the middle line), which disappears when the kidney is replaced, dragging pain in the loin, and paroxysms like nephritic colic. Sudden attacks of violent pain in the

kidney or stomach may occur—attacks which are accompanied by nausea, vomiting, great weakness or collapse, vertigo, chills, and subsequently elevated temperature (*Dietl's crises*). Dietl's crises are due to kinking or twisting of the ureter or renal vessels or to inflammation of the kidney. They may be caused by physical exertion or indiscretion in diet and may be followed by hydronephrosis or by strangulation of the renal vessels. A few years ago I operated upon a man suffering from a violent and prolonged crisis and found a twist of the vessels and ureter. In a Dietl's crisis there is congestion or strangulation, or both. An incomplete or temporary twist of the renal pedicle may induce simply pain in the abdomen and loin, hematuria, albuminuria, and cylindruria.

The question as to whether or not abdominal pain is due to movable kidney is sometimes in doubt. The localization of the pain may lead us to suspect chronic appendicitis. Some surgeons think that catarrhal appendicitis is often associated with movable kidney, but I do not think the association is common. "Dr. Kelly has shown us how to solve this doubtful question between appendicular pain and the pain of movable kidney. He catheterizes each ureter separately, and introduces into each catheter as much fluid as the renal pelvis will hold without causing pain. He then measures this fluid from each side, and determines whether it is in excess of an estimated average. If it is in excess, he is sure that dilatation has begun. He then injects the kidney again, with the deliberate purpose of producing pain, and if the patient recognizes this pain due to the distention as of the same character and in the same position as that which he has previously felt, Dr. Kelly assumes that the pain has been due to the kidney, and not to the appendix, and recommends an operation to fix the kidney" (the author in "New York Med. Jour.," Aug. 4, 1906). Usually in a case of movable kidney there is a sense of a moving body in the abdomen, and the patient has aggravated indigestion, often accompanied by vomiting. Constipation is the rule, and violent attacks of cardiac palpitation are common. Most subjects of kidney mobility are extremely nervous—many of them hysteric or hypochondriac. Persistent vasomotor paresis causes cold hands and feet and often albuminuria. Temporary jaundice is not uncommon. There is frequently irritability of the bladder. Vertigo and insomnia are present in many cases. The patient cannot sleep when lying on the sound side (Goelet). In women the sexual organs are almost invariably deranged, and menstruation aggravates the pain and discomfort. All the symptoms are intensified by exertion and are modified by rest. The urine is normal except after violent exercise, when it may contain blood. Splanchnoptosis may also exist, and if it does, the pulsations of the abdominal aorta are strongly noticeable because that structure is bared by gastroptosis. The proof of the existence of movable kidney is the finding of a mass, movable on respiration, change of position, and palpation, shaped like that organ, pressure upon which occasions no sensation or causes pain or a sickening feeling. A "lumbar recess" (Morris) may sometimes be found, and percussion over the loin gives resonance. In some cases a movable kidney can be readily detected when the patient stands up, but is difficult to find when he is recumbent. Franks's method of examination is very satisfactory in most cases (Fig. 1025). The patient is placed recumbent. If dealing with a right kidney, the surgeon stands to the right side and pushes four fingers of his left hand in the loin below the twelfth rib, and rests the thumb lightly in front just below the ribs. The patient takes a full breath and holds it a moment, and just before he empties his lungs the surgeon presses his thumb up deeply below the ribs. During expiration the thumb follows the liver, and the fingers press toward the front. If with the right hand the kidney can be felt entirely below the left hand, the case is one of movable kidney. If such a condition is detected, press hard with the right hand, and gradually loosen the grasp of the left hand, and the kidney will slip between the fingers and ascend. A normally mobile kidney descends so that its lower end can be felt, but it moves back during expiration.[1] Goelet uses Kendal Franks's method of palpation, but has the patient stand, with the weight resting on the leg of the sound side and with the leg of the impaired side slightly flexed and resting on the toes. The body leans a little forward (Fig. 1025). A movable kidney must not be mistaken for a distended gall-bladder, a tumor of the mesentery, stomach, or omentum, a phantom tumor, an ovarian tumor, or a cancer of the pancreas. A distended gall-bladder can be pushed upward, but not backward, and not downward unless the liver be movable; it is extremely tender, and cannot be pushed out of reach. A kidney can be pushed upward and backward—in fact, in all directions. An enlarged gall-bladder can always be palpated. A movable kidney which is not enlarged can

[1] "Brit. Med. Jour.," Oct. 12, 1895.

be felt at times and not at others (Henry Morris). A movable kidney may pass between the examiner's fingers, and if pushed into the loin, it tends to remain; but if a distended gall-bladder is pushed into the loin, it springs out as soon as pressure is relaxed (Henry Morris). The *x*-ray study of the kidney pelvis after injection with a radiopaque solution is known as *pyelography* (see page 1452). The *x*-ray picture of a kidney so injected is a pyelogram. This method is of the highest diagnostic value. It will always show a displaced kidney, and it also shows hydronephrosis. One picture should be taken with the patient standing, another with the patient recumbent. It is important to remember that in about one-half of the cases of movable right kidney the left kidney is also movable, but to a less degree. Appendicitis is thought by some to be more frequent in individuals with movable right kidney than in those free from renal mobility. Sometimes a movable kidney endangers life, rupture of the kidney, twisting or rupture of the ureter, or strangulation of the renal vessels occurring, the ultimate cause of death being nephritis, uremia, or hydronephrosis.

Treatment.—Mobile kidney is treated as follows: If the kidney is but slightly mobile and there are no local symptoms, the treatment should be non-operative: (1) The *rest treatment of S. Weir Mitchell* may be tried; it often markedly mitigates the symptoms, but does not seem to cure. (2) *Mechanical support* should always be tried. The most satisfactory mode of applying it is by the corset recommended by Gallant ("Amer. Jour. Obstet.," July, 1901). This corset is long and straight in front, and when applied fits firmly over the hips and lower abdomen, less firmly at the waist, and least firmly above.

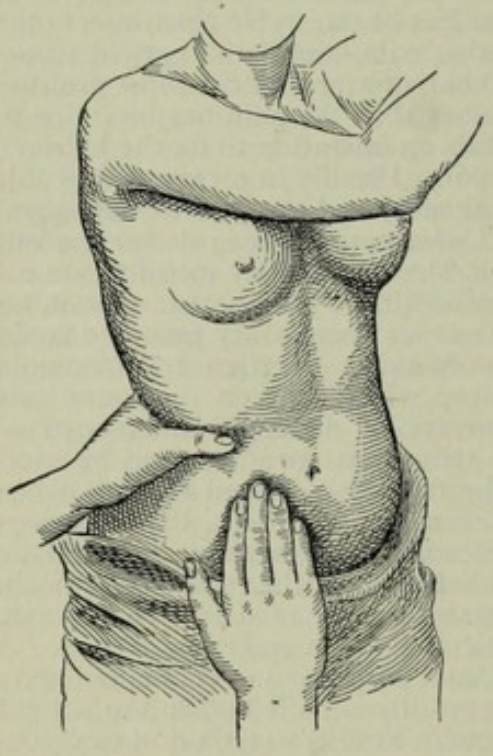


FIG. 1025.—Franks's method of palpation for the detection of a prolapsed kidney, as practised by A. H. Goelet.

The patient lies down, a pillow being under the buttocks and the knees being drawn up. While in this attitude the corset is put on and it is laced in front from below up. If the attempt to apply the corset develops tenderness, keep the patient at rest in bed until it can be applied without pain. In some cases conservative treatment is not indicated; in others it fails.

"The distinct local symptoms mean the beginning of actual harm to the kidney, and the progressive increase of movability means the ultimate attainment of a wide range of movement. A kidney which is widely movable may at any time twist upon the ureter and the renal vessels; and it is certain to suffer from partial or slight twists, probably many times repeated in the twenty-four hours, even if a severe twist does not occur. A deduction from the foregoing statements is that a patient suffering with nephroptosis, even when the mobility is slight, should be examined at regular intervals, to note whether the area of movement is extending, or whether local symptoms have arisen. Three local-symptoms that should be regarded as indications for operation are severe pain in the renal region, distinct tenderness of the kidney, and enlargement of the kidney" (the author in "New York Med. Jour.," Aug. 4, 1906). Billington ("Brit. Med. Jour.," May 1, 1909) formulates the following indications for operation:

1. When renal pain is so severe or persistent as to cause serious inconvenience. The ordinary dragging pain in the loin is not an indication. Billington refers to severe pain due to perirenal inflammation, ureteral obstruction, or impeded venous return.
2. When there are harassing and depressing gastric and colonic troubles (gross lesions being absent).
3. Cases of spinal and cerebral neurasthenia.
4. Cases of lunacy. Personally I do not operate on Groups 3 and 4 unless there are signs of grave renal disaster.

The usual operation chosen will be nephropexy, very seldom nephrectomy. (1) *Nephropexy* is the operation employed in most instances (see page 1295). It is the author's experience that if the patient has had marked nervous symptoms for a long

time, nephropexy will rarely cause them to pass away permanently, even though the kidney remains firmly anchored. (2) *Nephrectomy* is necessary in very rare cases only; it may be done for dislocated kidney, when grave kidney disease exists, or when nephropexy has failed in a case of great severity.

In many cases of this trouble no operation should be performed, the use of Gallant's corset securing, perhaps, decided or complete relief. I do not operate if the kidney is only slightly movable and if there are no local symptoms or if there are merely the general symptoms of hysteria. If the mobility is slight and the hysteric and neurotic condition is pronounced, anchoring the kidney will not cure the nervous condition. In these nervous cases, associated with prolapse of the kidney, there is usually also prolapse of the other abdominal viscera; and both kidneys are, as a rule, movable, the right, however, in most cases being decidedly more movable than the left.

If there is but slight mobility of the kidney, but the range of movement is, week by week and month by month, increasing, or if we find a case of movable kidney in which there are distinct symptoms, an operation should be performed. The existence of definite local symptoms means beginning harm to the kidney; and if we find the area of movement gradually increasing, we know that eventually it will become extensive. Any widely movable kidney may twist the ureter and the renal vessels, producing serious trouble or even disaster, and consequently should be fixed by operation. Even if a severe twist does not take place, the kidney is bound to suffer from partial or slight twists. Such kidneys will eventually become hydronephrotic. The meaning of the term "slight mobility" is indicated on a previous page (see page 1274).

One is not unusually in doubt in cases of movable kidney whether a pain indicates local trouble with the kidney or catarrhal appendicitis, because the pain may be located in the appendix region. Kelly, of Johns Hopkins Hospital, has shown how to solve this problem (see page 1275).

There are many operations for movable kidney. In all of them the kidney is exposed in the loin. Some make a vertical and some an oblique incision. Edebohls makes a vertical incision, forces the kidney out of the wound, incises the fibrous capsule longitudinally, turns a cuff down on each side, and applies sutures. These sutures traverse the kidney substance and the fold of capsule on each side. The upper suture catches the periosteum of the last rib; the other sutures catch the lumbar fascia. Drainage is not required, and the suture material employed is kangaroo-tendon or chromicized catgut.

Some surgeons simply pass sutures through the uncut capsule and the kidney substance and thus fasten the kidney to the lumbar fascia. Others split the capsule and pass sutures through the edge of the capsule and the wound edges, but not through the kidney substance.

To promise success, an operation ought to restore the kidney nearly to its normal position and fix it permanently in place. It is undesirable to inflict damage on the kidney itself, and I do not believe in any operation that seeks to obtain fixation by passing sutures through the kidney substance. In cases in which decapsulation is performed the kidney will grow fast without any special method of suturing.

Most of the operations suggested do not place the kidney sufficiently high up to get it into a fair position. Kelly's operation gets it higher than most of them, and Goelet's operation gets it well into place. In many of the suture operations the sutures are placed in the convex surface of the kidney or the kidney capsule, and, on fixing the kidney by tying the sutures, there is a permanent quarter twist of the ureter—a condition that may be responsible for great pain. This may be obviated entirely by the ingenious method of Goelet ("Annals of Surgery," Dec., 1903). I believe, however, that the suture operations which do lift the kidney well up toward its proper place and in which the sutures are applied on the posterior surface and not the convexity, tilt the upper pole forward into a permanent and perhaps disastrous position. Such operations lift the kidney from below its midline and thus fix the lower half of the organ, but leave the upper half unfixed. I believe, too, that in many cases in which kidneys have been sutured they get loose again, and that the best operation, after all, is that by the use of slings of iodoform gauze (see page 1296).

Injuries of the Kidney.—Laceration or **rupture** is caused by falls and by blows upon the back or the belly.

Symptoms.—In some cases the parenchymatous structure is torn, but the capsule is not torn, and in consequence urine and blood are not extravasated into the perirenal connective tissue or into the peritoneal cavity. In other cases the parenchyma and capsule are both torn and urine and blood are extravasated into the perirenal tis-

sues, the peritoneal cavity, or both of these regions. The laceration may be trivial, may be considerable, or may tear the kidney apart. The symptoms depend on the gravity of the injury. A slight tear without involvement of the capsule may produce practically no symptoms at all. A more severe injury produces shock, and, if profuse bleeding occurs, the general symptoms of hemorrhage. In intraperitoneal rupture there is profuse and usually fatal hemorrhage. In laceration of the kidney there are lumbar tenderness and severe loin pain which shoots into the groin or testicle. If there is considerable perirenal bleeding the loin will be full and dull on percussion, and if the hemorrhage is large, a palpable mass will form after a time, and after some days the overlying skin will become discolored. There is usually frequent and painful micturition, and in some cases suppression of urine. Hematuria occurs in renal laceration unless the rupture has been intraperitoneal or the ureter has been torn. If the rupture has been intraperitoneal there are evidences of profuse internal hemorrhage, abdominal rigidity, etc. (Daniel N. Eisendrath, "Jour. Amer. Med. Assoc.," Oct. 25, 1902). It is important to remember that hematuria can arise from simple renal contusion, and that even severe kidney damage does not of necessity cause bloody urine to be passed by micturition. If there be hematuria, the use of the cystoscope, or catheterization of the ureters will demonstrate from which kidney the blood comes. A kidney laceration may be followed by secondary hemorrhage, perirenal suppuration, hydronephrosis, or pyonephrosis. The force of the injury may have caused kidney displacement.

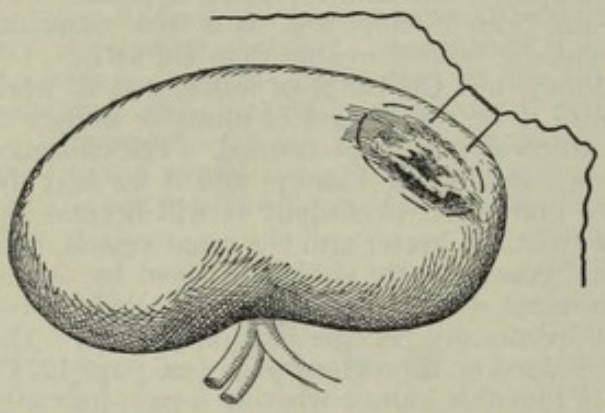


FIG. 1026.—Purse-string suture applied to a perforation (after Schacher).

Treatment.—In an intraperitoneal rupture laparotomy should be performed. As a rule, nephrectomy is necessary, but it may be possible to arrest hemorrhage by packing. If the shock is pronounced and if there is increasing fulness in the loin, whether hematuria exists or not, or if blood comes profusely from the ureter, whether or not there is much shock or lumbar fulness, make an exploratory lumbar incision

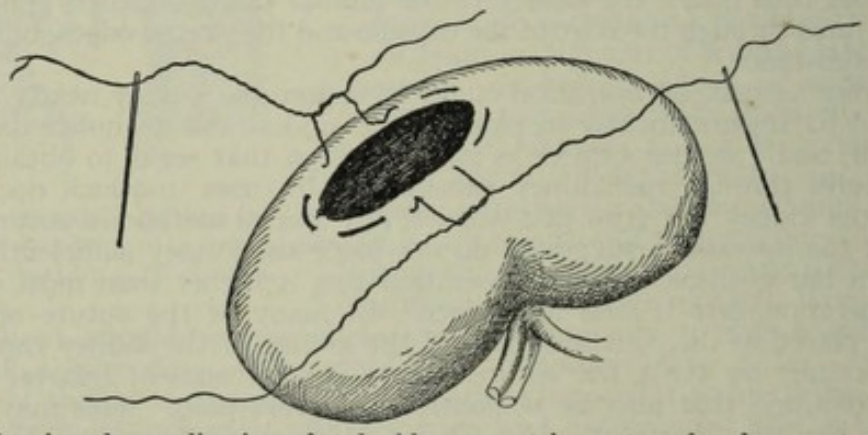


FIG. 1027.—Showing the application of a double purse-string suture for the arrest of hemorrhage in large wound (after Schacher).

and stop the bleeding by packing or by a purse-string suture (Figs. 1026, 1027), or, if necessary, perform partial, or even complete, nephrectomy. Ordinarily, after a kidney injury, when there is not great shock, but is increasing lumbar swelling, or severe hematuria, treat by rest in bed and by feeding with liquid food or by nutritive enemata to prevent vomiting. Opium, tannic acid, or gallic acid may be used. Apply ice-bags to the loin and to the side of the abdomen, and after bleeding ceases strap the loin and apply a binder. If large blood-clots in the bladder cause pain or retention of urine, introduce a catheter and inject the bladder with boric acid, or use the tube and evacuator of a Bigelow apparatus. If this procedure fails, open the bladder by a suprapubic incision and drain. Enzymol in 15 to 25 per cent. solution may digest the clots.

Results of Operation.—Up to 1894 there had never been a case of intraperitoneal rupture operated upon. During the following seven years 6 were operated upon and all recovered (Daniel N. Eisendrath, "Jour. Amer. Med. Assoc.," Oct. 25, 1902). Küster collected 47 cases of nephrectomy, and 83 per cent. recovered. Keen estimates the mortality of primary nephrectomy for rupture at 20 per cent., and of secondary nephrectomy at 38.5 per cent. Without operation intraperitoneal rupture is inevitably fatal. Of extraperitoneal ruptures, 70 per cent. recover without operation (Eisendrath). Francis S. Watson ("Boston Med. and Surg. Jour.," July 16, 1903) has collected 660 cases of subparietal injury of the kidney. The following statistics are of interest: Treated expectantly: 273 cases with 81 deaths, a mortality of 29.6 per cent. Treated by operations other than nephrectomy: 99 cases with 7 deaths, a mortality of 7.7 per cent. Treated by nephrectomy: 115 cases with 25 deaths, a mortality of 21.7 per cent.

Penetrating wounds of the kidney, if purely posterior, they do not involve the peritoneum; if anterior, they do. The *symptoms* are escape of blood and urine from the wound; hematuria is usual, but not invariable; pain as in rupture; the patient may be unable to micturate; and nausea, vomiting, and constitutional signs of hemorrhage exist. Traumatic peritonitis, perinephric abscess, or general sepsis may ensue. Confirm the diagnosis by exploration with the finger after operative exposure. Extraperitoneal injuries give a good, and intraperitoneal a bad, prognosis.

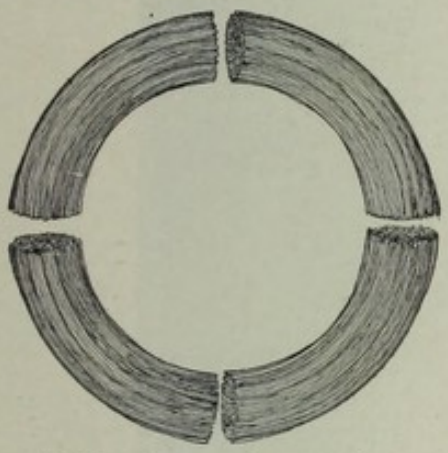


FIG. 1028.—Catgut ring cut into quarters to be inserted under the suture as shown in Fig. 1029.

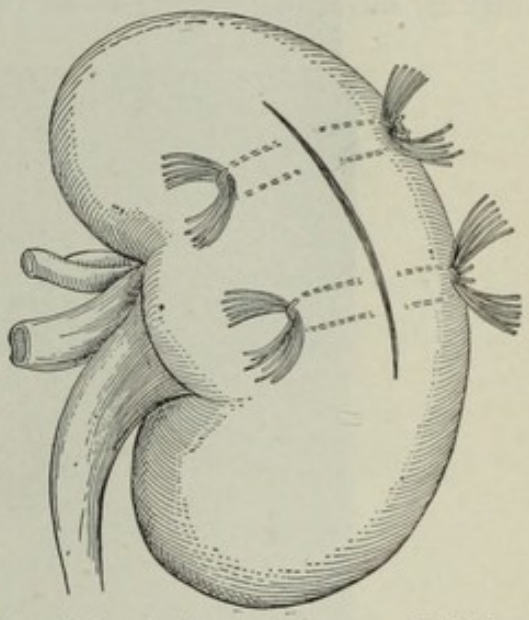


FIG. 1029.—Stellwagen's suture of kidney to prevent cutting after tying.

Treatment.—If the wound of the kidney be extraperitoneal, enlarge the lumbar wound to permit of drainage, and arrest hemorrhage by packing and hot water, by a purse-string suture (Figs. 1026, 1027), or by suture ligatures.

Suture of the Kidney.—The tendency of any suture material to cut through the kidney structure is great. The following simple procedure greatly lessens this danger: Cut the ordinary catgut roll into three or four parts, as shown in Fig. 1028. Slip beneath the exposed loops of the purse-string suture, as shown in Fig. 1029, a section of the catgut roll consisting of a series of short stiff strands. These permit fairly firm tying of the suture-ligature without cutting of the kidney structure by the suture. In nephrotomy the same procedure can be used in closing the kidney wound.

Asepticize the wound, insert a drainage-tube down to the kidney, dress with sterile gauze and make frequent changes of dressings, keep the patient in bed and on a low diet, and give gallic acid and opium. In some cases nephrectomy, partial or complete, will be required. In intraperitoneal wounds perform an abdominal section and, as a rule, remove the damaged organ (see Nephrectomy).

Wounds of the Ureters.—Rupture from external violence is an extremely rare accident. Eisendrath ("Jour. Amer. Med. Assoc.," Oct. 25, 1902) found only 3 undoubted cases on record. A rupture or wound from accidental violence is almost invariably associated with other serious injuries. The ureter may be wounded accidentally by the surgeon during the performance of a pelvic operation, or it may be cut intentionally, as in Morris's case, in which the ureter was found incorporated

within a malignant growth. There is particular danger of injuring the ureter in operations upon intraligamentary growths, because the ureter is displaced and often resembles an adhesion. The rule of surgery is that when working about the ureter the surgeon neither clamps nor cuts any structure without a careful preliminary examination to identify the exact position of this tube. Rupture causes severe shock and extravasation of urine around the kidney or into the peritoneal cavity. In extraperitoneal rupture a palpable mass forms in the loin. When the ureter is divided in an operation a flow of urine is seen.

Treatment.—The upper three-fourths of the ureter can be reached by an extraperitoneal incision, which is a prolongation of the incision for lumbar nephrectomy, running from the twelfth rib downward, and forward to 1 inch anterior to the anterior superior spine of the ilium, and then parallel to Poupart's ligament until a point is reached above the latter's center (Fenger). Israel's incision begins at the anterior edge of the erector spinæ mass, one fingerbreadth below the twelfth rib, is taken forward parallel with the rib until it reaches the line of the rib's tip, and is then carried toward the middle of Poupart's ligament until the line for ligation of the common iliac artery is reached, and is then taken toward the middle line as far as the outer border of the rectus muscle. The lower fourth of the ureter can be reached by abdominal section, by sacral resection, or by an incision like that for extraperitoneal ligation of

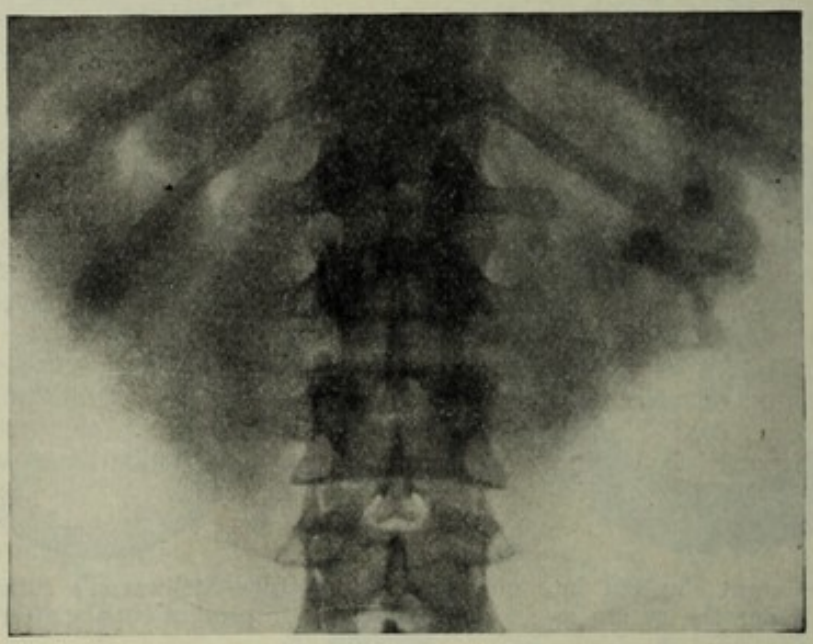


FIG. 1030.—Stones in both kidneys (U. S. Naval Hospital, League Island, Pa.; skiagraphed by Lieut. George U. Pillmore, Medical Corps, U. S. Navy).

the iliac vessels. The best operation to reach the lower ureter is Gibson's (see page 1297). If it seems probable that the ureter is wounded or ruptured, explore, and if a breach in the ureter is found, endeavor to restore the continuity of the tube. A longitudinal cut can be sutured with fine catgut. If the ureter is cut across near the bladder, implant the proximal end into the bladder and ligate the distal end (Van Hook, Penrose, Kelly). If it is cut above the bladder portion, perform lateral implantation by Van Hook's method (see page 1299).

A longitudinal wound of the ureter inflicted during an abdominal operation should be sutured, but if the duct cannot be readily reached, simply make a posterior incision and drain with rubber tissue, as the longitudinal wound will heal by granulation if no sutures are inserted (Van Hook). In a case of transverse division perform ureteroureterostomy (page 1299), or vesical implantation; or, if neither of these methods be feasible, make a urinary fistula in the loin or perform nephrectomy.

Renal Calculus (Nephrolithiasis).—A stone in the kidney is formed by the precipitation of urinary salts upon the renal epithelial cells and the gluing together of these salts and cells by material from mucus or blood-clot, this mass serving as a nucleus on which accretion takes place. Most calculi escape when small, as *gravel.* The **cause** is said to be highly acid urine, which induces catarrh of the renal tubes. Such high concentration of urine is favored by a sedentary life, by the ingestion of

much alcohol or nitrogenous food, by constipation, by an inactive skin, and by a torpid liver. Infection is certainly a cause in many cases. Any obstruction to the ureter favors stone formation by producing stasis, and stasis leads to precipitation and favors infection. O. S. Fowler ("Jour. Amer. Med. Assoc.," 1914, lxii) points out that stones tend particularly to form in the lower pole of the kidney and cites this fact as evidence that renal drainage is deficient from that portion of the organ. The slaves of poverty are particularly liable to calculi because of the use of unsuitable foods and the formation of great amounts of nitrogenous waste. Males suffer more often than females; certain occupations and regions favor the development of the malady, and a family tendency sometimes exists.

The **symptoms** of stone in the kidney may not appear for years after the stone forms, but generally they are manifested early. There may be no pain. There had been none in 13 cases out of 23 which came to autopsy and were reported by Clark. Usually there is pain; the severity of the pain depending upon the roughness and

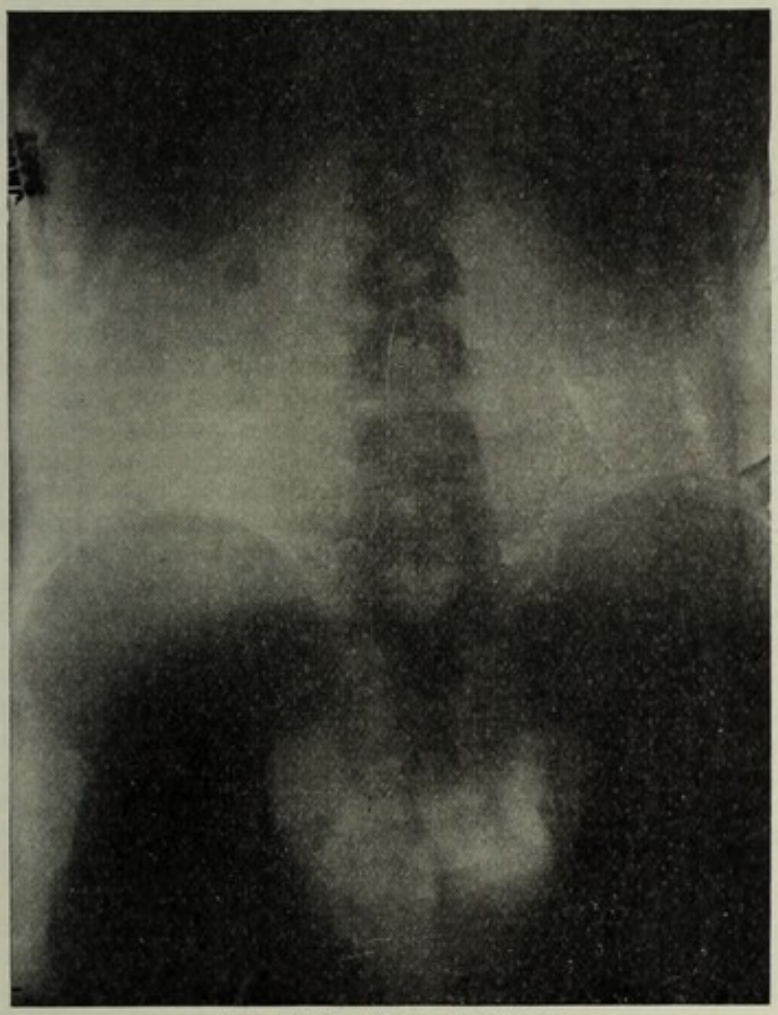


FIG. 1031.—Stone in kidney.

movability rather than upon the size of the stone. A fixed stone in the kidney and a smooth stone in the pelvis may cause little or no pain. A rough stone in the pelvis causes severe pain. The patient usually complains of pain in the loin, and sometimes in the iliac region and testicle. Deep percussion over the kidney may cause pain in the loin even when pressure is painless (*Jordan Lloyd's symptom*). Pain is aggravated by exercise and pressure, and the kidney is, in most cases, enlarged. The urine is often somewhat albuminous, and may from time to time contain blood. Frequency of micturition is noted during the day, but seldom when at rest at night. The urine may be purulent. *Nephritic colic* is due to the washing of a calculus into the orifice of the ureter, which it blocks, tears, or distends. The pain is either sudden or gradual in onset, is fearful in intensity and runs from the lumbar region down the spermatic cord and corresponding thigh (the testicle being retracted), and into the abdomen and back. There are nausea, vomiting, collapse, sometimes unconsciousness or convulsions. Frequent attempts at micturition are productive of pain, but of little urine. Rectal

tenèsmus is common. The urine is often, but by no means always, smoky from blood. Blood may be found by the microscope when it cannot be detected by the naked eye. In rare cases fatal hemorrhage occurs. Blood is present in about one-half the cases. After a time the pain vanishes, the stone having passed into the bladder or having fallen back into the pelvis of the kidney. Slight attacks of colic occur from the passage of small stones, sand, or plugs of mucus. A calculus retained in the kidney eventually excites pyelitis, pus appears in the urine, and soreness or pain exists in the loin. Kelly says: Even if pus is found, we are not always sure from which kidney it came. Pain or swelling may point to one side, but we are not sure that the other organ is not also affected. The cystoscope must be used. Bloody or purulent urine may be seen coming from one ureter. If able to pass the renal catheter into one ureter, attach a syringe, and by making suction draw out any pus which may be present. In renal calculi cases this fluid is apt to contain fragments of uric acid. By using a renal bougie coated with dental wax it may be possible to make scratches on the instrument when it comes in contact with a concretion.[1] When a stone is impacted in the renal pelvis the point of greatest tenderness on pressure is below the last rib, at the edge of the erector spinæ muscle. In septic cases there may be chills and irregular fever, and often there is leukocytosis. In most cases a stone in the kidney or ureter can be skiagraphed. Pure uric acid stones may not show. Nephrolithiasis may cause death by exhaustion, by sepsis, by rupture of a hydronephrosis or a pyonephrosis, or by amyloid degeneration.

Treatment.—For the gravel of the uric-acid diathesis use alkalies, especially the liquor potassii citratis, and reduce the amount of nitrogen in the diet to a minimum, at the same time washing out the organs by copious drafts of distilled water. Citrate of lithia, given in the water, is supposed to add to the therapeutic effect. Some surgeons prescribe natural lithia water. Piperazin, in doses of 5 to 8 gr. three times a day, was once highly commended. Exercise is to be insisted on. When gravel is phosphatic, order strychnin, the mineral acids, and rest at the seaside. When oxalate of lime is found, restrict the diet, use the mineral acids, recommend travel or rest amid new surroundings, and give an occasional course of sodii phosphas, ½ dram three times a day, taken in a natural lithia water. Nephritic colic is relieved by hypodermic injection of morphin and atropin, a hot bath, diluent drinks, and possibly the inhalation of ether. After an attack watch all the urine passed to see if a stone appears. If one does not soon appear, use the cystoscope, and if a stone is found in the bladder, wash out that viscus with an evacuator. This is very important, as the vesical stone may fail to pass, and if it remains in the bladder it will progressively enlarge. Small stones in the bladder can often be crushed by the grasping cystoscope or the lithotrite. Finding a stone proves the diagnosis of renal colic. If a stone impacts in the ureter, and obstinately refuses to pass, in most cases perform the operation of *ureterolithotomy*. The diagnosis of this impaction is in many cases aided by the *x*-ray, but is sometimes possible only after exploratory laparotomy. If the symptoms point to stone in the kidney, always make a radiographic picture. Take a radiograph of both kidneys for comparison. If this shows a stone on the affected side, if medical treatment fails, or has failed, and if the other kidney is not organically diseased, operate and operate early; that is, if there is no chance of the stone passing. Delay may mean disastrous or fatal sepsis. The danger of delay is often greater than the danger of operation. If in doubt in spite of the skiagraph, make an exploratory lumbar incision; feel the surface of the kidney with the finger, sound the inside of the organ with a needle, or open the organ for exploration, and if a stone be detected, incise the kidney and remove the stone. Keen is of the opinion that operation should not be performed if the urea is below 1 per cent. If, after nephrolithotomy, suppression of urine occurs, cut into the other kidney, as in one-half of all cases a stone will be found lodged there. I agree with Brewer ("Med. Record," March 20, 1909) that "a kidney containing one or more calculi, and also the seat of an advanced septic process, should be removed if the opposite organ is healthy. To leave such a kidney is to invite subsequent trouble from recurrence of stone, pyonephrosis, or long-continued sepsis." I agree with him when he says: "It is also often safer to remove a kidney with multiple calculi embedded in its substance than to inflict the trauma necessary to remove them, as alarming primary or secondary hemorrhage is apt to occur." In a case of my own a most persistent postoperative hemorrhage forced me to perform nephrectomy to save life. If each kidney contains a stone or stones operation is perilous. The mortality of operation in this condition is at least 30 per cent. and fistula is apt

[1] Howard Kelly in "Med. News," Nov. 30, 1895.

to result. If there is little or no infection, operation is inadvisable, otherwise it must be done in spite of the risk.

Calculus Impacted in the Ureter.—A ureteral calculus comes from the kidney, sometimes dropping, but more often being forced, into the tube. A stone may be arrested at any one of the points of constriction. There are three points of constriction in the ureter: one point is about 2 inches below the renal pelvis, another is at the pelvic brim, another is about ½ inch from the bladder orifice of the ureter. The highest point has a diameter of about $\frac{1}{7}$ inch, the middle point a diameter of about $\frac{1}{4}$ inch, the lower point a diameter of about 1/10 inch. A small stone may completely block the ureter. A large stone may fail to block it completely because the ureter dilates above, the stone acts as a ball-valve, and urine trickles by.

Symptoms.—Attacks of violent pain of the nature of renal colic occur, and not unusually there is a rigor with the attack and fever after it. Such an attack may be followed by hematuria. The urine should be examined microscopically during several days after a colic to see if it contains blood-cells. Tenderness can be developed at the point of impaction, the point of greatest tenderness being in the loin *below* the level of the kidney or in the iliac region (Perkins). In stone in the ureter pain is not developed by pressure in the loin at the level of the kidney. If a stone partly obstructs the ureter, the urine is pale, of low specific gravity, and free from albumin. Impaction near the bladder causes symptoms similar to stone in the bladder (Jordan Lloyd). These symptoms are frequent micturition, pain at the seat of impaction, pain in the head of the penis, and bloody urine. If a stone is impacted in the lower end of the ureter a finger in the vagina or rectum will find tenderness and perhaps will feel the stone. In a woman, a stone lodged in front of the broad ligament may be felt by a finger in the vagina. Back of this region and up to the pelvic brim a stone may be rarely felt by a finger in the rectum. A cystoscopic examination, in unusual cases, may show a portion of stone projecting from a ureter (Kelly). Impaction near the kidney is accompanied by hematuria and pyuria, lumbar pain, pain radiating into the groin, thigh, or testicle, and retraction of the testicle. These symptoms are identical in character with the symptoms caused by stone in the renal pelvis. Complete obstruction of the ureter causes hydronephrosis. Pyonephrosis results from infection of a hydronephrosis or from blocking of a suppurating kidney. In some cases a stone acts as a ball-valve, plugs the ureter for a time, during which a lumbar mass develops, and then allows the urine to flow. A copious flow of urine is accompanied by disappearance of the lumbar mass (*flush tank phenomenon*). Complete urinary suppression may follow blocking of a ureter by a calculus. If a ureteral catheter tipped with wax be introduced, a calculus will make distinct scratches upon it (Kelly). The Cunningham catheter (see Fig. 1047, *e*) may assist in detecting a stone. It has not been successful in our hands when the stone has been impacted more than 6 c.c. above the ureteral outlet. This catheter may also be of assistance in dislodging the stone.

The *x*-rays are very valuable in diagnosis. A pyelographic study of the ureter and pelvis may give material assistance.

Treatment.—During a painful paroxysm give morphin and use hot packs. Belladonna is useful by inducing relaxation of spasm. The ozonized oil of turpentine, given in capsules in 10-min. doses, is often valuable. It was employed by the elder Gross. The attack may terminate and not return, because the calculus passes. If such an attack does pass away, the urine should be examined after every act of micturition to see if the stone has been voided from the bladder. After a day or two, if the stone does not appear, use the cystoscope, perhaps catheterize the ureter, and thus discover if the stone is in the bladder or if it is impacted in the ureter. If the stone is in the bladder use the Bigelow evacuator to effect removal, or crush the stone and then evacuate. The stone must never be allowed to remain, as it will surely enlarge and cause subsequent trouble. If a stone is found impacted in the ureter have the patient drink distilled water freely. Sterile olive oil may be injected into the ureter through a ureteral catheter, or the ureteral orifice may be dilated by a suitable bougie. If the impacted stone is very near the bladder the ureteral orifice may be slit. Simple catheterization of the ureter may be followed by expulsion of the stone. If in spite of these procedures the stone remains impacted in the ureter, the question of operation presents itself. An impacted stone is certainly a peril, but how immediate the danger is it is often impossible to say. In some cases stones have remained impacted for many years without doing obvious harm. In other cases the kidney has been rapidly destroyed. The stone may pass after having been retained for a long time,

and drinking freely of distilled water favors its expulsion. One of my cases had long carried a retained stone. He came to the hospital for operation, and passed the stone the morning set for operation. Sooner or later a retained stone will lead to disaster and it ought to be removed by operation, and it should be removed early if the surgeon is convinced it will not pass. The danger of delay exceeds the danger of operation. It will cause, if retained, thickening or ulceration of the ureter, dilatation of the ureter above it, and kidney trouble from blocking or sepsis. A lodged stone increases gradually in size and other stones may form above it. The extraperitoneal operation is to be chosen in most cases. Even when the stone is impacted below the pelvic brim it is usually better to do the extraperitoneal operation (see Ureterolithotomy).

Infections of the Kidney.—Bacteria may reach the kidney by the blood, by the ureter, or by way of the lymphatics. Mechanical obstruction favors infection greatly. So does inflammation. Blocking of the ureter may result from stone or from pressure without. The gravid uterus may obstruct the ureter and this may be an explanation of that common lesion, the pyelitis of pregnancy. In the male enlargement of the prostate and urethral stricture interfere with kidney drainage.

Intestinal inflammation or stasis is not unusually followed by kidney inflammation. In any general infection the kidneys may suffer.

In over 90 per cent. of renal infections the colon bacillus is responsible (Koll, "A Collective Review" in "Internat. Abstract of Surgery," April, 1915). According to Koll (Ibid.), next in order of frequency is the Staphylococcus pyogenes albus, rarely the aureus; the Streptococcus pyogenes; the typhoid bacillus; the gonococcus; the Bacillus fæcalis alkaligenes; and the pneumococcus.

Gonococcus infection is so rare as to be a surgical curiosity. Stellwagen has seen but one authenticated case of gonococcal infection.

Staphylococcic infection comes from the urethra. These bacteria can be found in one-fifth of healthy male urethras (Koll, Ibid.). In scarlatina or tonsillitis streptococci may reach the kidney by the blood and cause acute nephritis.

One-fourth of all typhoid patients have typhoid bacilli in the urine after the third week of the disease. These organisms may continue in the urine for weeks, months, or several years.

Abscess of the kidney may be caused by traumatism, by calculus, by stricture of the ureter, by disease of the bladder, by the union of miliary abscesses (tuberculosis), by pyemia, and by certain parasites.

The **symptoms** are pus in the urine (this is usual, but not invariable), hematuria in traumatic cases, and pain running into the groin. The urine in most cases is alkaline. Constitutional symptoms of suppuration exist, the fever being far higher than that generally encountered in renal tuberculosis. The bladder should be examined with a cystoscope to determine whether or not the turbid urine is flowing from the ureter and to identify the diseased side. It is well, if possible, to catheterize the ureters.

The **treatment** in the early stage is rest, morphin, purgation, anodynes, and hot fomentations. In some cases repeated lavage through the ureter is employed. When the diagnosis is clear, and lavage fails or is not thought desirable, incise the loin, open the kidney and stitch it to the abdominal wall, or, if the organ be badly damaged, remove it.

Pyelitis.—This is inflammation of the pelvis of the kidney. It may be unilateral, but is usually bilateral. It may arise by a descending process from nephritis, by an ascending process from a ureteritis, or, in very rare instances, by spread from a perinephric inflammation.

The pelvis of the kidney is predisposed to inflammation by irritation and congestion. Among the irritants are large doses of sandalwood oil and hexamethylenamin. Exposure to cold may cause congestion. Highly concentrated urine and calculi cause irritation. Interference with drainage of urine strongly favors infection and aggravates existing infection. Interference with urinary drainage may be caused by a stone in the kidney, ureter or bladder, by a blood-clot in or stricture of the ureter, by pressure upon the ureter from without (by an abdominal tumor or a pregnant uterus), by kinking of the ureter (in movable kidney), by vesical paralysis, by urethral stricture, by prostatic enlargement, by ascending tuberculous infection, and by growths in the calices. In rare cases trauma is responsible. Nephritis, especially the chronic interstitial nephritis of the gouty, and heart disease predispose. Perinephric abscess, malignant disease, or parasites may be responsible. Intestinal stasis is blamed in some cases. The organisms chiefly responsible for infection are pus bacteria and colon bacilli.

In nine-tenths of the cases arising secondarily to bacterial nephritis colon bacilli are responsible. In most ascending infections staphylococci are to blame. Gonococcal infection almost never occurs. Pyelitis is not uncommonly caused by the exanthemata. If infection be mild a catarrhal inflammation may arise, but it is rare and most inflammations are suppurative. A pyelitis is greatly aggravated if the ureter becomes blocked with pus (pyonephrosis follows).

Pyelitis may lead to ulceration and ascending pyelitis frequently causes parenchymatous and more frequently interstitial nephritis.

Symptoms.—Pain in the loin, which may be severe and is apt to have acute exacerbations. Pain may radiate into the penis, the testicle, or even the corresponding shoulder, and it is associated with tenderness of the kidney. The pain is increased by motion (especially by cough). The output of urine may be, but seldom is, diminished. The urine is acid, and contains hyaline casts, albumin, and in most cases numbers of pus-cells or even obvious pus. It may contain blood. In catarrhal cases fever may be slight or absent, but in purulent cases there is certain to be fever. Chills and sweats occur in many cases. In an acute case the kidney is seldom enlarged. If pyonephrosis occurs the kidney of course enlarges.

In acute Bright's disease there is edema, the skin is dry, the urine is scanty and contains blood, and there may be convulsions. In pyelitis the urine is usually plentiful, contains pus, albumin and bacteria, seldom contains blood, there is no edema, the skin is moist, and convulsions do not occur.

In grave cases a chill is followed by fever, with headache, stupor, dry tongue, and usually scanty urine. The prognosis in catarrhal cases is of the best, but in severe infections is extremely grave. Pyelitis may at any time originate kidney inflammation (pyelonephritis). When, during the existence of pyelitis, the ureter becomes blocked the condition is known as *pyonephrosis* (page 1288).

Treatment depends upon the course or the severity of the infection. Trivial inflammations, such as may arise during an exanthematous fever, require merely rest in bed, liquid diet, and the use of diluent drinks. In a more severe case give morphin if the pain be severe.

In colon infections the kidney may be involved, the urine is almost never sterile, and some practitioners use an autogenous vaccine. The use of vaccines in pyelitis is sometimes followed by brilliant results, but in my experience they usually fail. The source of infection must be sought for in some focal area such as the teeth, the bowel, the gall-bladder, the tonsils, or the sinuses. I have seen some very good results follow the removal of such a focus. Deformity or malposition of the kidney, ureter, or bladder may be responsible and should, if possible, be corrected.

If the urine be acid, give liquor potassii citratis; if alkaline, give benzoate of ammonium and boric acid or hexamethylenamin. Gallic acid, eucalyptol, and small doses of copaiba or cubebs are recommended. Venice turpentine, camphor, and opium may be given in pill form. Quinin is used to stimulate the patient. If cystitis exists the bladder is to be washed out every day with boric acid solution (3 grains to the ounce of water) and at intervals with a solution of nitrate of silver (1 : 8000). In some cases a catheter is inserted and retained. Cups, dry or wet, and hot sand-bags or bran-bags are to be applied to the loin. Alcohol may be sparingly administered. Hexamethylenamin is a useful drug if the urine be alkaline. Lavage of the pelvis of the kidney by means of the hydrostatic apparatus shown in Fig. 1053 may be practised and is often useful. For lavage, use a return-flow catheter (1047, *b*); first wash the pelvis gently with normal salt solution or sterile distilled water. Silver nitrate in solution, of a strength of 1/10,000, may be used.

S. B. Dudgeon and A. Ross, of London ("Annals of Surgery," March, 1910), give small doses of autogenous vaccine—100,000,000 to 200,000,000 administered every five days. Relapses are apt to occur. If pyonephrosis develops, perform nephrostomy, or, perhaps, nephrectomy. Small doses of neo-arsphenamin given over a period of five or six weeks are often valuable. Start with $1\frac{1}{2}$ tenths of a gram and increase up to 3 or $3\frac{1}{2}$ tenths of a gram at weekly intervals.

Pyelonephritis.—This is a septic inflammation of the kidney which is associated with or secondary to pyelitis. In a hematogenous infection (for instance, with colon bacilli) the nephritis precedes the pyelitis (E. G. Crabtree and Hugh Cabot in "Jour. Amer. Med. Assoc.," Feb. 24, 1917). In an ascending infection the pyelitis precedes the nephritis.

Some restrict the term "pyelonephritis" to the ascending form of renal suppuration and call the descending form suppurative nephritis. The causes of pyelitis and

pyonephrosis are the causes of pyelonephritis. The calices, the uriniferous tubules, and the renal parenchyma are involved in suppuration.

Symptoms.—In the acute form the symptoms arise suddenly. There is a chill. High fever follows. Delirium is common. Loin pain is severe. In a short time the patient becomes dull and drowsy, stupor comes on, and finally, in most cases, the patient dies. Death is the rule in from one to two weeks. A few cases recover. The symptoms "are due in part to septic intoxication, in part to renal insufficiency" ("Genito-urinary Surgery and Venereal Disease," by Martin, Thomas, and Moorhead). In chronic pyelonephritis the chief symptoms may be indicative of irritation of the gastro-intestinal tract, in fact, there may be no sign pointing to the urinary organs. A urinary examination and a bladder study are, of course, imperative. The patient suffers from indigestion, flatulence, dry mouth, loss of flesh and strength, and from attacks of violent diarrhea.

Treatment.—A liquid diet, diuretics, diluent drinks, laxatives. In acute cases dry cup over the kidneys. Alcoholic stimulation is required. Martin gives salol. If pyonephrosis develops open the kidney and drain (nephrostomy).

Spontaneous Perirenal Hematoma.—Traumatism is the common cause of a hematoma in the perirenal tissues (page 1277). Spontaneous hematoma is a rare but recognized affection. It was described by Wunderlich in 1856 under the name of spontaneous apoplexy of the capsule of the kidney. In most of these cases acute or chronic nephritis exists. In some cases the hematoma is under an unruptured capsule. In some the capsule is ruptured and a mass is palpable. This mass may reach up to the diaphragm and down into the pelvis and even to the median line of the body. In a case of perirenal hematoma a cyst may form (*perirenal hygroma*).

Lippens ("Jour. de Clin.," 1913, xi, 1) collected 23 cases of perirenal hematoma. He found records of 2 bilateral cases. The condition is much more common in the young than in the elderly and is more frequent in men than in women. It causes sudden and violent pain in the loin, with symptoms of concealed bleeding, and the formation of a palpable mass, which is immovable, tender, and dull on percussion. In some cases violent attacks of colic occur during a number of months. The temperature is usually elevated after reaction from the initial hemorrhage. Without operation the condition will be fatal sooner or later.

The **treatment** in some cases is incision and packing with gauze; in some, is nephrectomy. The earlier the operation, the better the prognosis. I operated, but in vain, on one case.

Perinephritis is an inflammation of the perinephric fatty tissue produced by cold, febrile disease, slight traumatism, the spread of inflammation from another part, or a focal infection.

The **symptoms** of this condition are rigidity of the spine, the inclination being toward the affected side, flexion of the thigh, pain in the loin and iliac region, and often pain in the knee. The symptoms resemble those of hip-joint disease in the second stage. Suppuration may or may not take place. In some suppurative cases the condition strongly suggests woody phlegmon (see page 65). I have seen one case in which there was severe, unilateral abdominal pain, rapid pulse, elevated temperature, abdominal distention, a mass in the loin, and compression of the iliac veins. After incision and drainage necrosis of the kidney was found to exist and the kidney was removed.

In another case the kidney sloughed away without hemorrhage. There is a chronic form in which masses of fibrous tissue develop.

The **treatment** is wet cups and heat to the loin, rest, purgation by salines, morphin for pain, and, after the acute stage, potassium iodid internally. In a lingering case an incision should be made. It will frequently be followed by cure. Decapsulation has advocates. If suppuration occurs it is necessary to incise and drain. Necrosis of the kidney calls for nephrectomy.

Perinephric or Perirenal Abscesses.—An abscess in the perinephric fat is known as a perinephric or perirenal abscess. There may or may not be renal involvement. *Primary abscess* may follow a chill, may develop during or after an acute febrile disturbance, or may be caused by pus flowing from some other part, as from the spine. Slight traumatisms, by producing hemorrhage, make the perinephric region a point of least resistance and lead to abscess of hematogenous or renal origin. A focal infection may be responsible. The causative injury may be produced by digging, stamping, coughing, falling, carrying a burden, lifting a weight, or riding on a horse, or on a jolting wagon. *Consecutive abscess* is secondary to kidney inflammation, suppuration, calculus, tuberculosis, or cyst. Some cases follow furunculosis. The

staphylococcus is the organism usually found. In the consecutive form the symptoms may be masked by the malady to which perinephric abscess is secondary. As a rule, in a case of perinephric abscess there are found the constitutional symptoms of suppuration. As Dr. Morris Miller has shown, there is high leukocytosis. The chief local symptom is a deep aching and paroxysmal pain in the loin, intensified by lumbar pressure. There may be pain in the iliac region and pain in the knee. Edema of the corresponding foot and lameness are not unusual. The thigh is often drawn up. The spine is rigid and inclined toward the diseased side. Edema of the skin is usual, but fluctuation is not. An exploratory incision will settle a doubtful diagnosis.

The **treatment** is to lay open the abscess, wash it out, and drain. The mortality is over 10 per cent.

Stricture of the Ureter.—This is usually at or near the termination of the ureter. It is due to gonococcic inflammation, pyogenic inflammation, or tuberculosis. The symptoms, as Howard Kelly says, are at first those of a vesical or renal inflammation. The diagnosis is made by the ureteral catheter. We may be unable to introduce it; we may introduce it with difficulty and find that the pelvis of the kidney is distended and that the urine obtained is slightly acid or even alkaline, much lower in urea than the urine from the other kidney, and perhaps contains pus. Stricture of the ureter may cause hydronephrosis, pyelitis, pyelonephritis, or pyonephrosis. Great care must be exercised in the examination of the ureter for stricture, and we know of cases diagnosticated as stricture that were simply spastic contractions or deviations in the course of the tube and resembling stricture. Some urologists have regarded the condition as quite common, but I do not believe it is so; in several of the cases so diagnosticated a pyelographic study of the ureter revealed tortuosities due to a descended kidney. These cases will often have greatly enlarged pelves and many of them suffer from mild attacks of kidney colic. Before arriving at a diagnosis a ureterogram should be made if possible.

Treatment.—Dilatation with bougies, resection of the diseased portion and anastomosis, resection of the diseased portion and implantation of the sound end into the bladder, or division of the stricture and suture. In unilateral tuberculosis the diseased kidney and ureter may be removed.

Hydronephrosis is a condition of the kidney resulting from an impediment to the outflow of urine by obstruction in the ureter, the bladder, or the urethra, the calices of the kidney becoming overdistended with urine and the glandular tissue being absorbed by pressure. It has been asserted by Albarran that secretion of urine ceases in a kidney the ureter of which is completely blocked, enlargement being due purely to congestion. Hydronephrosis may be congenital, due usually to twisting of the ureter or to valve formation obstructing the ureter at its point of junction with the pelvis of the kidney, the valve having been produced because the ureter passed into the kidney pelvis at an unnatural angle. Occasionally imperforate urinary meatus produces hydronephrosis of both kidneys.

The **causes** of the acquired form are the pressure of pelvic growths or pregnancy; inflammation or tumor of the bladder; stone in the bladder, kidney, or ureter; twisting or kinking or stricture of the ureter of a movable kidney; enlargement of the prostate gland; and stricture of the urethra. Acquired hydronephrosis may involve both kidneys, all of one kidney, or only a part of a single gland.

Symptoms.—Hydronephrosis is most frequent in females. When a lumbar mass is absent there may be no symptoms, or there may be pain in the back and abdomen, frequent micturition, a persistent or intermittent diminution in urine, or even occasional anuria followed by a large outflow known as the *flush tank symptom*. In the loin may be found a mass which is dull on percussion, which shrinks and enlarges, and which may disappear with a large urinary flow. Hydronephrosis may last a long while if only one kidney be involved, but death is not far distant if both glands suffer. Death occurs from uremia, from pressure on adjacent organs, or from rupture into the peritoneal cavity. The diagnosis is aided by a function test, by the use of the cystoscope, by catheterizing the ureters, and by pyelographic study.

Treatment.—Some few cases have been cured by catheterizing the ureter (Pawlik). The proper operation in many cases is nephrectomy. If the kidney has been opened, explore the ureter by means of a uterine sound or an elastic bougie. A healthy ureter will permit the passage of an instrument of the size of from No. 9 to No. 12 of the French scale (Fenger). If the opening of the ureter into the pelvis cannot be found, open the pelvis or open the ureter. A valve should be slit longitudinally and sutured

transversely (Fenger). If a permanent suppurating fistula ensues or if the organ is found extensively damaged, nephrectomy is to be performed, provided the other kidney is in reasonably good condition. Plastic operations upon the kidney pelvis or ureter can sometimes be done with success and a cure follows.

Pyonephrosis or **surgical kidney** is a condition in which the pelvis and the calices of the kidney are distended with pus or with pus and urine. The whole kidney may be destroyed. This condition has the same causes as hydronephrosis, for it is, in reality, usually an infected hydronephrosis. In some cases the inaugural malady is pyelitis, which causes blocking of the ureter.

The **symptoms** are those due to the obstructing cause plus pyelitis. Pus may be constant in the urine in incomplete obstruction, or it may intermittently appear. Bacilluria, and especially colon bacillus infection of the urine, has a strong tendency, unless speedily controlled, to cause pyonephrosis. Constitutional symptoms of suppuration are soon manifest. A mass like the mass of hydronephrosis may appear in the loin. If only one kidney be involved, and if the disease be due to blocking of a ureter, recovery is to be expected. The diagnosis is rendered more certain by the use of the cystoscope and by catheterizing the ureters and employing a function test.

The **treatment** in the early stages comprises removal, if possible, of the cause of obstruction, and the employment of measures directed to the cure of the pyelitis. If obstruction is not complete, palliative measures may be employed. If fever continues; if there is great visceral derangement; if pain is severe and constant, and if the mass continually enlarges, perform nephrostomy, stitching the organ to the surface if possible, or removing it if it be hopelessly disorganized and the other kidney be in good or fairly good condition.

Chronic Tuberculosis of the Kidney.—This condition may begin in one kidney, no other area of infection being discovered in the body. In such cases the bacteria have been deposited from the blood in the renal tubules. "From these they reach the surface of the papillæ or calyx recess, where they are amassed in sufficient number to bring about a tuberculous lesion" (Leo Buerger in "Interstate Med. Jour.," 1914, No. 11). Even when the bacteria are deposited from the blood there is, in most cases, an initial focus of tuberculosis somewhere else in the body. In a man always examine the epididymis and prostate. Primary renal tuberculosis remains for a long time a local disease, but, unfortunately, the other kidney, sooner or later, is very apt to become involved, the process in the first kidney affecting the bladder and secondarily the other kidney. The important point is that tuberculosis of the kidney arising in this manner is at first a unilateral disease.

Tuberculosis of the kidney is seldom a primary disease and usually arises secondarily to tuberculosis of the prostate, bladder, or epididymis. In such a condition the kidney disease is always bilateral. Renal tuberculosis is particularly common in the third and fourth decades of life, and is more frequent in males than in females.

Symptoms.—Renal tuberculosis of arterial origin may exhibit no symptoms until the disease is far advanced. As long as a tuberculous kidney drains pain is absent. When the urinary passages are blocked suddenly, tension ensues and renal colic occurs. If the blocking be gradual pain may never occur. Renal tuberculosis secondary to disease of the bladder or prostate always presents symptoms.[1] A common symptom of renal tuberculosis is the sudden onset of profuse urinary flow and frequent micturition. The patient is annoyed day and night, and in some cases micturition is distinctly painful. Paroxysms of renal pain are not unusual. As stated above, there may be no pain. Tenderness may be absent. The urine is acid and may contain pus or blood. Tubercle bacilli may be found in the urine or in the sediment of centrifuged urine, but they may be absent. Repeated examination should be made before it can be stated certainly that bacilli are absent. The presence of bacilli proves the diagnosis, but their absence does not negative it. If bacilli are not found, inject some of the urinary sediment into a guinea-pig, and note if tuberculosis arises in the animal. Czerny has shown that in cases of tuberculous kidney in which bacilli are not found in the urine the administration of tuberculin will cause great numbers to appear. This agent will also cause a marked febrile reaction if tuberculosis exists. The urine may or may not be albuminous.

In many cases the kidney is obviously enlarged, and the renal area is frequently tender and occasionally painful. When pain and tenderness are absent (*silent renal tuberculosis*) the diagnosis is often missed. The patient loses flesh, and there is nocturnal fever followed by sweating. The use of the cystoscope furnishes important

[1] F. Tilden Brown, "New York Med. Jour.," April 10, 1897.

information. It shows from which ureter turbid urine is coming. Catheterization of the ureters should be practised by some one who is expert. Always examine carefully to determine if one or both kidneys are involved, if the bladder is diseased, and, in males, if the prostate gland or seminal vesicles are tuberculous. A function test may be of the greatest value.

Treatment.—Lumbar nephrectomy is not justifiable in the very beginning of a case, because such a patient may be cured by a combination of medical and hygienic treatment, and the weakening effect of the operation of nephrectomy may cause the other kidney to develop tuberculosis rapidly. Tell such a patient to lead an outdoor life. Brown recommends camp-life in the Adirondacks during the summer, and sends such patients south during the winter. If a patient cannot go to another climate, urge upon him the necessity of practically living out-of-doors (see page 164). Insist upon the taking of plenty of nutritious food. Full antituberculous treatment is indicated (see page 162). Probably the best climate is that of southern California.

If the kidney is markedly enlarged; if there is profuse hematuria; if the fever is high and persistent; if only one kidney is involved, if the other kidney has a satisfactory functional capacity, and if the bladder and prostate are free from disease, perform nephrectomy. After nephrectomy for tuberculous kidney a tuberculous sinus not uncommonly forms. If a diseased ureter is removed as far as possible at the operation, if an open ureter stump is injected with 5 to 10 minims of a 95 per cent. solution of carbolic acid (Mayo), and if the fatty capsule is removed with the kidney, a tuberculous sinus will seldom form. In cases with involvement of the other kidney or of the genito-urinary tract lower down, or in which the functional capacity of the other kidney is not satisfactory, nephrectomy is not justifiable, although nephrostomy for drainage may, for a time, greatly benefit the patient.

Operations on the Kidney and Ureter.—Operations for Chronic Nephritis.—In 1897 Mr. Reginald Harrison advocated puncture of the kidney to relieve tension in cases of albuminuria, and in 1901 advocated incision of the true capsule of the kidney and puncture of the gland to accomplish the same purpose ("Brit. Med. Jour.," Oct. 19, 1901). Alexander Hugh Ferguson in March, 1899, reported 2 cases of interstitial nephritis cured symptomatically by decapsulation and multiple punctures ("Jour. Amer. Med. Assoc.," March 11, 1899). Dr. Geo. M. Edebohls observed, between 1892 and 1897, that in certain cases of movable kidney with albuminuria the albumin and casts disappeared after nephropexy. Rose, Wolff, and Ferguson have observed the same fact. Harrison believes that renipuncture removes the symptoms by abating tension, but Edebohls concludes that nephropexy relieves the condition and possibly cures it by establishing vascular adhesions which carry an additional supply of blood. He proposed to operate for Bright's disease in 1899 ("Med. News," April 22, 1899). Edebohls deliberately operated for chronic nephritis and claimed 8 complete recoveries from chronic Bright's disease ("Med. Record," Dec. 21, 1901). There can be no doubt whatever that operation is sometimes followed by polyuria, disappearance of edema and other symptoms, and apparent cure. But in some cases the disappearance of symptoms has been too rapid to permit of the assumption that new vessels have caused it. In such cases it seems much more probable that relief of tension is the real curative factor. The capsule of the kidney is only slightly elastic, and tension may be brought about by an increase in the blood-supply, by edema, and by cell proliferation. Increased tension causes pain and perhaps hematuria, and tension is relieved by Harrison's plan of incising the capsule. Simple incision is easier, safer, and probably just as useful as stripping the capsule off of the kidney. Edebohls advocates decapsulation and says that the polyuria begins about the tenth day after operation; that improvement begins in one month and is gradual; that the cure is due to vascular adhesions; that the adhesions contain more arteries than veins; that the free blood-supply absorbs exudate and products of inflammation, frees the tubes and glomeruli from pressure and constriction, causes the re-establishment of a normal circulation and the regeneration of epithelium (Ibid.).

The exact status of the operation is not as yet determined. It does, however, seem to be proved that operation is in some cases followed by apparent cure or great amelioration of the condition. Whether permanent cure is ever thus obtained is doubtful, and the part played by rest in bed and drugs in effecting an improvement must not be lost sight of. I have seen no case of genuine cure. I doubt if cure is ever obtained. Albumin has always continued present in the urine. It is certain that the operation is unjustifiable unless medical treatment has been tried and failed, unless the symptoms are growing worse, and unless they indicate danger. James Tyson

("Med. Record," July 8, 1911) sets forth dangerous symptoms as follows: Persistent dropsy, uremia (violent headache, convulsions, or coma), excessive amount of albumin causing anemia and weakness, anuria. The best results are obtained in chronic parenchymatous nephritis associated with marked anasarca. Pain and bloody urine are often much improved by incising the capsule. *Postoperative suppression* and the anuria of acute infectious diseases may be favorably influenced by the operation. In perinephritis it may prove curative. An important fact which Rovsing maintains and Edebohls proves is that chronic nephritis may be for some time a unilateral disease. (Read the views of Schmidt in "Med. Record," Sept. 13, 1902; of Rovsing, of Copenhagen, in "Mittheilungen aus den Grenzegebieten der Medicin und Chirurgie," vol. x, 1902, and editorial in "Jour. Amer. Med. Assoc.," Jan. 11, 1902; James Tyson in "Trans. of Amer. Physicians," 1911, and "Med. Record," July 8, 1911.) Personally, I would not operate for Bright's disease in the presence of grave and advanced cardiovascular disease. Tyson believes that albuminuric retinitis, very irregular heart, and valvular disease forbid operation, and that in patients over fifty the operation is of slight value. I believe the operation has its highest indication in an acute congestion arising in the course of chronic nephritis. It has saved life in acute alcoholism and the nephritis due to bichlorid poisoning.

The operation as practised by Edebohls may be done on both kidneys either in one or in two séances. In some cases only one kidney is subjected to operation. Edebohls takes a very radical view and would operate on any case free from incurable complications, if an anesthetic can be given and if the life expectancy without operation is not less than one month ("Med. Record," Dec. 21, 1901). Ether is given or nitrous oxid and oxygen. Lay the patient prone with an air-cushion under the belly and expose the kidney by a vertical incision at the edge of the erector spinæ mass. This incision does not open the sheath of the muscle. Remove the fatty capsule from the true capsule, continuing the dissection around each pole until the pelvis of the kidney is reached. The kidney is extruded from the wound, the true capsule is incised along the convex border and around each pole, is separated from the kidney, and is cut away close to its junction with the kidney pelvis. The kidney is then returned to its bed of fat and the wound is closed (Ibid.). Edebohls does not drain unless there is considerable edema. He reported 18 operations without a death. In 9 of the cases the operation had been done more than one year, and 8 of them were said to be cured. Personally, I do not believe that the operation can really cure Bright's disease. It cannot restore altered connective tissue and epithelial cells. The new blood-supply must be through scar tissue, and we have yet to learn that such a blood-supply can be efficient. The operation should be restricted to acute nephritis, to acute exacerbations in chronic cases, to conditions with severe renal pain, hematuria, anasarca, very high albumin percentage, or persistent, and notable diminution in the amount of urine voided (Ertzbischoff in "Archiv. générales de Chirurgie," April, 1908).

Nephrotomy means incision into a kidney, but the term is sometimes, though wrongly, applied to the exploratory exposure of the kidney without incision into the organ. When the kidney wound is kept open, as it very often is, the operation should be called *nephrostomy*. The operation is employed to evacuate infectious material, relieve tension, permit of the removal of a calculus or exploration of the ureter, and for diagnosis of renal disease. The patient lies upon the sound side, a sand-pillow or a cylindric air-bag being placed under the flank or a special support being used (Fig. 1032). The *incision* is made ½ inch below the last rib and close to the outer border of the erector spinæ mass, and runs obliquely downward and forward toward the iliac crest for 3 inches, the cut being enlarged later if required. Divide the skin, the superficial fascia, the fat, the external oblique, the posterior border of the internal oblique, and the outer edge of the latissimus dorsi. This incision exposes the lumbar fascia. Push aside the last dorsal nerve and incise the lumbar fascia, when the perirenal fat will bulge into the wound. Two distinct layers of fat exist. Tear through this fat with dissecting forceps to expose the kidney, which can now be opened while it is forced into the wound by the hand of an assistant making abdominal pressure. In some cases the kidney can be brought out of the wound for exploration and operation. In others it cannot. When it cannot be drawn out it is brought into the wound and supported by means of a pad of gauze under each pole, the slings being crossed so as to control bleeding (Fig. 1038).

Kocher's incision for nephrotomy is begun in the angle between the sacrolumbalis muscle and the twelfth rib, and is carried downward, forward, and outward to the axillary line (see Fig. 273). This incision divides the skin, subcutaneous tissues,

lumbar fascia, the latissimus dorsi, and the serratus posticus inferior muscles. If possible, the kidney is brought out of the wound.

Edebohls's method enables the surgeon to explore the kidney thoroughly because this organ is brought outside of the body. It is not suited to cases in which the organ is much enlarged or when it has a short pedicle. Its best field is in operations for movable kidney. The patient lies prone, with a large cylindric inflated rubber pad beneath his abdomen. A vertical incision is made close to the border of the erector spinæ muscle, from just below the last rib to just above the iliac crest. The sheath of the muscle is not opened. The fibers of the latissimus dorsi are separated by blunt dissection. The iliohypogastric nerve is found and retracted. The transversalis fascia is incised and the fatty capsule reached. The two layers of the fatty capsule are torn through and the kidney exposed. The fatty capsule is *well separated* from the kidney front and back. The patient is pulled by the legs toward the foot of the table, the pad remaining stationary. This change of position brings the pad beneath the chest, abdominal respiration takes place, the kidney is forced into the wound, and can be easily withdrawn and thoroughly examined. In many cases the lumbar incision does not expose the kidney pedicle enough to make the surgeon feel that he can readily clamp it should nephrectomy become necessary, and in any operation upon the kidney nephrectomy may at any minute become necessary. Cutting the twelfth rib adds to the exposure, but in cutting it the pleura may be opened. William J. Mayo ("Annals of Surgery," Jan., 1912) in 203 lumbar operations divided the twelfth rib 51 times, and in 13 of the operations accidentally opened the pleural cavity. In not a case did the lung collapse (probably because the patients lay upon the abdomen with the hips somewhat elevated, the chest being fixed by the position). In each case the torn pleura was sutured, the stitches including tissue of the diaphragm.

Mayo discovered that after division of the quadratus lumborum muscle and the lateral arcuate ligament (which binds the twelfth rib to the transverse process of the first lumbar vertebra) the rib can be lifted out of the way and does not need to be divided. Mayo now operates as follows: Beginning over the eleventh rib 2½ inches external to the spines of the dorsal vertebræ make a longitudinal incision 3 inches in length. From this point carry the incision downward and forward along the anterior margin of the quadratus lumborum to 1 inch above the crest of the ilium; then carry it forward parallel to the crest. The twelfth rib is cleared nearly to its articulation; the pleura is pushed up out of the way. The erector spinæ mass is retracted toward the spine. The costal margin is raised by retraction. A wide area for operation is exposed, the kidney can be brought out of the wound, and the pedicle can be seen and reached.

A common method of opening the kidney is to make a longitudinal incision through its convexity sufficiently large to admit the finger into the renal pelvis. This incision may be enlarged if necessary until the kidney is almost split in half. When the operation is finished close the kidney wound completely by means of a round needle and catgut (Fig. 1029), unless drainage is necessary or packing is required. Another popular incision is placed longitudinally a little posterior to the convex border. This goes through the bloodless zone of Hyrtl, and causes less hemorrhage than the incision along the convexity. Marwedel's incision is a transverse cut at the middle of the convex border of the kidney into the renal pelvis. It is doubtful if this incision is accompanied by less bleeding than longitudinal incision of the convexity. After the completion of our work on the kidney the lumbar wound is closed completely or it is partially closed to permit of drainage.

Operation for Stone in the Kidney by Pyelotomy or Nephrotomy (Pyelolithotomy, Nephrolithotomy).—It used to be held that incision of the pelvis of the kidney was far more apt to be followed by fistula than incision of the substance of the kidney. The Mayos, Bevan, and others proved that this conviction was untrue. In many cases of stone pyelotomy is preferred to nephrotomy. It is used for single stones of moderate size in the pelvis and unaccompanied by suppuration. When we have a large branched stone, coral-shaped stones, multiple stones, and stones accompanied by distinct and gross evidences of infection, then nephrotomy should be preferred to pyelotomy (Bevan and Smith in paper read before the American Surg. Assoc. in 1908). In both operations the patient is placed on the sound side upon a special support or with a sand-pillow or cylindric air-bag under the flank. In both cases the incision recommended for nephrotomy is used. In both cases the kidney is lifted into the wound or brought out of the wound so that it may be satisfactorily palpated. In both cases bleeding is controlled by slings; or by having an assistant, if possible,

grasp the pedicle with his fingers or with a pair of forceps, each blade of which has been covered with a bit of rubber tube, while the surgeon opens the pelvis or divides the kidney tissue, removes the stone, and explores with the finger.

Pyelolithotomy.—Remove the fat from the posterior surface of the pelvis of the kidney. We may then be sure that no aberrant vessel is in our way. The normal vessels are all in front of the pelvis. The posterior wall of the pelvis is now opened, the stone is extracted, the pelvis explored, the cut in the pelvis is sutured with fine catgut sutures, the kidney is restored to place, a cigarette drain is introduced, and the wound in the loin is closed. A gauze drain should not be used as it might lead to the formation of a fistula.

Nephrolithotomy.—The methods of incision, exposure, and opening the kidney are described on page 1290 under Nephrotomy. When the kidney has been opened, loosen the calculus with the nail, and remove it with the finger, with a scoop, or with forceps. After removing the stone, suture the incision with catgut, and release the pressure on the pedicle. Hemorrhage will usually be controlled, but sometimes violent bleeding occurs. If in spite of this plan bleeding occurs, take out the stitches and apply pressure and hot water, compress the bleeding points by suture ligatures, and close again by the stitches shown on page 1279 (see Figs. 1028, 1029). In some cases plug with iodoform gauze, suturing the gauze in place within the kidney by fine catgut and leaving it until it loosens. When hemorrhage ceases, put a large drainage-tube down to the kidney. Close the wound in the muscles and integument and dress antiseptically. The dressings must be changed frequently and the tube should be shortened daily. In some cases nephrectomy is necessary (see below.) Formerly in such

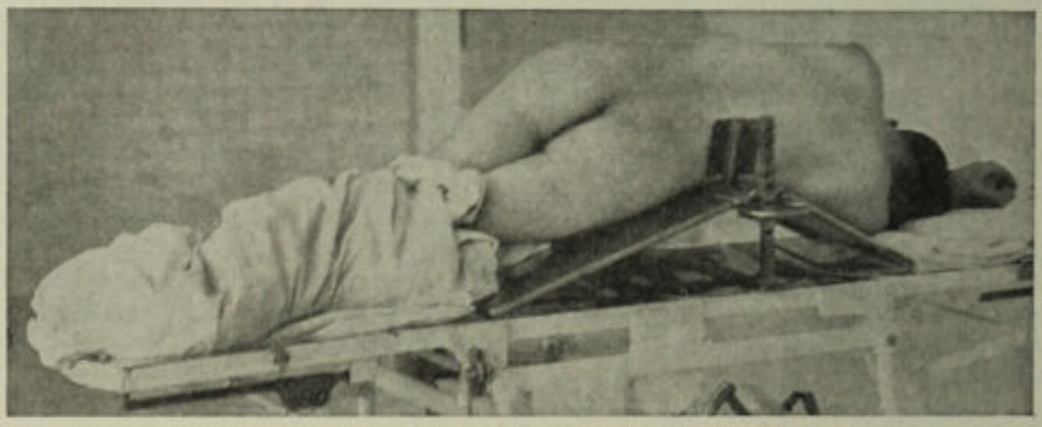


FIG. 1032.—Side position for nephrectomy (Stellwagen).

cases I always drained for a time and removed the kidney secondarily, believing that the patient would gain strength in the interval and stand the severe operation of nephrectomy better. I am satisfied that in most cases this view is wrong, because removal of a kidney bound down by adhesions is one of the most perilous and difficult operations of surgery.

Nephrectomy is the removal of a kidney. There are two methods of nephrectomy—the *lumbar* and the *abdominal.* The first nephrectomy (according to Watson) was performed in 1861 by an American, Walcott. The operation was transperitoneal and was for the removal of a cancerous kidney. Simon, in 1869, performed the first lumbar nephrectomy and it was the first successful nephrectomy. Before performing nephrectomy ascertain the competence of the kidneys. Phenolsulphonephthalein and indigocarmin are used for this purpose. If at least 1 per cent. of urea is not being excreted, it is very unsafe to operate. Be sure that the patient possesses two kidneys. Examination of the bladder by the cystoscope will show the ureteral orifices, a strong indication that both kidneys are present. Nevertheless, when we reflect that a horseshoe kidney has two ureters, the proof is not absolute. Pyelograms of the separate kidneys will establish the presence of both. Simultaneous pyelography is not to be done unless imperatively necessary. Do one side at a time. Catheterization of the ureters is imperative. Proof absolute of the presence of two kidneys consists in feeling both of them. If in doubt as to the question, and if uncertain as to the ability of the organ which is to be left, feel each kidney during the operation before removing either, or perform a preliminary exploratory laparotomy.

Lumbar Nephrectomy.—In lumbar nephrectomy the position of patient greatly facilitates exposure and delivery of the kidney. In my experience it has not been often necessary to lay patient upon the side (Fig. 1032). Usually he can be laid prone as in Fig. 1033. The bag or pillow has not been satisfactory. He is liable to change



FIG. 1033.—Prone position for nephrectomy (Stellwagen).

position, and should respiratory function be embarrassed during the operation the above attachment greatly facilitates lowering of the body. This may be most important. After completion of the nephrectomy lowering the patient flat on the belly will make suturing easier.

Several incisions have been proposed. In many cases the oblique incision is first made to permit of exploration. This incision is begun ½ inch below the last rib and at the edge of the erector spinæ muscle, and is carried downward and forward toward the iliac crest. In some cases a kidney can be removed through this cut. In other cases the cut must be enlarged. It can be enlarged by extending the cut downward. Morris enlarges it by adding to it a vertical incision, which begins 1 inch below the origin of the oblique cut. König's incision for nephrectomy consists of a vertical cut at the edge of the erector spinæ, carried almost to the iliac crest, from which point it is curved forward toward the umbilicus, and is carried to or even through the rectus muscle. The incision I prefer is shown in Fig. 1034. It begins a trifle above the twelfth rib and extends in a curvilinear direction downward just within the outer margin of the erector spinæ mass. The fascia of this muscular group is opened and the musculature retracted toward the spine, leaving a lozenge-shaped area as shown in Fig. 1035. The ilio-inguinal and iliohypogastric nerves are retracted out of the line of work, the kidney fat is exposed, and the organ delivered by first freeing its attachments and then making traction upon its fatty capsule. The twelfth rib may have to be mobilized or possibly resected in cases in which the gland is large or the seat of a tumor. Always have rib instruments at hand when exposing a kidney. After thorough exposure lift the kidney and separate it from the peritoneum, if possible, with the finger; clamp the pedicle; pass an armed aneurysm needle between the vessels of the pedicle;

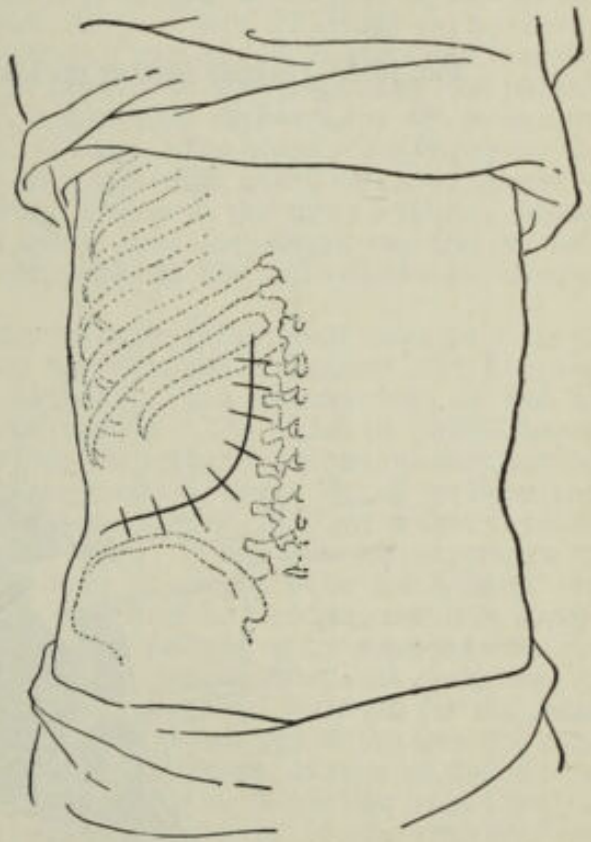


FIG. 1034.—Incision for exposure of the kidney through the loin. The crossed markings facilitate closure in the proper placement of the sutures (Stellwagen).

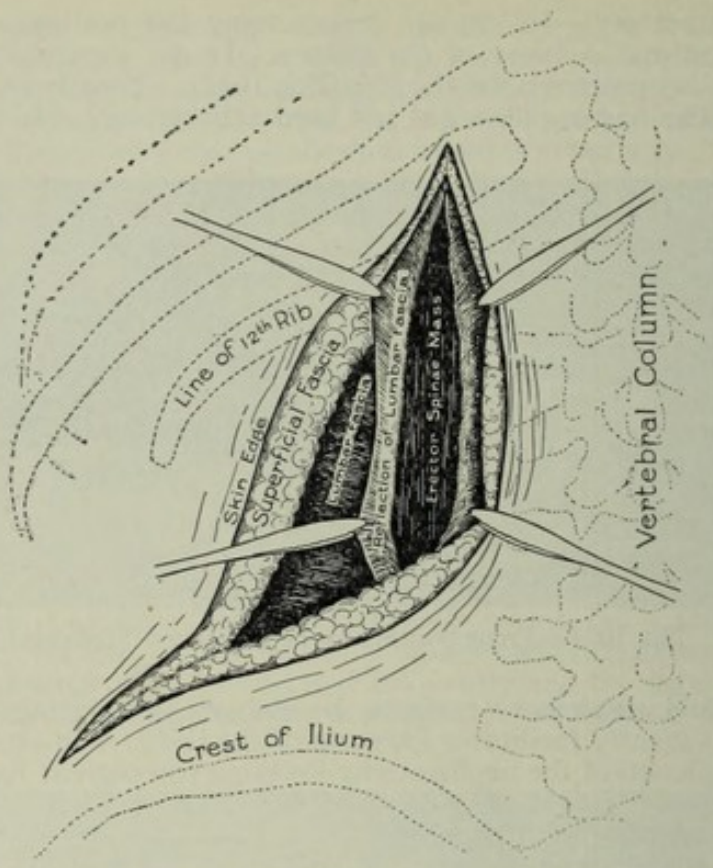


FIG. 1035.—Diagram presents the border of the erector spinæ mass (Stellwagen).

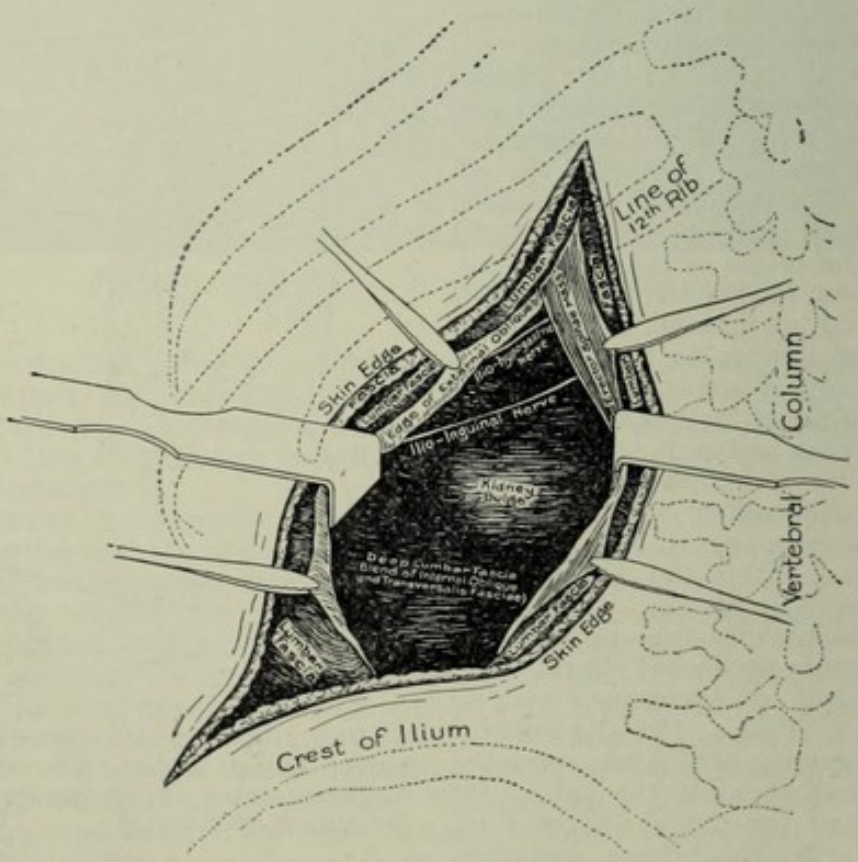


FIG. 1036.—Diagram shows the bulge produced by the presenting kidney (Stellwagen).

ligate in two places; cut between the threads, and arrest hemorrhage permanently by ligation of each vessel. If the ureter be healthy, ligate it with silk and drop it back; if it be foul and purulent, scrape it with a sharp spoon, and inject it with 5 to 10

minims of a 95 per cent. solution of carbolic acid (Mayo), and then either ligate it with catgut and drop it back or sew it into the wound. If hemorrhage persists from the wound, plug with gauze. Insert a drainage-tube and close the wound. If the peritoneum be accidentally opened, close it with Lembert sutures. Kocher's method is excellent, and enables the surgeon to feel the opposite kidney before removing the one which is known to be diseased. The incision is begun as described on page 1290, and is carried forward so as to expose the reflection of the peritoneum onto the colon in the posterior axillary line.[1] At this point the peritoneum is opened, and the surgeon's hand is inserted into the abdominal cavity to feel the other kidney. If another kidney exists and it is found to be healthy, the diseased organ may be removed. Brewer's personal statistics show 53 cases of nephrectomy, with 2 deaths, a mortality of 3.8 per cent. ("Med. Record," March 20, 1909).

Abdominal nephrectomy is more dangerous than the lumbar operation. The position is supine. The incision is that of Langenbeck—4 inches in length in the linea semilunaris, its center corresponding to the umbilicus. Open the abdomen, introduce a hand, feel the kidneys, and if both show serious disease, do not perform nephrectomy. If we decide to remove one kidney, keep the small intestine away by pads, push the colon toward the umbilicus, incise the outer layer of the mesocolon, and bare the kidney. Strip off the peritoneum from the kidney and its vessels, and ligate the vessels by passing strong silk through the center of the pedicle with an aneurysm needle. Ligate the ureter if healthy, and divide it. If the ureter be septic, fasten it in an opening made in the loin by cutting down upon forceps pushed to the outer edge of the quadratus lumborum. Stop bleeding, irrigate the belly cavity, and dress as usual, employing drainage only when septic matter has passed into the peritoneal cavity or when oozing of blood is persistent.

Nephrectomy in Children.—The operation is proper in certain non-malignant troubles. William Jopson ("Jour. Amer. Med. Assoc.," Sept. 28, 1910) did a successful nephrectomy for a congenital cystic kidney on a patient four months and fourteen days of age. Rovsing did it successfully for congenital hydronephrosis, the patient being nine months old. Roswell Park did a successful nephrectomy for congenital cystic kidney on a child twenty-three months of age. The value of nephrectomy for sarcoma is certainly doubtful. The operation never really cures, and if an operative recovery is obtained the disease appears after a time in the other kidney. Jessup performed nephrectomy in 11 children and every child died within two and one-half years of the operation. The operation often prolongs life and relieves discomfort, but does not cure.

Partial Nephrectomy.—This operation may be performed in some cases for wounds, cysts, and innocent tumors. After removing the damaged or diseased part, bleeding points are ligated with catgut. The wound surfaces are approximated as well as possible by catgut sutures. Drainage is introduced. The value of partial nephrectomy in some cases seems certain, and we should perform it when possible instead of the complete operation,[2] except in cases of malignant disease. Partial nephrectomy necessitates the insertion of catgut sutures into the kidney. Catgut within the kidney is dangerous and uncertain as to its absorption. It has been my experience to have fatal hemorrhage from rapid disappearance of catgut from the kidney. In all partial nephrectomies the surgeon must be watchful for bleeding, and if it supervenes, be prepared to control it by gauze slings and packing or by nephrectomy. It always is a wise procedure to explain to relatives the dangers from such operations.

Renipuncture.—This is an operation devised by Reginald Harrison for the relief of albuminuria due to elevated tension. The kidney is exposed in the loin, the capsule is incised, and punctures are made in the kidney. Simple incision of the capsule will usually relieve nephralgia. (See Operation for Chronic Nephritis, page 1289.)

Nephropexy is fixation of a movable kidney. The term "nephrorrhaphy," so long used for the operation, really means suturing a wound in the kidney.

The Author's Modification of the Elder Senn's Operation.—Many surgeons feel that it is not desirable to pass sutures through the kidney substance, and I have entirely abandoned the use of them in operations for movable kidney. Urinary fistula has followed suturing. Again, the value of such sutures is very doubtful. The kidney is a very soft organ, and if it be suspended by sutures, they are certain to cut through. In most suture operations the kidney when restored is not placed sufficiently

[1] Kocher's "Text-book of Operative Surgery."

[2] See Oscar Bloch in "Brit. Med. Jour.," Oct. 17, 1896; also reports of Czerny, Bardenheuer, Tuffier, and Kümmell.

high and has its ureter and vessels looking forward; in other words, there is a one-fourth twist in the ureter. In operations like Goelet's and Kelly's, which raise the kidney much nearer its proper level and which do not twist the ureter and renal vessels, the upper pole is not anchored and tends to tilt forward (see page 1277). The operation herein described fixes the kidney without using sutures.

The patient lies upon his abdomen, Edebohls's bag being placed directly beneath the lower abdomen. A vertical or slightly oblique lumbar incision is made, the perirenal fat is exposed, and its two layers are torn through until the kidney is reached. The fatty capsule is thoroughly stripped from the entire organ. The kidney is brought out of the wound. This is accomplished by pulling the patient toward the foot of the bed, so that the pad gets under the ribs, when traction on the fibrofatty capsule will cause the kidney to emerge from the wound. The posterior fatty capsule is cut away, and also the anterior fatty capsule up to the hilum. The true capsule of the kidney is scarified. I always have slings prepared by suturing together with the finest plain catgut the ends of two pieces of iodoform gauze. Two such strands are prepared (Fig. 1037). One piece of iodoform gauze is placed under the upper end of the kidney and another piece under the lower end, the sling in each instance being directly under the kidney with the suture line external and not in front, as the kidney protrudes from the wound in the back (Fig. 1038). When the kidney is replaced

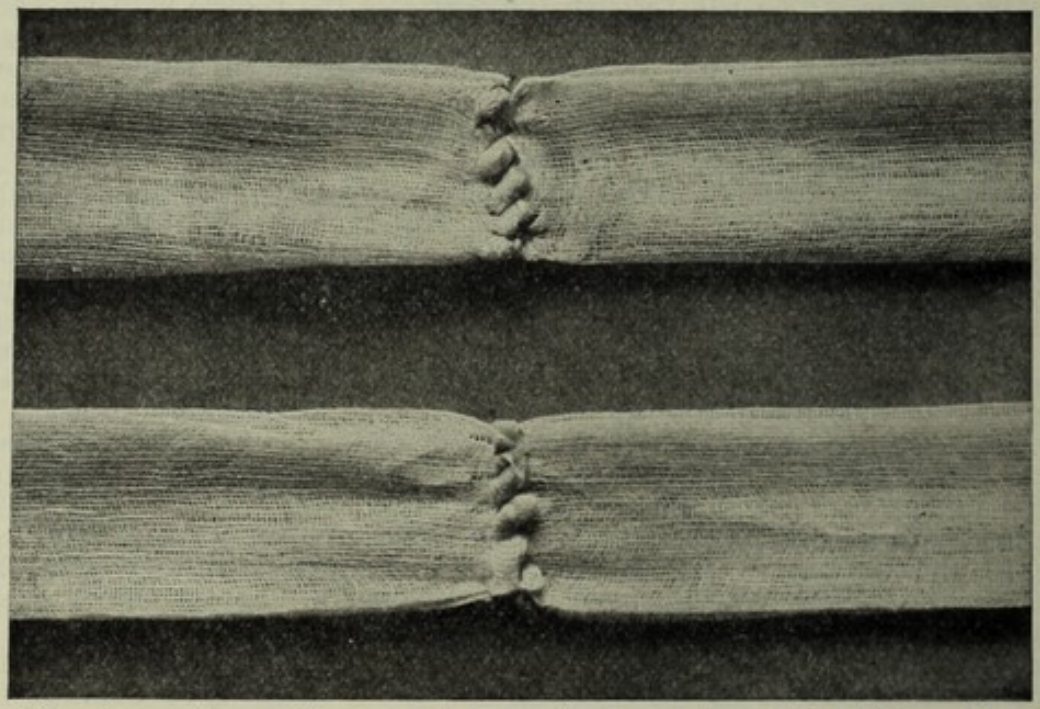


FIG. 1037.—Gauze slings, each composed of two pieces sutured together with fine plain catgut.

the suture line will lie in front (Fig. 1039). The kidney is replaced and will then lie in a sling composed of two pieces of gauze, the ends of which protrude from the wound. Another piece of gauze is placed below the lower renal pole to fill up the space which always exists there and to stimulate granulation. This space below the kidney is a frequent cause of subsequent loosening in most suture operations, because the kidney hangs in it unsupported, as a bucket hangs in a well. Harris recognizes this, and in his operation closes the space by sutures. Gauze is packed in over and about the kidney, and over this the two long slings are fixed. The two upper ends are brought lightly to the lower angle of the wound, the two lower ends to the upper angle, and the four ends are tied together with silk. Several sutures of silkworm-gut are inserted to close the superficial parts and the lumbar aponeurosis; some are tied and some are left untied. A large gauze pad is placed upon the abdomen over the anterior surface of the kidney, and the lumbar wound is dressed with gauze. The dressing and gauze pad are held in place by a binder. In about eight or ten days the gauze should be soaked with dripping salt solution during half an hour and the packing removed. At this time the catgut is destroyed and the gauze can be easily pulled out. The tied sutures are cut and removed, the sutures left unfastened are tied, and a small piece of gauze is inserted as a drain between the granulating surfaces. If a continuous piece of gauze has been used as a sling, ether must be given before removal is attempted

Further, in the old operation, a large wound was left to granulate and weeks were often required to obtain healing. In this operation the wound is usually entirely healed in from eighteen to twenty-one days. After the performance of nephropexy the patient remains in bed for three weeks. By this operation the kidney is placed in a proper situation, is surrounded with granulations which are converted into scar tissue, and the organ becomes encased in a box of fibrous tissue. I believe that a kidney so treated will probably remain fixed.

If a kidney has been decapsulated, gauze slings should not be placed around it, because removal of them might lacerate the kidney. After decapsulation the surgeon rests content when he has filled the space below the kidney with a support of gauze.

The operation of nephropexy is not as frequently resorted to as it was a few years ago. It was supposed that fixation of a movable kidney or a floating kidney would cure many of the nervous symptoms from which these cases often suffer. In fact, many cases were made worse by such procedure, consequently it, today, is an operation that is rarely done. Most of the trouble caused by fixation, we believe, is due to an abnormal position producing a dislocated kidney. There are some cases, however, where fixation is advisable. These can be determined by careful pyelographic studies combined with an opinion of a responsible neurologist. Don't enter into operation unless you have tried rest, the corset, a change of scene, or after you have established the diagnosis of marked filling defects or ureteral distortions that will eventuate in hydronephrosis or other kidney lesions. If the case is made worse by operation, it will haunt you. Don't give a too optimistic prognosis as to cure of symptoms after fixation of the kidney.

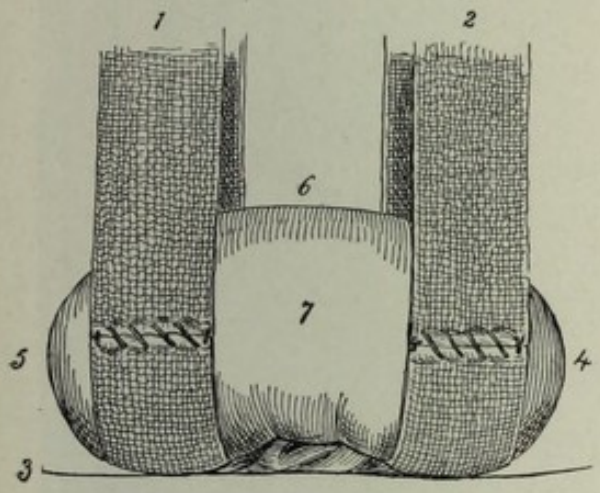


FIG. 1038.—Right kidney projecting from wound. Observer standing on right side of patient: 1 and 2, Slings in place, with sutures external; 3, skin of the back; 4, upper renal pole; 5, lower renal pole; 6, convex border of kidney; 7, external surface of kidney. (Slings should be broader than those shown in illustration.)

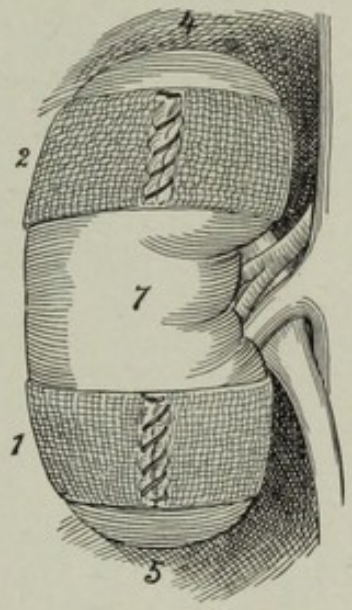


FIG. 1039.—Right kidney restored to place, seen from in front: 1 and 2, Slings in place, sutures anterior; 4, upper renal pole; 5, lower renal pole; 7, anterior surface of kidney. (Slings should be broader than those shown in illustration.)

Ureterolithotomy.—If the stone be impacted in the upper two-thirds or three-fourths of the tube, it may be reached by an incision from the twelfth rib downward and forward to just anterior to the anterosuperior spine of the ilium and then parallel to Poupart's ligament to above its middle. The peritoneum is stripped up as in extraperitoneal ligation of the iliac vessels. The ureter adheres to the peritoneum and is lifted with it. The operation is strictly extraperitoneal.

Gibson's incision for operations on the lower ureter ("Amer. Jour. Med. Sci.," Jan., 1910) is the most useful for reaching and amply exposing the lower ureter. Further, it enables us to feel and accurately to operate upon the tube, the entire operation being extraperitoneal. Gibson thus describes his operation:

"The skin incision runs from the midline about a fingerbreadth above the pubes, horizontally outward nearly parallel to Poupart's ligament at first (Fig. 1040), and curves rather sharply upward at its midpoint to end about opposite the anterior

superior spine of the ilium. This incision is deepened in the same line through the aponeurosis of the external oblique and the internal oblique muscle—the latter is the only structure which suffers any real damage, and only to a slight degree, for the lower part of the incision runs about parallel to its fibers, cutting only the ascending leg across a small part of these fibers. The incision stops short of the transversalis, which is not disturbed at all. With efficient retraction of the upper flap the external border of the rectus muscle is identified (Fig. 1041) and the *fascia* of the transversalis is now divided by a vertical incision close to and parallel to the rectus—that is, at *right angles* to the original incision. Two retractors are now inserted, the outer one retracts the cut edge of the transversalis outward, the other (Fig. 1042) pulls the rectus muscle well toward the midline. A generous space is thus obtained, situated well toward the midline (the lower part of the ureter is practically in the midline and difficult of access by other extraperitoneal exposures). The floor of this space is occupied by the peritoneum. The patient being in a complete Trendelenburg position, the peritoneum is easily and gently pushed away, and a free access to the pelvis is secured. So ample is the space and view that the whole hand can be introduced

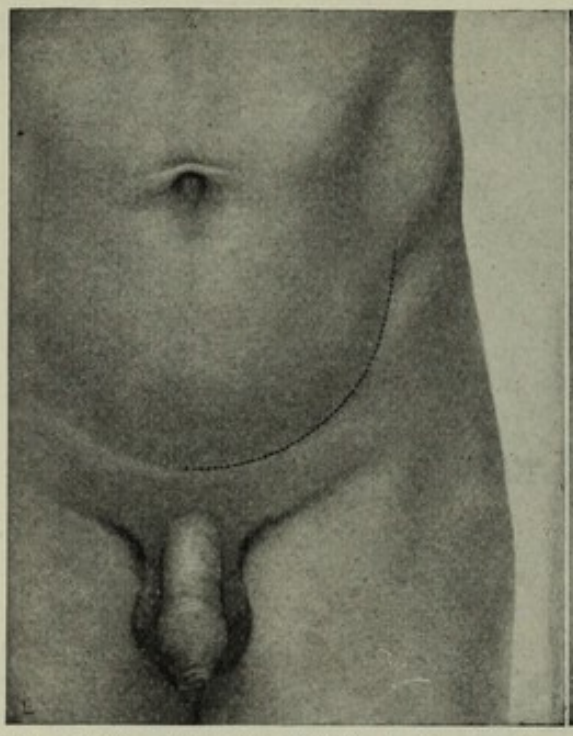


FIG. 1040.—Gibson's incision for operations on the lower ureter. The superficial incision (C. L. Gibson).

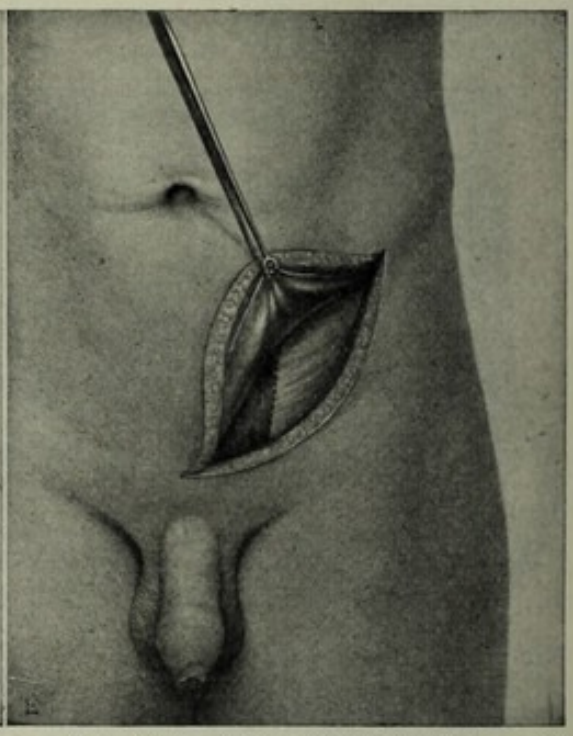


FIG. 1041.—Gibson's incision for operations on the lower ureter. The upper flap, consisting of skin, external and internal oblique muscles, is retracted. The dotted line represents the line of incision in the transversalis fascia (C. L. Gibson).

under the control of the eye. The ureter is released from its surroundings and easily brought to the level of the wound" (Fig. 1043).

When the tube has been exposed it is opened by a longitudinal incision. The stone is removed. The ureter is explored by means of a sound to see if it be patulous. After removing the stone some surgeons close the wound in the ureter with sutures of very fine chromic gut which pass through all the coats, also a layer of superficial sutures. Stitches within the ureter may cause trouble from subsequent urinary sinus. We do not often resort to them. Close the tissues about the ureter and drain from the depths by rubber tissue. Never drain by gauze. To do so will cause a urinary fistula. In a woman a stone near the vesical opening can be reached by a vaginal incision. Stone in the vesical portion of the ureter may perhaps be removed by aid of an operating cystoscope, or by forceps after the performance of a suprapubic cystotomy. The slit in the ureter will, as a rule, close readily. When the stone is low down within the intravesical portion of the tube or in the lower third it can often be milked upward and readily delivered through the slit in the ureter. When the stone is attached, as it often is, or has become too large to pass up the ureter, care

must be exercised not to tear off the attachment of the tube to the bladder. In such cases the ureter is exposed lower down and an incision made over the stone and its delivery effected. The ureter will bear a considerable pull when normal, but it is often weakened by ulceration at the point of impaction of the stone. Don't be too ready to operate for stone in the ureter; in a majority of cases the stone will pass. Unless the kidney is being damaged by its presence give it time to pass and, while waiting, check up from time to time upon the kidney function. The use of the Garceau catheter (Fig. 1047, *c*), and the injection of oil into the ureter may assist in the passage of the stone. We have used the ordinary sterile catheter lubricant with better success than the oil. Protracted attempts at removal by fancy instruments often cause trouble by inducing added inflammatory changes that may result in a complete block. We believe it better surgical judgment to refrain from them. Many so-called stones are impactions of sand or, at least, their texture is so friable that they are ejected as small particles of sand or gravel. Put the patient upon turpentine, 10 gtt. t. i. d., and give a dose of morphin and belladonna when colic intervenes, but not until the colic has been under way some time, for the back pressure is necessary to deliver the stone into the

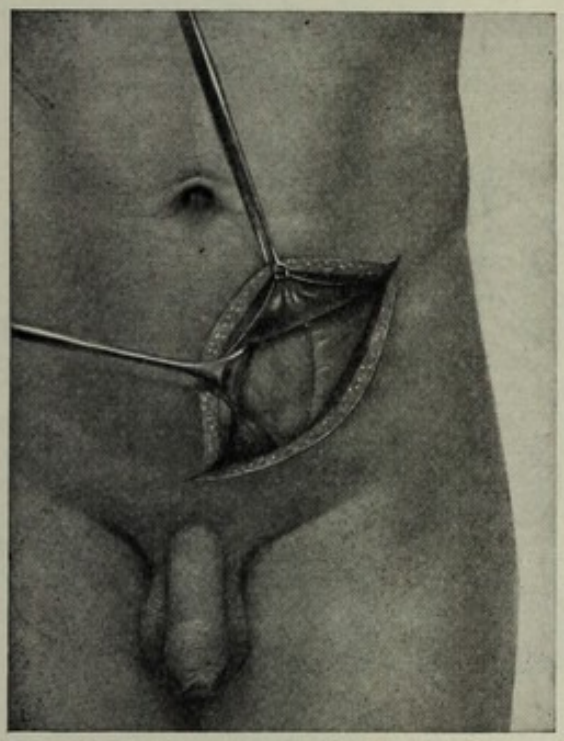


FIG. 1042.—Gibson's incision for operations on the lower ureter. The edge of the rectus muscle is strongly retracted inward; between it and the cut edge of the transversalis fascia the peritoneum is exposed (C. L. Gibson).

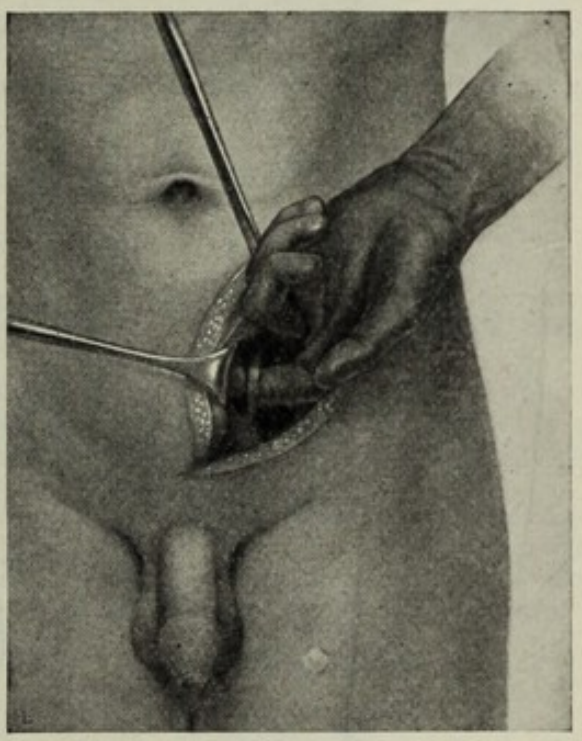


FIG. 1043.—Gibson's incision for operations on the lower ureter. The peritoneum has been pushed upward. The ureter is lifted out of the pelvis and brought to the level of the external wound (C. L. Gibson).

bladder. Stones that are low down, as shown by radiography and cystoscopy, and are held by the ureteral outlet ring, may pass after dilatation or slitting of the constricting ring. Benzyl benzoate may do good, but has not been successful in our hands. A generous hypodermic of morphin has worked best.

Judd exposes the lower 2 or 3 inches of the ureter by making a median incision from the umbilicus to the symphysis, by retracting but not opening the peritoneum, and by drawing the bladder toward the median line ("Annals of Surgery," 1914, lix).

My colleague, Prof. John H. Gibbon, advocates a combined intra- and extraperitoneal route for stones anywhere in the lower two-thirds of the ureter. The peritoneal incision permits of exploration and exact localization of the stone, allows the surgeon to push the calculus from an inaccessible into an easily reachable position, and makes the removal vastly easier. The stone is removed by extraperitoneal incision of the ureter, and the peritoneum is closed (Gibbon in "Annals of Surg., Gynec., and Obstet.," May, 1908).

Uretero-ureterostomy (*Van Hook's Operation*).—In this operation ligate the lower end of the divided ureter with silk or catgut. About $\frac{1}{4}$ inch below the ligature make an incision in the long axis of the tube. This incision is in length equal to twice

the diameter of the tube. Each end of a piece of fine catgut is threaded to a fine needle. This thread is passed through the upper end of the ureter (Fig. 1044). The needles are made to enter the lower end of the tube through the door made by the surgeon. They are pushed through the wall of the ureter ½ inch below the door (Fig. 1044). Traction upon the strings causes invagination, and the ligature ends are tied. If the operation be intraperitoneal, the ureter is wrapped about with peritoneum.

Intestinal Implantation of the Ureters.—This operation may be employed in exstrophy of the bladder and in vesical cancer in which it is necessary to remove the bladder. After this operation there is danger of infection of the ureters and consequent ascending ureteritis and pyelonephritis, and the presence of urine in the bowel usually causes inflammation of the rectum and incontinence of urine may arise.

Maydl asserts that a piece of the bas-fond of the bladder should be removed with the ureter, and implanted with it into the intestine, the flange hanging free in the lumen of the gut. If this be done, the relations of the ureter to the muscular coat of the bladder are not interfered with, stricture is less likely to occur, ascending infection is antagonized, and suppurative conditions arise at the margin of the flange rather than, as in other methods, directly in the cut ureter. Maydl has collected the records of 14 cases operated upon by this method, with 2 deaths.[1] I performed it twice, with 1 death. In vesical exstrophy Peterson transplants a vesical flap containing both ureteral orifices into the descending colon.

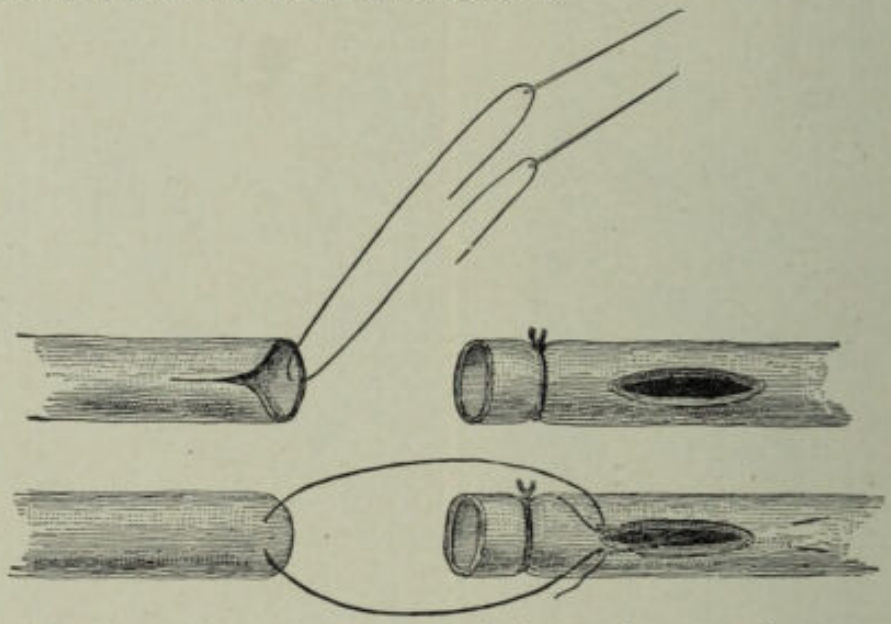


FIG. 1044.—Van Hook's method of ureteral anastomosis.

Cystoscopy is the employment of the cystoscope for the study of the interior of the bladder, the prostate, the ureteral orifices, and the appearance of the fluid from each kidney.

The cystoscope is an instrument of enormous value in the hands of a skilful and experienced man, but is practically useless, in fact, dangerous, when employed by a novice. All of my cystoscopic examinations are made for me by Dr. Stellwagen or some other expert. In earlier days in using a cystoscope the mucous membrane was sometimes burned with a hot lamp. This caused inflammation, and if an eschar formed, it was cast off, exposing a granulating surface. Schmidt, in calling attention to this injury, spoke of the condition as *ulcus cystoscopicum*. He said that it was in the fundus, had the shape of the instrument, and healed in from fourteen to twenty-one days ("Jour. Amer. Med. Assoc.," July 19, 1902).

Cystoscopic examination of the bladder owes its present position to Messrs. Max Nitze and Joseph Leiter, who were the first to introduce practical instruments: Nitze in 1876 and Leiter in 1879. The great obstacle in former years was the danger of burning the mucous membrane by overheating of the lamp. The invention of the cold lamp by E. C. Preston eliminated that danger, and was a great step forward. Nitze was the first to recognize the futility of examination by reflected light and constructed an instrument with the light on the end, a plan which today is imitated by all of the modern instruments.

[1] Editorial in "Jour. Amer. Med. Assoc.," May 6, 1899.

Cystoscopes may be divided into several types: (1) The examining instrument; (2) the instrument carrying ureteral catheters or the catheterizing cystoscope; (3) the operating cystoscope. They all have certain mechanical features in common, but differ in their construction and lens arrangement.

The examining instruments are of two fundamental types—the direct and the indirect. In the direct there is a straight telescope with a series of wide angle lenses that give the picture of the bladder in front and slightly to the side. In the indirect the lens is so ground and set as to enable the operator to look toward the prostate.

Catheterizing cystoscopes are also of two kinds—the direct catheterizing and the indirect. In the direct catheterizing cystoscope the catheters are passed directly from the carrying tubes into the ureters. In the indirect catheterizing cystoscope the catheter is bent or directed by a lever on the end of the instrument operated by a thumb-screw on the penile end. By raising or lowering the lever the angle of the catheter is altered to facilitate its introduction into the ureteral orifice.

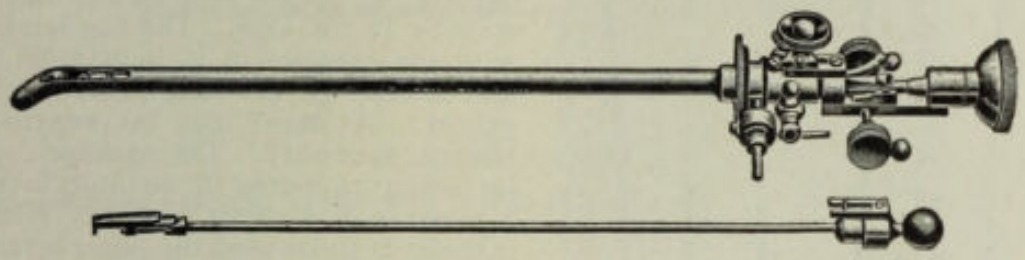


FIG. 1045.—The A. C. M. I. double catheterizing cystoscope.

It is obvious that the bladder should be distended in order to permit of cystoscopic examination. For this purpose air and water have been utilized. The modern tendency is in favor of water distention.

Water as a dilating medium is superior to air, unless operative work is to be done through the instrument, in which case the inevitable hemorrhage precludes the use of water. The air instruments show but a small field, the distention causes pain and is often followed by mild cystitis.

From the foregoing it is plain that one type of instrument is not suited to all cases, and each has its field of practical utility. Some cases can be most readily catheterized by the direct, others by the indirect, plan. Stellwagen asserts that if the ureteral orifices are normally placed, the direct method is quicker and more readily learned by

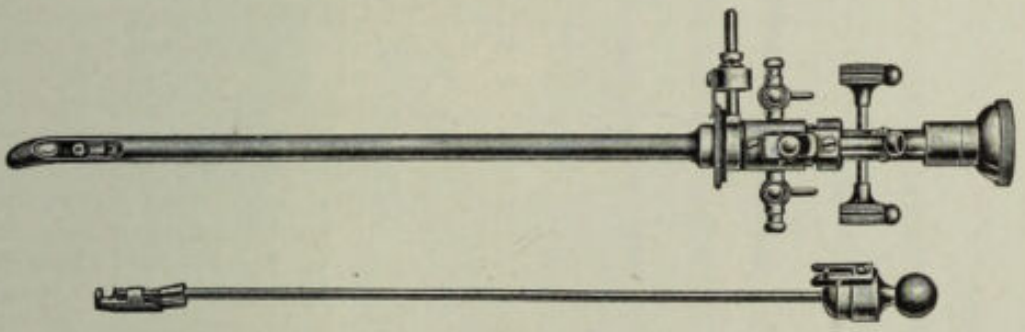


FIG. 1046.—The A. C. M. I. operating cystoscope.

the beginner. Men who have had training had best use the A. C. M. I. cystoscope (Figs. 1045, 1046). It is an indirect or oblique cystoscope, but has a corrected image field which enables the operator to work as he sees and not the reverse (as is necessary with the uncorrected image field). These new instruments cause less pain than direct instruments, and give a very wide field. When from any cause the ureteral orifice turns backward (which only happens in a very small percentage of cases) the indirect cystoscope is indispensable, it being practically impossible to reach the ureteral orifice by the direct instrument.

There are at present many different forms of cystoscopes on the market, notable among them being the Nitze, Casper, Tilden Brown, Cabot's modification of the Tilden Brown, Buerger, Albarran, Bransford Lewis, and the so-called Universal.

Sterilization of Cystoscopes and Ureteral Catheters.—In order to sterilize the cystoscope before using, place it for five minutes in a solution of mercury oxycyanid (1:1000)

or formaldehyd (1:500). The sterilizing power of formaldehyd gas is not to be relied on. Some operators use a 5 per cent. solution of phenol, in which the instrument is immersed for twenty-four hours, after which it is dipped into glycerin, which both neutralizes the phenol and lubricates the tube. The mercury oxycyanid solution is easily used and is thoroughly satisfactory. Should formaldehyd solution or formalin gas be used, always wash the instrument thoroughly with salt solution before introducing it to prevent irritation by the sterilizing medium.

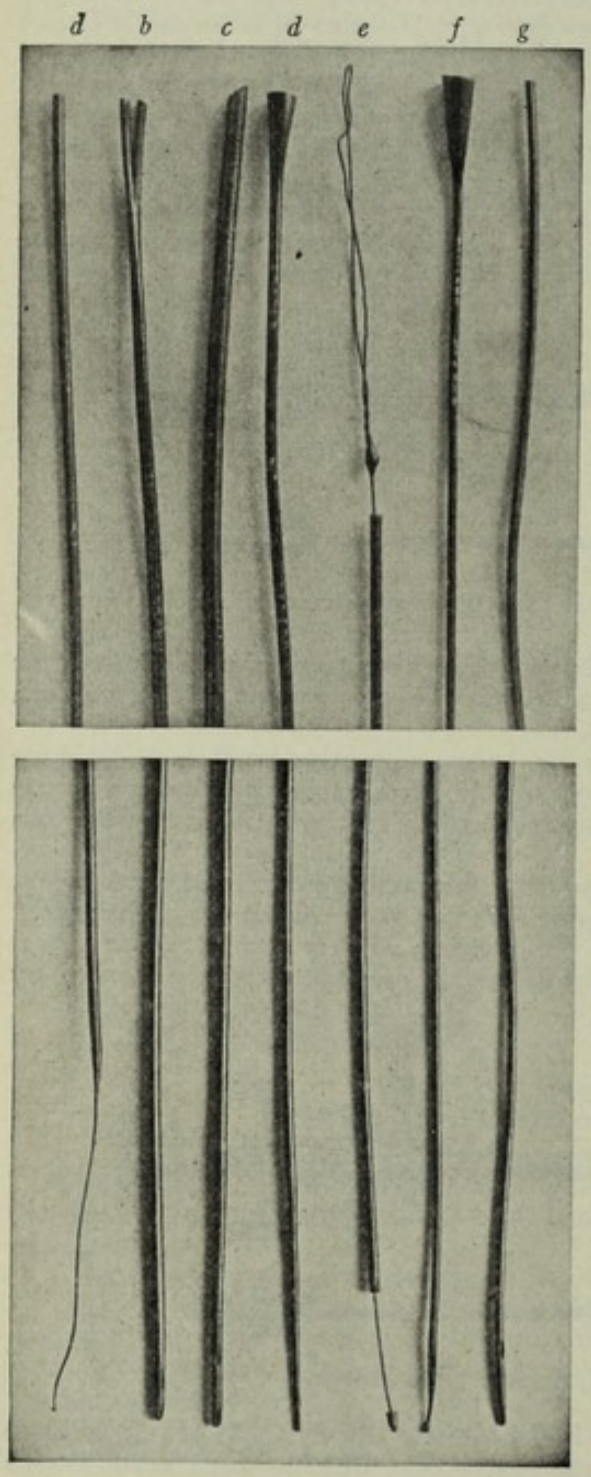


FIG. 1047.—Different types of ureteral catheters: *a*, Blasucci; *b*, return flow for irrigation; *c*, Garceau; *d*, another type of Blasucci; *e*, Cunningham; *f*, olivary tipped; *g*, *x*-ray whistle tip.

Dr. M. P. Willard, of San Francisco, in "Jour. Amer. Med. Assoc.," October 4, 1913, advocates the following method for sterilizing ureteral catheters: The ureteral catheter is placed in a muslin bag 2 cm. wide by 75 cm. long. The bag is enclosed, with the catheter in it, in paraffin paper, and secured by encircling strips of adhesive plaster. As many may be prepared as is thought necessary. The package is placed for twenty minutes in an autoclave with a pressure of 8 to 10 pounds. When the catheter is to be used the paper is removed and the end of the instrument is exposed by pulling back the linen bag and the tip of the catheter is engaged in the carrying tube of the cystoscope. As the catheter is fed through the cystoscope the linen bag is pulled back; in this way the fingers do not come in contact with the catheter.

Ureteral catheters can be sterilized by placing them in an open shallow dish containing a saturated solution of ammonium sulphate or sodium chlorid and boiling them for five or ten minutes. The following precautions must be observed: Each catheter should be wrapped in gauze and the bottom of the pan covered with gauze. If the catheters are allowed to touch each other or curl upon themselves the shellac coating will melt and ruin the instruments. They may also be sterilized in the same manner as the cystoscope, care being taken if formalin has been used to wash away carefully the germicide, especially from the lumen of the catheter. Stellwagen recommends the sterilization of condoms and coiling the sterile ureteral catheter within them for further use. Also a sterile rubber tube may be placed about the ureteral catheter and so protect it from contamination.

Contraindications to Cystoscopy.—The bladder must hold at the very least 50 c.c. of fluid. If it holds less, cystoscopy is useless. Examination is either impossible or unsatisfactory if the prostate be greatly enlarged. Contracted meatus urinarius and stricture of less caliber than No. 24 of the French scale are correctible contraindications. Papillomata and other tumors and foreign bodies in the urethra are impediments. In acute Bright's disease instrumentation is dangerous, because it may be followed by suppression of urine. The following are further contraindications, as suggested by Follen Cabot and Henry G. Spooner in "Med. Record," July 11, 1903:

When it is obvious that operative intervention would be useless; when there is a large tumor; in acute cystitis; in tuberculosis in which the diagnosis is evident without the cystoscope. In women, pelvic adhesions and large exudates may interfere with cystoscopy. In male children under six to eight years of age cystoscopy must be done with

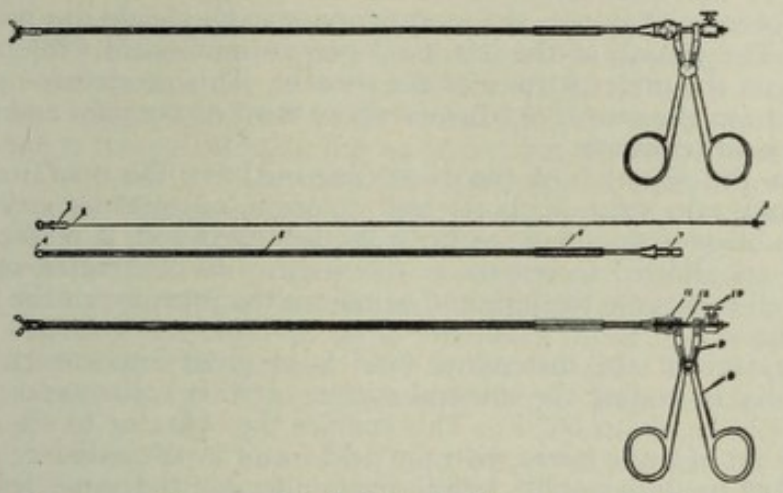


FIG. 1048.—Buerger's rongeur forceps with flexible shank for use with Buerger's operating cystoscope.

the greatest of care. We have seen a urethra ruptured in a boy of three and a half years. Remember the urethra of the male child is a very delicate structure, easily torn. Prof. H. R. Loux seriously questions the advisability of cystoscopy upon very young males. At least it should, as he says, be entered upon only after most careful consideration.

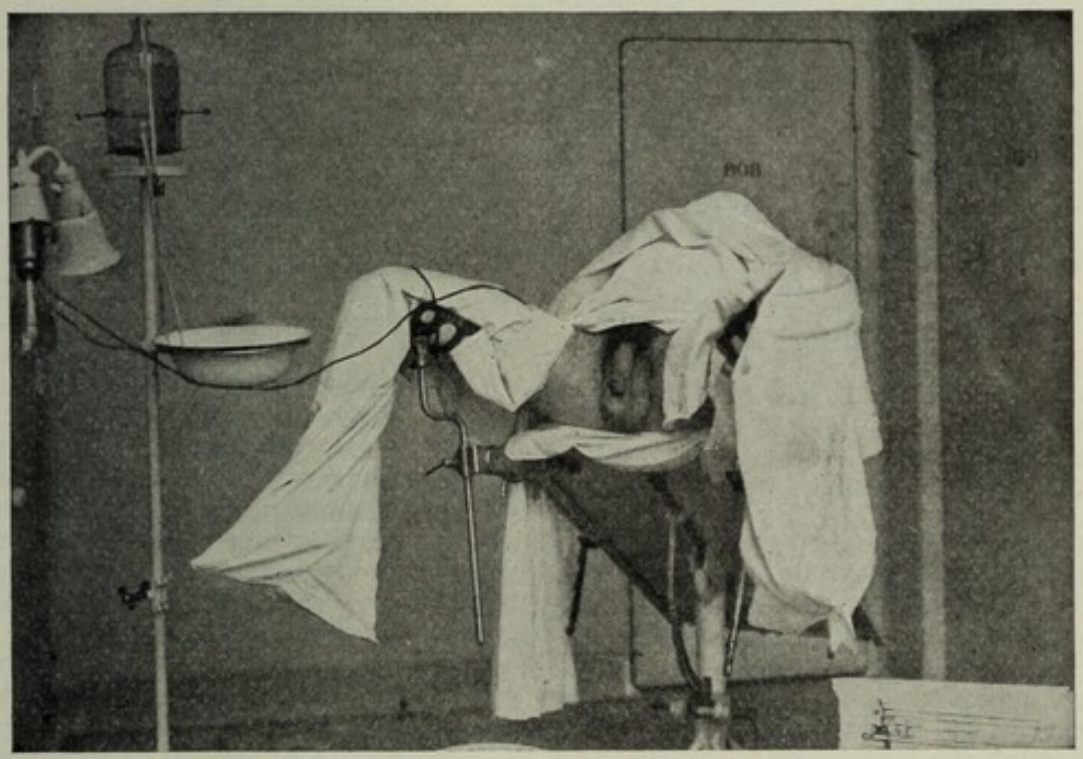


FIG. 1049.—Tilden Brown's cystoscopic table with patient in position for examination.

Technic of Cystoscopy.—The patient should, if possible, be carefully sounded once a day for several days previous to the cystoscopic examination; this establishes tolerance of the urethra. He should be placed upon a suitable table (Fig. 1049).

The urethra is cleaned by irrigation with salt solution. General anesthesia is rarely necessary provided the operator is gentle in his manipulations. There are, however, some urethras so hypersensitive as to make general anesthesia necessary. Cocainization of the urethra will usually suffice. This is carried out by instillation through

the Keyes-Ultzmann syringe or, better, through a soft-rubber catheter into the posterior portion of the canal of 1 dram of a 4 per cent. solution of cocain or 1 per cent. novocain. In cases complicated by cystitis preliminary lavage of the bladder should be practised. This may be given through the cystoscope sheath or through a soft-rubber catheter. If the bladder be not diseased, it is merely necessary to draw off the urine. After the urine has been withdrawn, the cystoscope sheath should be firmly but gently held in place. The thumb of the left hand presses downward while the index-finger presses upward on the under surface of the sheath. This procedure raises the beak of the instrument from the sensitive trigone, where most of the pain and hemorrhage are produced by vesical tenesmus.

In regard to the selection of the distending medium, the operator may use sterile water, normal salt solution, boric acid solution, or mercury oxycyanid solution (1:5000). The bladder should be moderately distended and, if possible, from 8 to 10 ounces of fluid are allowed to remain in the viscus. In contracted or hypersensitive bladders it is well to elevate the hips and so relieve the pressure on the sensitive vesical neck and trigone.

The temperature of the distending fluid is of great importance, particularly if there be difficulty in finding the ureteral outlet. If this is the case, the temperature of the fluid should be about 60° F. This enables the operator to see a so-called swirl when the warm jet of urine mixes with the cold water in the bladder. It is sometimes advisable to give methylene-blue before examining for the same reason. The blue stream from the ureter at once identifies the tube.

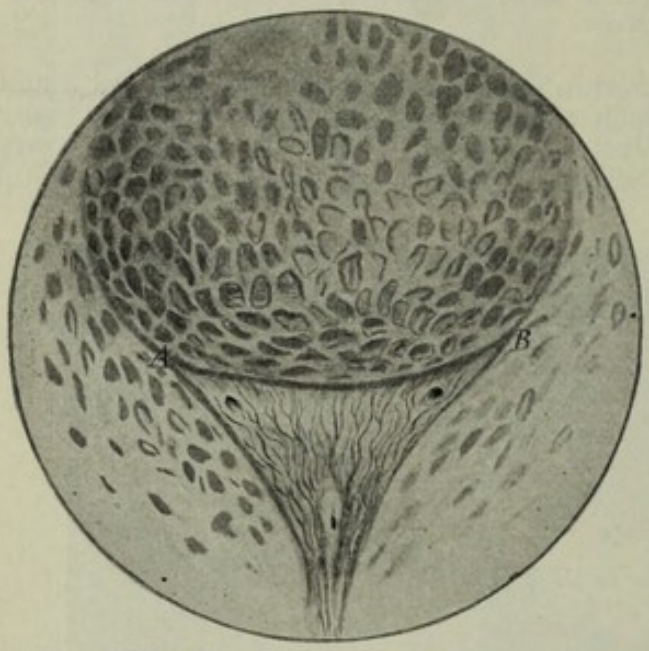


FIG. 1050.—The interior of the bladder, showing arrangement of the vessels of the trigone: *A*, *B*, interureteral bar.

After the bladder has been filled the telescope containing the catheters is inserted and the light is turned on. The instrument, then held in the median line, is pushed gently back, well into the bladder, pressure being always made to keep the beak from impinging upon the floor of the viscus. The cystoscope is now slowly withdrawn, a careful watch being maintained through the telescope for the *interureteral bar* (Fig. 1050). This structure (there has been much argument as to whether this structure really exists) marks the posterior border of the trigone. The examiner has still another guide to the trigone in the blood-vessels, which in a general way run anteroposteriorly. There is a distinct line of demarcation between the fish-net loop arrangement of the mucous membrane of the sides and base of the bladder and the mucous membrane of the trigone. Figure 1050 gives a general idea of the vascular arrangement. When the interureteral bar or posterior border of the trigone has been located, the instrument is gently and slowly moved laterally, so that the border of the cystoscope is kept in the field until the end of the bar is reached. The instrument is then held stationary for a moment and a sharp lookout is kept for the jet of urine or the swirl. The ureteral orifice is thus indicated. Should the field become blurred by blood on the lens, or should the solution in the bladder become mixed with blood, continuous irrigation must be kept up through the cystoscope.

The Ureteral Orifices.—As before mentioned, the ureteral orifices are usually located at the terminations of the interureteral bar, and occupy the basal angles of a triangle formed by the vesical outlet and the base of the trigone. They are usually about 1 to 1½ cm. from the median line and about 2½ cm. from the vesical end of the urethra. They are recognized as small slits or as tubercles on the surface of the mucous membrane. Their position is not always the same. Some of the abnormal positions more commonly met with are as follows: one ureter closer to or further removed from the median line, both ureters emptying into the bladder close to the median line, generally about one-quarter or one-half the length of the bar. Malposition is toward the

vesical outlet and in some very rare instances both ureters empty on the same side. Sacculation and pocketing of the bladder with swelling of the mucous membrane often make localization of the ureteral orifices difficult. It is then that the administration of methylene-blue or indigocarmin may enable the investigator to locate the ureters more readily.

After locating a ureteral orifice the vesical end of the cystoscope is carried directly over the opening and the catheter is projected against the opening, where it is allowed to remain for a moment in order to overcome the spasm of the sphincteric muscular fibers. The patient is instructed to hold his breath and the opening is carefully watched until a jet of urine is forced through, during which act the catheter is gently inserted into the ureter. The passing of the urine is accompanied by dilatation of the opening and greatly facilitates the entrance of the instrument. After the catheter has passed the sphincter muscle it should be carried up the canal by *very gentle* pressure. The practice of passing the instrument quickly, so commonly resorted to by the novice in order to gain time, is pernicious, and almost invariably causes laceration and hemorrhage. Before inserting the catheter some operators prefer to coat it with paraffin in order to render it absolutely smooth and further to assist in the detection of calculus. This is not necessary. Any instrument with an imperfect eye should be discarded.

The round-pointed catheter should be used wherever possible, as with it there is less danger of injuring the delicate mucous lining of the canal. The sharp-pointed

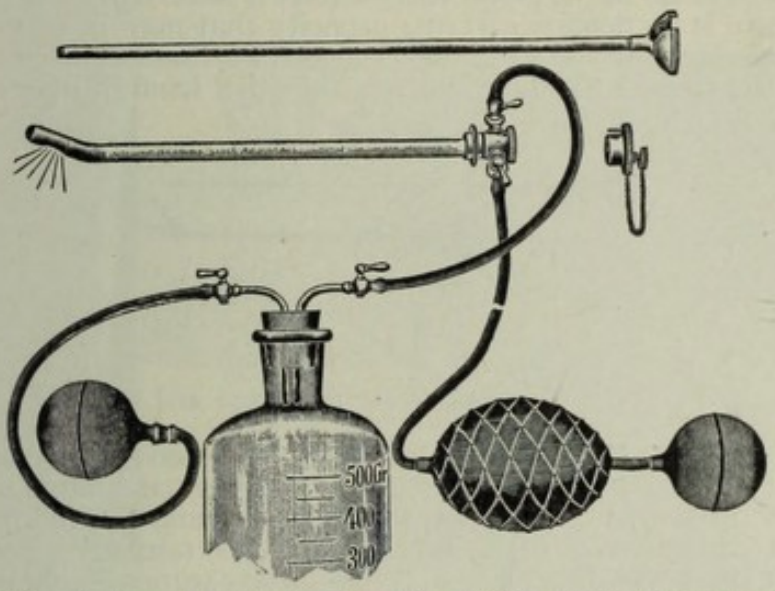


FIG. 1051.—Bulbs and bottle for distending bladder and collecting washings.

olivary tipped instrument often causes blood to appear. If possible, insert the catheter into the renal pelvis, for then hemorrhage from trauma is less likely to invalidate the examination, and spasm of the ureter, with sucking of the mucous membrane into the eye of the catheter, will not occur. Having finished the catheterization of one side, the catheter is left in place, the instrument handle is swung to the opposite side and a similar procedure is carried out. Always have a distinguishing mark upon the catheters. A very good method is to use different colored instruments, so that there may be no confusion after withdrawal of the cystoscope. In some cases only one ureter can be catheterized. In such a case the bladder should be thoroughly washed, and the other catheter, left on the floor of the bladder, will collect the urine from the uncatheterized side and give a fair idea of the condition of that kidney.

Removal of the Cystoscope.—The light should be turned off and a small amount of fluid allowed to escape through the barrel. The lens system carrying the catheter is then loosened and gently rotated from side to side to free the catheters. During this procedure the catheters are drawn gently backward, but not with sufficient force to cause kinking, and the lens system is removed. Next the sheath is withdrawn by carrying it straight up over the abdomen.

Collection of the Urine.—The protruding catheters are carefully wiped with sterile gauze and are permitted to drain into separate bottles or test-tubes, marked respectively right and left. The orifices of the receivers should be plugged with sterile absorbent

cotton, which will collect and prevent any admixture of urine or water coming from the bladder by capillary drainage. The bottles should also be held in such position as to prevent such capillary drainage reaching them. With regard to the collection of the samples, there are certain precautions that should be observed: (1) The samples should, if possible, be collected in three separate bottles from each side, allowing each set to remain in position a definite time, generally one-half hour. These should be carefully watched and marked first, second, and third half-hours. They should each be examined separately, and by a summation of the examinations the opinion should be reached. Almost invariably microscopical blood can be found in the urine drawn by catheterization of the ureters. In a study of 15 cases of normal ureters, blood not having been present before catheterization, microscopic blood was present in all but 3 after careful catheterization. The erythrocytes are usually most numerous in the first bottle, gradually diminishing, until in the third there are few or none. Should the blood increase in the second or third bottle, it is an important clinical fact.

In some instances one or both catheters fail to drain. This may be due to a bubble of air in the instrument, impinging of the mucous membrane upon the eye, plugging by blood-clot, mucus, pus, or particles of gravel. A syringe is then essential. The blunt hollow needle should be inserted into the catheter and suction applied; should this fail, not over 4 c.c. of sterile normal salt solution may be injected through the catheter. This procedure, however, must be carried out very gently, because of the danger of overdilating the renal pelvis and thus producing colic.

The carrying capacity of the pelvis of the kidney is uncertain. Careful observations indicate that there is no definite carrying capacity that may be called normal. The range of difference is great and even differs at certain times in the same kidney. In many kidneys it is about 8 to 10 c.c., but, on the other hand, it may be as high as 20

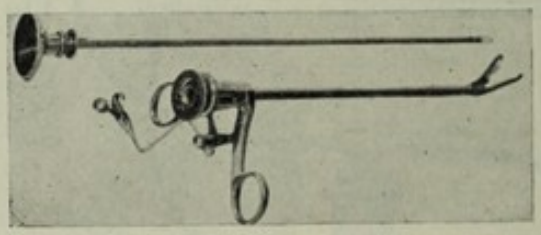


FIG. 1052.—Young's grasping cystoscope and rongeur.

c.c. and still be normal. It would seem as though the blood-supply of the organ had something to do with the pelvic capacity, for a congested circulation means distended vessels, and they probably impinge upon the pelvis. Again, the question of producing renal colic by overdilatation of the pelvis is a very uncertain guide as to the capacity, for in many instances the ureteral and pelvic musculature is sufficient to force the fluid down the ureter with the catheter *in situ* and yet produce no evidence of colic. This has been seen in many instances in making a pyelographic study by means of a solution of collargol, which is much thicker than urine or water.

A uropyknometer is used for taking the specific gravity of small quantities of urine removed by the ureteral catheter.

Stellwagen has found the grasping cystoscope of Prof. H. H. Young an admirable instrument for removing foreign bodies from the bladder. It was designed originally as a cutting instrument for removal of portions of prostate. He has not been successful with it for this purpose, but recommends it most highly for the removal of small stones or small foreign bodies.

Practical Value of Cystoscopy and Ureteral Catheterization.—The cystoscope has attained a very important position in the surgeon's armamentarium. It undoubtedly affords the best method of establishing an accurate diagnosis founded on pathologic findings. By it one is enabled to determine the presence and character of cystitis, stone, foreign bodies, and malformations. Without it the presence of ulcerations could merely be guessed at by the clinical history. Its greatest field is in the early diagnosis of the cause of renal and vesical hemorrhages. In the detection of renal neoplasms it may be said to have revolutionized surgery. It makes possible the early removal of such growths before malignancy has signed the patient's death warrant. Cases of prostatic hypertrophy, in which the lobes project backward, cannot be accurately diagnosticated without the cystoscope; with it the parts can be seen and the clinical diagnosis positively confirmed. It makes possible the removal of small foreign bodies,

such as stone, pieces of cotton, or filiform bougie through the urethra, thus obviating formidable cutting operations. It is needless to mention the great difficulty found by surgeons in former years in determining the source of symptomless hemorrhage, a problem which is now comparatively easy of solution.

Ureteral catheterization makes possible the irrigation of the ureter and pelvis of the kidney in cases of ureteritis and pyelitis.

The technic of lavage is as follows: The gravity tubes for instilling fluid, shown in Fig. 1053, are carefully sterilized and the metal nozzles arranged so as to fit correctly the lumen of the ureteral catheters. It is always necessary to make certain that the nozzles will fit and that they and the catheters are free. This should never be neglected. It has been found on several occasions that one or the other was blocked, and, again, any particles of catheter or other material which might form a nidus for stone formation should be washed out. The irrigation should be done by means of gravity rather than by the syringe, as the fluid may be delivered more evenly and, so to speak, may be "sneaked" into the pelvis of the kidney. The gentle trickle of warmed fluid does not seem to excite acutely the musculature of the ureter and pelvis; in consequence there is not so much colic, and if colic occurs it does not persist long. About this point there has been some difference of opinion, but the evidence is in favor of the gravity method both for lavage and pyelography.

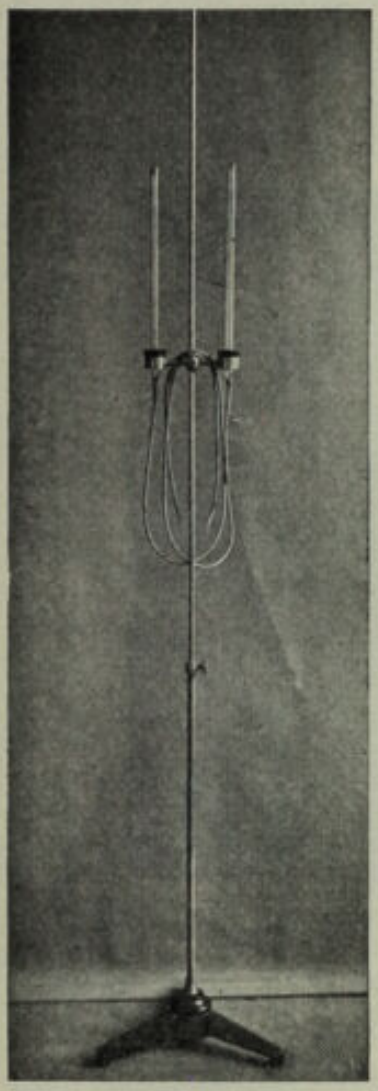


FIG. 1053.—Apparatus for filling pelves in pyelography; also for doing lavage of ureters and pelves.

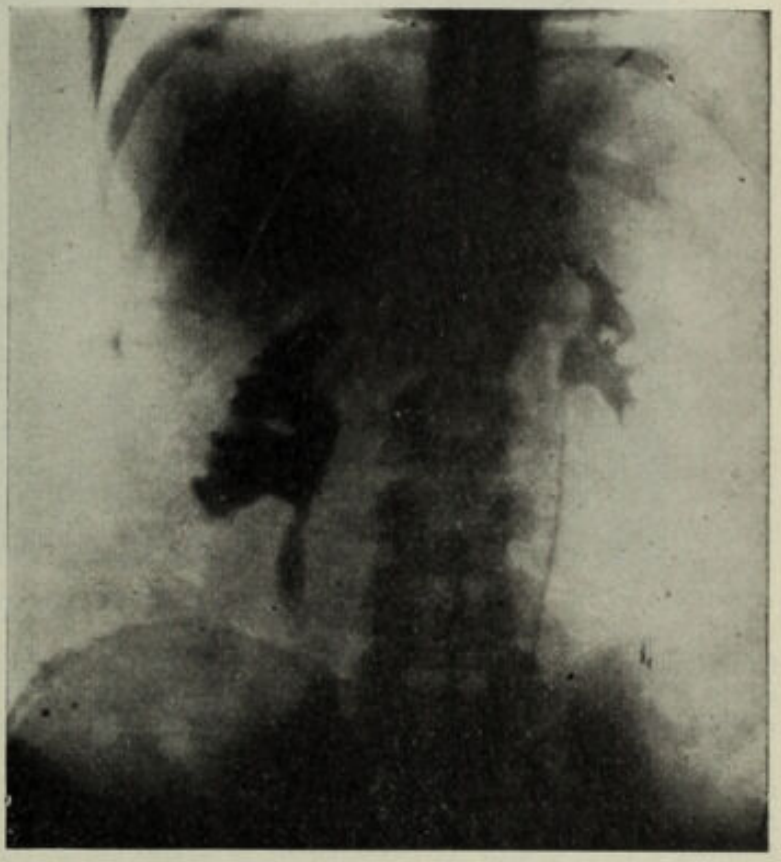


FIG. 1054.—Hydronephrotic kidney.

There are several solutions that may be used. We believe that normal salt solution is the best for mere cleansing purposes. A saturated solution of boric acid may be used if a mild antiseptic be needed. Either of these solutions may be followed by one of the silver solutions of a strength calculated to suit the case in hand. The nitrate of silver is generally used in a strength of 1:8000, but a much stronger solution may be resorted to.

The catheters are passed in to one or both ureters and the fluid is permitted to pass very slowly into the pelvis or ureter, as the case may be. Overdistention must be guarded against, and a safe rule is not to allow over 8 c.c. to be introduced at any one time.

The type of catheter to be used may accord with the fancy of the operator. There is at present on the market a very excellent two-way pelvic irrigating ureteral catheter, or the single tube instrument may be used and the fluid allowed to escape after filling the pelvis (Fig. 1047). This procedure should be repeated until the return fluid is clear. Should hemorrhage complicate the procedure, an irrigation of adrenalin may be used. (This procedure has apparently cured essential renal hematuria.)

After completion of the irrigation the bladder should be thoroughly washed out and the patient put upon some mild genito-urinary antiseptic, of which there are several. Hexamethylenamin is the one usually given.

It would seem a wise plan to irrigate thoroughly the kidney, pelvis, and ureter before certain surgical operations. When a surgeon is about to open the kidney in the presence of pus or infected urine, before cutting down upon the kidney it is well to wash away as much as possible of the purulent matter through a ureteral catheter and then instil some nitrate of silver.

Irrigation of the pelvis and ureter has become a rational surgical procedure and in many cases is followed by a marked improvement in the general health of the individual, making operative procedure safer and not complicated by so marked a toxemia. In all cases when operative work is to be done on a kidney with a large pus sac of other



Fig. 1055.—Pyelogram of normal ureters and pelves.

than tuberculous origin, irrigation of the pelvis by means of one of the milder antiseptic silver solutions would seem to be a proper surgical procedure. It is especially so when the necessity may arise for opening the peritoneal cavity.

A differential diagnosis must sometimes be made between gall-bladder disease, appendicitis, and movable kidney with dilated pelvis. This is done by determining the carrying capacity of the pelvis by means of the injection of salt solution and by making a pyelogram. If the trouble is in the kidney, pain caused by injection of salt solution will be similar in character and situation to the pain of the attacks. As a rule, in movable kidney producing marked symptoms the renal pelvis is dilated. When the trouble is due to the kidney the pain induced by the distention is similar to that from which the patient has suffered (Howard A. Kelly). If a stone be present in the ureter the *x*-ray picture will usually reveal it, but here again there may arise doubt as to the exact course of the canal. Catheters which cast a shadow with *x*-rays should be passed into the ureters and the patient radiographed with them *in situ*. The radiographer will be able to determine the general course of the ureters. Figure 1055 shows the practical utility of such manipulation. Phleboliths, fecal masses, appendoliths, intestinal concretions, and calcified lymph-nodes have been mistaken for ureteral stone even after a study of skiagraphs. Appendices have been removed when the source of trouble has been impacted stone in the right ureter.

In several cases seen by Stellwagen appendectomy had failed to cure. In each case a stone was subsequently removed from the ureter and the patient cured. An impacted stone in the ureter may sometimes be dislodged by passing a catheter into the ureter and, if possible, beyond the stone. Through the catheter are then injected a few minims of sterile olive oil or sterile catheter lubricant which act as a lubricant and assist in the passage of the stone. Dilatation of the ureteral orifice, by leaving the catheter *in situ* or by passing a second instrument alongside of the first, may cause the stone to pass into the bladder. Incision of the ureteral outlet may be necessary.

Diseases and Injuries of the Bladder

Disinfection of Urethral Catheters.—Metallic instruments are cleansed by boiling. Soft-rubber and elastic catheters can be sterilized by mechanical cleansing with soap and water and by boiling for five minutes. The common custom of immersing a soft-rubber or elastic catheter for five minutes in a 1 : 2000 solution of corrosive sublimate is a useless waste of time, as such a procedure will not sterilize an infected instrument. Formalin vapor is not reliable. A catheter coated with varnish or resin cannot be placed in steam, and cannot be boiled in water if it be allowed to touch the metal of the boiler or another catheter. Woven and varnished instruments can be boiled in salt water (3 drams of salt to 1 pint of water), provided each instrument be wrapped in a piece of gauze so that it cannot touch another instrument or the side or bottom of the metal sterilizer. This plan secures the most certain sterilization. Catheters, after being cleansed mechanically and disinfected, may be kept ready for use in a glass cylinder containing calcium chlorid (R. W. Frank in "Berliner klin. Woch.," No. 44, 1895). By this plan the catheters can be kept straight. Some prefer to keep them in a glass cylinder containing a few formalin tablets.

An excellent way to keep sterile catheters clean is to place each catheter in an individual bag of linen or waxed paper. Stellwagen boils a number of rubber condoms at the time he boils the catheters. When the instruments and condoms are dry he encloses a curled up instrument in each condom. Before using catheters which have been in formalin vapor they must be washed in sterile water or salt solution.

Retention of Urine in the Male.—Retention of urine is not, of course, a disease; it is rather a result of one of a number of different diseases. By this term is meant an absolute inability to micturate voluntarily. The retention may be *complete*, not a drop emerging, or it may have been complete, a dribbling setting in after a time, due to paralysis of the bladder, which becomes unable to contain more fluid, expulsion of the overflow from the ureters being produced by atmospheric pressure. This condition is known as *the engorgement, the overflow*, or *the incontinence of retention*. There may be *retained* urine in a man with enlarged prostate, a portion only of the urine being voided. This is not retention, and the urine so retained is called *residual urine*. Of course, true retention may arise in a person with enlarged prostate. Retention may be caused by: (1) *Obstruction*, resulting from urethral stricture, hypertrophied prostate, inflamed prostate, occluded meatus, impacted calculus or foreign body, urethral tumor, rupture of the urethra, perineal abscess, imperforate prepuce, congenital phimosis, tumor of the penis, tumor of the prostate, prostatic abscess, abscess of the penis, ischiorectal abscess, and pressure from a large pelvic tumor. The commonest obstructive cause is spasm of the membranous urethra arising during the existence of stricture, acute gonorrhea, or gleet. In some cases of chronic retention there is a spastic sphincter. This condition is not uncommon in children and is due to disease of the sacral portion of the spinal cord. (2) *Defective expulsion*, resulting from impairment of the nervous apparatus for inducing micturition. Hysteria is a rare cause in men. We see retention without obstruction after vertebral fractures or spinal concussion, in certain diseases of the spinal cord, sometimes in shock and peritonitis, often in the continued fevers and diseases characterized by muscular wasting, from the action of certain drugs (belladonna, opium, or cantharides), and after certain surgical operations upon or about the rectum. The last-named form of retention is due either to reflex inhibition of the expulsor muscle or to reflex stimulation of the sphincter vesicæ, causing it to remain firmly contracted. *Acute retention* comes on suddenly and is sometimes the first thing that causes a sufferer from urethral stricture to seek a surgeon. Retention in the newborn infant may be due to occluded meatus urinarius, imperforate foreskin, phimosis, paraphimosis, and cyst of the sinus pocularis. An intravenous injection of 5 to 10 gr. of hexamethylenamin in solution may bring about an efflux of urine in a case of postoperative retention. We have used it with success.

Symptoms.—In *acute retention* there is an agony of desire to urinate, the patient making acutely painful straining efforts, during which feces are often passed. There are severe pain and aching in the abdomen, thighs, perineum, and penis. All the symptoms rapidly increase, a typhoid state is inaugurated eventually, and death closes the scene unless relief be given. If retention is from time to time alleviated by the passage of a little water, the symptoms are slower in evolution and are less intense, and the case is said to be *chronic*. Some cases of gradual onset due to atony are very insidious, the patient feeling no particular pain and complaining only of the dribbling, which is really the overflow of retention, and is not a sign that the bladder is successfully emptying itself. In any case of retention the bladder rises above the pubes, and there is found a pyriform, elastic, fluctuating mass in the hypogastrium, and this mass is dull on percussion and gradually enlarges until the bladder is evacuated or incontinence sets in. The flanks give a clear percussion note, and the tumor is more prominent when the patient is erect than when he is recumbent. Long continuation of obstructive disease, producing partial retention with or without attacks of complete retention, disorganizes the kidneys. Acute and complete retention may induce rupture of the urethra or urinary suppression.

Treatment of Retention of Urine.—Place the patient upon his back and, if possible, upon a hard mattress. If the bed be so soft that the hips sink down in it, put an ironing board or some other support beneath the mattress at the level of the buttocks. This will facilitate catheterization. Never attempt to use a catheter when the patient is erect; to do so may cause serious or even fatal shock. Always keep the patient protected from cold. Obtain a full history of the case and always make a gentle rectal examination of the prostate; also examine the external genitalia. Failure is often traceable to a lack of thorough examination. It is evident that retention due to prostatic disturbance is not to be dealt with in the same manner as retention due to stricture, impacted stone, etc. If instrumentation does not rapidly succeed, give an anesthetic. Be sure that every instrument is aseptic, and irrigate the urethra before and after instrumentation. Grease the instruments with liquid cosmolin or other suitable lubricant. Prolonged attempts to introduce a catheter and excessive instrumentation are highly dangerous, especially in prostatic cases. Dreadful damage may be inflicted. There is no operation in surgery that requires a gentler touch. Haste, eagerness, carelessness, roughness are, alike, taboo. If a non-medical person knew the facts he would give more thought in the selection of a surgeon to relieve him of retention of urine than of a surgeon to amputate his leg. A surgeon with retention would give grave thought to the question. When the instrument enters the bladder, draw off but half of the urine, withdraw the instrument, wait a few hours, insert it again, and then empty the bladder and wash out the viscus with warm boric acid solution. To draw off all of the urine at once is dangerous, because the sudden relief of the pressure upon distended veins leads to bleeding from the mucous membrane and hemorrhage into the bladder walls. After the bladder has been catheterized the patient is wrapped in blankets, a bag of hot water is placed against the perineum, and a hot-water bag is laid upon the hypogastric region. If no anesthetic has been used, he is given at once after the operation a suppository of opium and belladonna. If an anesthetic has been used, he is given the suppository when he recovers from the effect of the anesthetic. Tablets of salol and boric acid are administered during the several days which immediately follow the operation. It is advisable to give a series of three doses of quinin sulphate and salol, of each 5 gr., about three hours apart. This will often ward off a chill. If the cause of retention is organic stricture, try to pass an elastic, olivary pointed catheter (Fig. 1056, *a*). Do not use any force until the neck of the elastic catheter is well engaged in the stricture. Then an experienced operator may warily use a certain amount of force, but never an amount which much exceeds the slightest. If it is found impossible to pass an elastic instrument, make an attempt

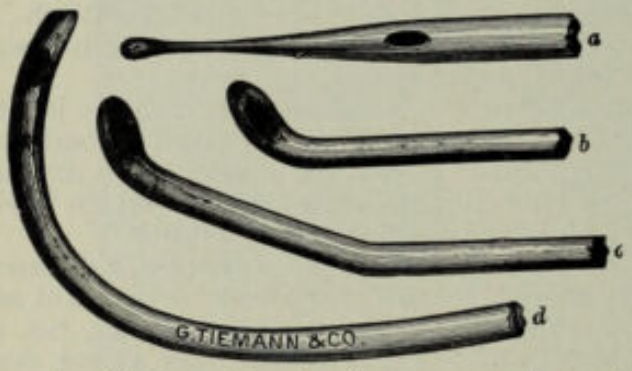


FIG. 1056.—*a*, French olivary gum catheter; *b*, Mercier's elbowed catheter (coudé); *c*, Mercier's double-elbowed catheter (bicoudé); *d*, curved gum catheter.

to carry a filiform whalebone bougie into the bladder. Figure 1057 shows filiform bougies. If the history shows that the man has long had an organic stricture, do not waste time with the gum catheter, but at once proceed to use the filiform bougie. On this bougie, after it has been inserted, Gouley's tunnelled catheter can perhaps be threaded (Fig. 1058) and carried into the bladder. A precaution to be carefully borne in mind in using filiforms and the Gouley tunnelled catheter is to see that the filiforms are of good tensile strength, that they are all of the same caliber and contain no rough or scaly spots, and that they will lace through the eye in the end of the Gouley. Also see that the eye or hole in end of the Gouley has its edges rounded and not square across, for if the latter condition is present it may shear off the filiform. I have made it a practice to ream the eye by means of a Morse twist drill and then stone it smooth with a fine Arkansas stone. This precaution may save trouble and

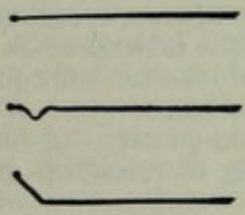


FIG. 1057.—Points of Gouley's whalebone guides (filiform bougies).

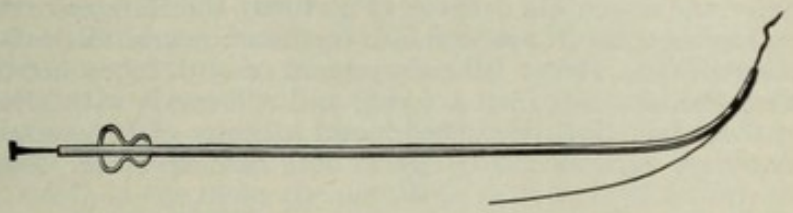


FIG. 1058.—Gouley's tunnelled catheter threaded on a filiform bougie.

a law suit. Filiforms are often shorn off, leaving a portion within the bladder. Instead of carrying in the catheter, we can simply leave the filiform bougie in place and fasten it. The filiform bougie will act as a capillary drain, and in a few hours will empty the bladder and will also dilate the stricture. Then insert another bougie beside the first and so on for several days, until there is a sheaf of them *in situ*, using also opium, ordering rest in bed, and making no attempt to dilate the stricture forcibly until retention has ceased and inflammation has subsided. Perhaps Phillips's catheter (Fig. 1062) can be passed. A filiform will often pass if the patient is put upon his hands and knees or is immersed in a tub of warm water. If no instrument can be passed, aspirate above the pubes or perform cystotomy (suprapubic or perineal). In *spasmodic stricture* hold a good-sized metal catheter firmly against the area in spasm; relaxation will occur and the instrument will eventually

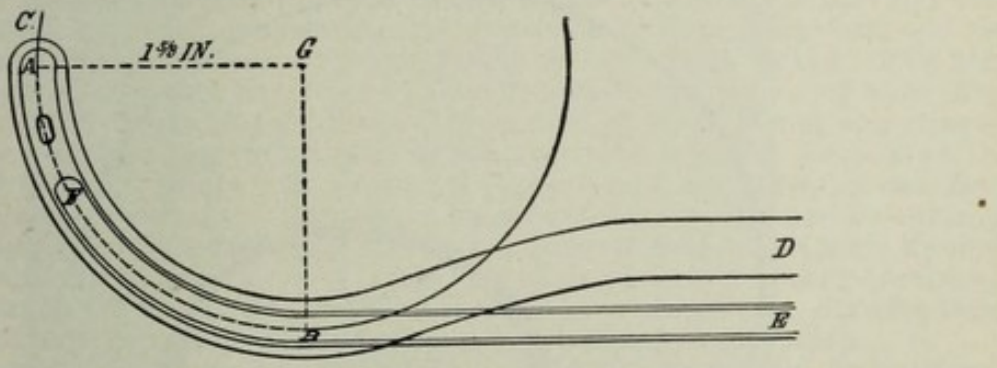


FIG. 1059.—*A–B–E* shows the proper curve (reduced in size) for unyielding male urethral instruments; *C–B–D* shows an improper curve.

pass. Figure 1059 shows the proper curve of a metal instrument. An individual who has an organic stricture which has given but little trouble may develop attacks of retention because of inflammatory edema of the mucous membrane and spasm of the urethral muscles. These attacks are temporary, and an instrument can usually be inserted when employed as above directed. In *inflammation* give a hot hip-bath and suppositories of opium and belladonna, and then use a hot sand-bag to the perineum and a hot-water bag over the hypogastrium. If these fail or if the symptoms are urgent, pass a soft catheter. In the *occluded meatus of the newborn* incise with a tenotome. In a *congenital cyst of the sinus pocularis* pass a steel bougie or large-sized probe properly curved, which will rupture the cyst. In *complete phimosis* split up the prepuce. In *impacted stone* try to pull out the calculus with urethral forceps; if this fails, cut the urethra or, in rare cases, push the stone back into the bladder. In *fecal impaction*

scrape out the rectum with a spoon. In *enlarged prostate* the rectal examination gives information as to the type of enlargement. If there be moderate enlargement of the middle lobe the coudé (Fig. 1056, *b*) or the bicoudé catheter (Fig. 1056, *c*) will probably pass. If these instruments fail, try the overcurved silver catheter of Sir Benjamin Brodie. This metal instrument has a large curve and will probably succeed, but it is a dangerous tool and one capable of inflicting grave injury. In enlargement of one lateral lobe with possible deflection of the urethra and valve formation try, in



FIG. 1060.—English silk-web catheter.

order, the woven silk catheter (Fig. 1060), the Nélaton catheter (Fig. 1061), strengthened by having a filiform passed into its lumen nearly to the beak, and the rat-tailed silk intrument (Fig. 1062). In enlargement of both lobes and the middle lobe try the coudé, then the bicoudé, then a coudé and a bicoudé with olivary or rat-tailed tips. If all of these fail, the overcurved metal catheter of Brodie must be used gently. In *retention from expulsive defect* use a soft catheter (Fig. 1061). Cases of retention after

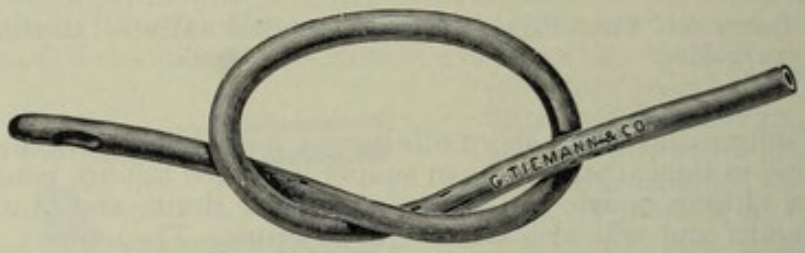


FIG. 1061.—Nélaton's catheter.

catheterization require warmth, confinement to bed, the administration of laxatives, free action of the skin, and the use of such drugs as salol, boric acid, hexamethylenamin and acid sodium phosphate, and quinin to asepticize the urine. In some few cases no instrument can be inserted in the bladder. In most of such cases aspirate—which may be done several times if necessary—and in a day or two, when swelling and con-

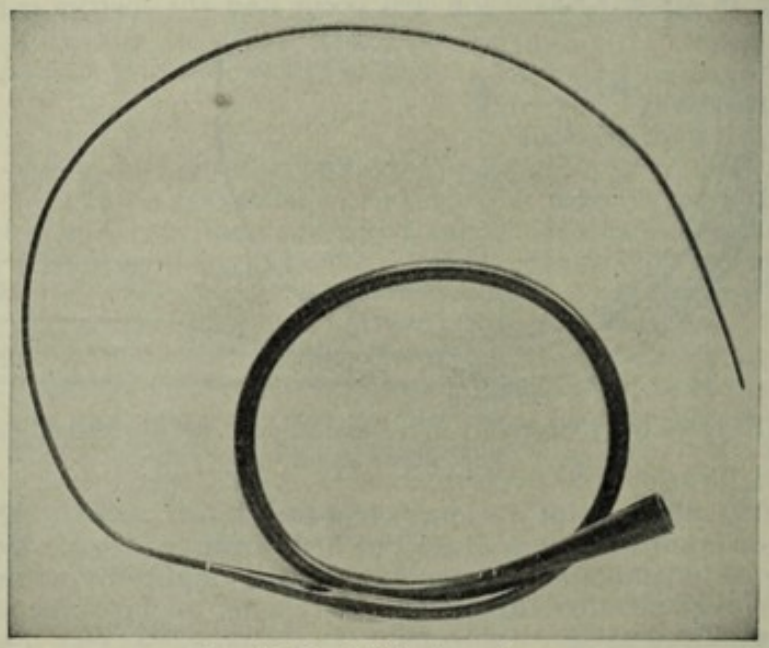


FIG. 1062.—Phillips's catheter.

gestion abate, an instrument can usually be passed. The skin is asepticized. A small aseptic trocar or aspirating needle is pushed into the bladder, the trocar or needle being inserted in the median line, just above the pubes, and taking a course downward and backward. After the completion of the operation the puncture is dressed with iodoform and collodion. Only half the urine is withdrawn at a first aspiration. Rectal

puncture is now obsolete. If incision be necessary in retention, due to stricture, the perineal route is usually chosen. In some cases the operation is done with, in some without, a guide. In prostatic retention not relievable by a catheter, make suprapubic drainage or do prostatectomy.

In *retention due to prostatic abscess* which is generally associated with an acute posturethritis the *boutonnière* or *buttonhole operation* may be used for evacuation of the abscess. Place the patient in the extreme lithotomy position; locate the abscess area by a finger in the rectum, pass a bougie if possible through the urethra, which procedure may rupture the abscess, and should it not, then enter the abscess alongside the urethra by way of the perineum, using a long straght bistoury. This is done by placing the tip of the index-finger in the rectum upon the abscess and pointing the tip of the knife at a point slightly above the finger-tip. Before withdrawing the knife pass a long slim hemostat down by its side and open it *in situ* after the method of Hilton. Insert drainage and dress with gauze and a perineal bandage.

Congenital Defects of the Bladder.—Exstrophy of the bladder (*ectopia vesicæ*) is a condition of defective development observed in one child out of 30,000 births and occurring eight times oftener in males than in females. It is a developmental defect of the bladder and urachus. The anterior abdominal wall has failed to close, the anterior wall of the bladder is absent, the arch of the pubes has not developed anteriorly, epispadias usually exists in the male, the umbilicus is at an unnaturally low level, the lower extremities are thrown outward to an unusual degree because of the broadening and flattening of the pelvis, and in many cases the testicles have not descended into the scrotum. Because of the turning outward of the femora the patient waddles (Hutchins and Hutchins in "Surg., Gynec., and Obst.," June, 1923). Inguinal hernia is not uncommon and other developmental defects may be noted. The prostate, the seminal vesicles, and the testicles are always present (Hutchins and Hutchins, Ibid.). A female with exstrophy may become pregnant, but a male cannot impregnate a woman. In this condition the posterior wall of the bladder projects into or beyond the gap in the abdominal wall; the urine constantly overflows and renders the condition of the patient dreadful. The condition shortens life by infection of the kidneys and only 30 per cent. of the victims live beyond the twentieth year, death being due usually to pyelonephritis.

The only treatment which offers hope is operation, and operation often fails. Over seventy years ago Simon transplanted the ureters into the gut, but the patient died. In 1852 Roux devised a plastic operation. "The first successful plastic operations for exstrophy were done by Ayres and Pancoast in 1858" (Hutchins and Hutchins, Ibid.). If possible, operate when the patient is about five years of age, and over rather than under five. Before operation the ureters should be catheterized and the urine from each side examined. Pyelonephritis of both sides forbids operation. Various operations have been suggested for this condition, viz.: covering with skin-flaps; implanting the ureters into the bowel (Maydl, Albert, Roux, Simon, and others); division of the posterior ligaments of the sacro-iliac joints, bringing the arch of the pubes forcibly together, the patient wearing a support until the parts become firm, when the greatly narrowed defect is closed in by integumentary flaps and by suturing the bladder edges (*Trendelenburg's operation* or *synchondroseotomy*); osteotomy through one ilium or both ilia instead of separation of the sacro-iliac joints (*Berg's operation*); or after extirpating the bladder, loosening the ureters from the bladder, drawing them down, and attaching them to the end of the penis (*Sonnenberg's operation*).

A bladder closed in by autoplasty, by Trendelenburg's operation, or by Berg's operation is never really continent, although when the patient is erect and wears a light compress he may perhaps be able to hold water two or three hours. The above methods are suited to young children and are far safer than ureteral transplantation. Tuffier maintained, over twenty years ago, that transplantation of the cut ureters into the bowel was very apt to be followed by fatal infection of the kidneys, and that the only way to prevent this was to retain the ureteral orifices which contain valves. As a matter of fact infection ascends by the lymphatics rather than by the tube, and it seems useless to retain the urethral valves (Sweet and Stewart in "Surg., Gynec., and Obst.," xviii, 1914). Ureteral transplantation may be by an intraperitoneal or by an extraperitoneal method, the latter being decidedly the safer. Maydl published his operation in 1894 ("Wien. med. Wchnschr.," 1894, xliv). Bergenhein, of Stockholm, in 1894 succeeded in an extraperitoneal implantation. Maydl implanted the trigone with the ureters into the sigmoid flexure, extirpating the rest of the bladder. I have twice performed a modified Maydl operation, with one death and one recovery.

The mortality in Maydl's operation is nearly 30 per cent. Buchanan ("Surg., Gynec., and Obst.," Feb., 1909) has collected 80 cases. In this collection there were 23 deaths (28.7 per cent.); 7 died of peritonitis and 9 of pyelonephritis. The cecum has been made a bladder and the appendix a urethra, but this cannot be done if the appendix has been removed, if it is blocked, or if the cecum is anchored by adhesions. Hutchins and Hutchins (Ibid.) report a brilliant series of operations on a case of exstrophy with epispadias. The transplantation was extraperitoneal. Among other methods we may mention that of Simon, who closed the bladder and made a fistula into the rectum; that of Diakonow, who pulled down a piece of bladder between the rectal sphincter and the mucous membrane, making a fistula; and that of Verhougen, who "divided the ascending colon and the ileum near the ileocecal valve, after which he closed the four ends and completed the intestinal canal by a union of the transverse colon and ileum. The appendix was drawn through a perforation in the abdominal wall and catheters were passed into the opening for irrigating the cecum. Later the base of the bladder with the ureter intact was united with the cecum and emptied of urine at regular intervals by means of a catheter" (Hutchins and Hutchins, Ibid.). Makkpa also employed the cecum as a bladder and the appendix as a urethra.

Lower, of Cleveland, has modified the operative technic and has had some excellent results.

Diverticula of the Bladder.—A diverticulum is a sac-like protrusion of a part of the bladder wall or of the mucous membrane alone. During recent years the cystoscope and cystograms have taught us that diverticula are much more common than we once thought. Some diverticula are congenital. These contain a muscular coat. Among congenital conditions is the hour-glass bladder and the double bladder (G. J. Thomas in "Surg., Gynec., and Obst.," Oct., 1916). An acquired diverticulum consists of mucous membrane. It may be of intra-uterine origin (due to temporary obstruction), traumatism, but most commonly to urinary obstruction. One diverticulum, several, or many may exist. The form most commonly seen is the pocketed bladder from chronic urinary obstruction. The mucous membrane of the bladder bulges out between layers of hypertrophied vesical muscle. The diagnosis of diverticulum is made by the *x*-rays and the cystoscope.

In most cases the best treatment is excision. The bladder is exposed, stripped of peritoneum, opened, the diverticulum packed with gauze, dissected free and excised and the wound in the bladder is sutured (Lower in "Jour. Amer. Med. Assoc.," 1914, lxiii). The various operations which have been performed for diverticula are set forth by G. J. Thomas (Ibid.).

Arthur H. Crosbie[1] believes all diverticula are congenital. He speaks as follows: "I personally have had an opportunity to examine histologically quite a number of diverticula and in none of them have I found the walls of the diverticulum corresponding to the walls of the true bladder." Crosbie prefers excision of the pouch and repair of the bladder mucosa.

Professor H. H. Young does excision after intravesical invagination by suction.

Always make a systematic search for a diverticulum before doing a prostatectomy. If found in conjunction with enlarged prostate it is a very unfortunate complication, and the surgeon should warn the relatives as to the danger of a fatality. The diverticulum should be operated upon first and the prostate subsequently.

Diseases and Injuries of the Bladder.—This viscus is so deeply situated, and the abdominal walls are so elastic, that it is rarely injured when empty. If the bladder be full and the abdomen tense—which is common in alcoholic intoxication—force applied to the abdomen may injure the bladder.

Contusion of the Bladder.—In this condition there are noted vesical hematuria, tenesmus, severe cystitis, and an impediment to the flow of water because of clots. Hemorrhage may be very severe and sepsis may arise, even causing death. When contusion exists retention is relieved by means of a clean soft catheter; if this fails because of occlusion of the eye of the catheter with blood-clot, at intervals there must be passed through the catheter from a fountain-syringe a solution of sodium bicarbonate in cooled boiled water. Gross's blood catheter can be used or the evacuator of Bigelow may be employed. The patient is put to bed, a hot-water bag is applied to the hypogastrium, morphin is administered in moderate doses, the bladder is washed out several times a day with boric acid solution or a solution of bicarbonate of sodium to disintegrate and remove blood-clots, and the urine is diluted and rendered aseptic by the stomach administration of salol, boric acid, and the free use of bland fluids.

[1] "The Journal of Biology," vol. vii, No. 5, May, 1922.

Hemorrhage usually ceases on relieving distention; if it does not, some more radical measure must be employed (see Hematuria).

Wounds of the Bladder.—The bladder may be injured by bullets; by stabs or punctures through the abdomen, the vagina, or the uterus; or by penetration by a fragment of a fractured pelvic bone. A gunshot wound may or may not damage bone. The greatest danger from a gunshot wound of the bladder is injury to the peritoneum. The next danger is urinary infiltration. Infection is common and may come from the wound or from bacterial urine. Bazy points out that in wounds from rifle bullets there is usually urinary retention, but in wounds from shell fragments there is a free flow of urine from the wound ("Bull. et Mem. Soc. de chir. de Paris," 1916, xlii). The symptoms of such conditions are those of rupture of the bladder (*q. v.*). The diagnosis is made by palpation, the *x*-rays, and the cystoscope. In an intraperitoneal wound at once open the abdomen, suture the wound in the bladder wall, irrigate and drain the peritoneal cavity, and drain the bladder by means of a retained catheter, perineal section, or suprapubic cystotomy. In an extraperitoneal wound drain the wound by a tube, and drain the bladder by a retained catheter, perineal section, or suprapubic opening.

Fistulæ may follow the injury. The wound itself may become fistulous or a collection of extravasated urine may break and form a fistula. The fistula may open upon the abdominal wall, the perineum, the scrotum, the buttock, the thigh, or into the intestine. The mortality of gunshot wounds is said to be 25 per cent.

Rupture of the bladder occurs in three forms: (1) intraperitoneal—a rupture involving the peritoneal coat; (2) extraperitoneal—a rupture of a portion of the bladder not covered by peritoneum; and (3) subperitoneal—a rupture of the mucous and muscular coats, the urine diffusing under the peritoneal investment. The *causes* are of two kinds, predisposing and exciting. *Predisposing causes* are: distention of the bladder; drunkenness; cystitis; ulceration; degeneration or atony of the bladder coats; prostatic enlargement, or urethral stricture. Distention of the bladder is the great predisposing cause. It causes the bladder to rise from the pelvis and so become exposed to a direct blow; it places the organ under tension, and force tends to rupture the weakest point. In about one-third of the cases collected by Bartels the individual was intoxicated at the time of the accident. Drunkenness predisposes because a drunken man is very liable to injury and is apt to have a distended bladder and a rigid belly wall. Males are much more liable to rupture than females (10 to 1). Most cases are between the ages of twenty and forty. Of Besley's 25 cases, 1 was a child of three, 1 a man of forty-nine, 3 were in the first and second decades, 5 were between twenty and thirty, 7 between thirty and forty, 6 between forty and fifty, and in 2 the age is not given (paper before Chicago Surg. Soc., Feb., 1907). The condition is very rare in children, but 1 of Besley's cases was three years of age, and King recorded the accident in a fetus with imperforate urethra.

It is amazing how readily a bladder at times can be ruptured. I have seen it done on the operating-table from distention by a stream of fluid. I have seen it from a very slight blow upon a full bladder. In young boys it may be associated with suppression of urine. I have operated upon a case three days after rupture of the bladder in which, because of suppression of urine, we decapsulated the kidneys. This case died of suppression.

Exciting causes are: obstruction to the outflow of urine (by stricture or enlarged prostate); external violence; falls upon the feet or the buttocks, as well as upon the abdomen; lifting; straining at stool, in micturition, or during parturition; and the forcing of injections into the bladder. A distended bladder may be ruptured by a concussion. The most usual cause of the injury is a crush. The mechanism of the injury is in dispute. It is certain that the bladder must have lost its elasticity by distention. When force is applied to fluid (which, of course, is incompressible) the bladder tears at its weakest point. The weakest point is not identical in all individuals. It may be weak anywhere from disease. The most common site of the tear is at the posterosuperior aspect, but it may be in front, at either side, or at the pubic or prostatic ligament (Staubenranch). The mucous membrane or the peritoneum may give way first and the tear may be anteroposterior, oblique, or longitudinal. Alexander maintains that the most usual cause of the injury is a crush which forces the distended bladder against the sacral promontory, but Besley's (Ibid.) experiments do not indicate that this is correct. A common complication, especially of extraperitoneal rupture, is fracture of the pelvis, due to the same force that ruptured the bladder.

Symptoms, Diagnosis, and Treatment.—The symptoms are not always definite,

and every characteristic one may be for a time absent, the patient seeming in some rare instances of extraperitoneal and intraperitoneal rupture to possess the power of retaining his urine and of voiding it. As a rule, however, there are found some or all of the following symptoms, following an accident or occurring during the progress of a causative disease: severe pain in the bladder and in the suprapubic region, collapse; inability to walk or great difficulty in walking; excessive desire to micturate, but inability to do so (sometimes a little pure blood or bloody water is squeezed out by painful effort); a catheter, when used, brings away pure blood or a very little bloody urine; the catheter in some cases slips through the tear into the extravesical cavity, and more bloody water comes away. In some reported cases clear water has been withdrawn. If a measured amount of boric acid solution is injected, it is improbable that all of it can be withdrawn by the catheter, although in some cases it may all come away (Alexander in "Annals of Surgery," Aug., 1901). Injecting fluid fails to lift the bladder into the hypogastric region so as to be recognizable on percussion. In a patient suffering from retention of urine in whom rupture occurs there is first a temporary sense of relief from retention, but very soon severe hypogastric pain and rectal tenesmus. In intraperitoneal rupture reaction may be obtained after a few hours or a number of hours. The evidences of peritonitis will be noted soon (rapid pulse, perhaps vomiting, rigidity, distention, obstruction of the bowel, elevated temperature, etc.). Shock in vesical rupture is so severe that death may ensue; if reaction follows, there may be delirium and after a time septicemia; extensive infiltrations of urine may occur. In *intraperitoneal rupture* general peritonitis is certain to arise, but its appearance may be postponed for several days if the urine be healthy. In these cases the extravasation is noted as a simple swelling, probably on one side only. In *extraperitoneal rupture* the urine may infiltrate the perineum, the scrotum, the thighs, and under the integuments of the abdomen and the back, and may soon induce sloughing. In *subperitoneal rupture* peritonitis is apt to arise.

In doubtful cases some surgeons pump air or hydrogen into the bladder. To insert air a bicycle pump can be used (Brown) or a Davidson syringe (Keen). Keen's directions are to insert a catheter, empty the bladder of urine, and connect to the catheter a disinfected Davidson's syringe, a mass of absorbent cotton being fastened over the distal end of the syringe. Air, after it has filtered through the cotton, is pumped into the bladder; an unruptured bladder will rise above the pubes as a pyriform tumor, tympanitic on percussion. A ruptured bladder will not so rise. In intraperitoneal rupture the air will pass into the general peritoneal cavity and abdominal distention will occur. In extraperitoneal rupture injection will produce emphysema of the extravesical connective tissue. On removing the syringe the air rushes out again if the bladder be unruptured, but little if any comes away if it be ruptured. Alexander considers gaseous distention unreliable, and claims that it adds to shock and disseminates infection. His rule is the wisest to follow; that is, in a case of suspected rupture of the bladder, make a suprapubic incision and inspect the prevesical space for signs of extraperitoneal rupture. If extraperitoneal rupture is not found, open the belly and explore. It is always a wise procedure to have an expert radiographer make a fluoroscopic examination to determine the presence of free fluid within the peritoneal cavity. A cystoscopic examination will generally reveal the rent in the bladder wall and guide the surgeon in his operative route.

Treatment.—In extraperitoneal rupture, after incision down to the bladder, insert a drainage-tube. In intraperitoneal rupture, place the patient in the Trendelenburg position, expose the tear in the bladder by abdominal incision, and suture the opening in the viscus.

Results.—Baron Larrey was the first surgeon to state that a wound through all the coats of the bladder might be followed by recovery. In intraperitoneal ruptures, if operation is not performed, the mortality is 98 per cent. If operation is performed many cases recover. Of the 78 cases collected by Dambriu and Papin in 1904, 34 died, a mortality of 43 per cent. (Besley, paper before Chicago Surg. Soc., Feb., 1907). Galactinoff ("Rovssky Vratch," Nov. 12, 1910) reports 15 cases operated upon for intraperitoneal rupture; 5 recovered (3 of them were operated upon during the first twenty-four hours; 1, after thirty-six hours, and 1, after forty-eight hours). In extraperitoneal rupture without operation there are 11 per cent. cures and with operation 30 per cent. (See Daniel N. Eisendrath, "Jour. Amer. Med. Assoc.," Oct. 25, 1902; Samuel Alexander, "Annals of Surgery," Aug., 1901.)

Atony of the bladder is a condition in which the expulsive power of the bladder is diminished or lost because of impairment of muscular tone. The bladder is very

thin, and the muscles are flaccid and often the seat of fatty degeneration. Sometimes the viscus is very large and sometimes it is very small. A slight degree of atony is physiologic after middle age.

The **causes** are senility, distention from true paralysis, chronic overdistention from obstruction, and acute overdistention. In most cases there is obstruction of the urethra. In that rare condition known as *idiopathic atony* there is no evidence of obstruction. Walker ("Annals of Surgery," Nov., 1910) reports 12 cases of idiopathic atony. He says the patients were between the ages of twenty-two and forty. He regards the condition as due to a lesion in the reflex centers.

In all cases of atonic bladder the luetic history should be gone into very carefully for some of them are undoubtedly mistaken for syphilitics. Always make a spinal fluid Wassermann test to be sure to differentiate between true atonic bladder and syphilitic paralysis.

Symptoms.—In atony of the bladder the patient passes water frequently (a symptom probably existing for some years), and especially at night; he may even do so while asleep. The stream, when voluntarily passed, has little projection, but seems to drop at once from the end of the penis. Residual urine exists for years and may at any time set up cystitis, and retention with incontinence is apt to occur. This condition is *not* vesical paralysis resulting from a lesion of the nervous system.

Treatment.—In treating atony of the bladder measure the residual urine: if it amounts to 4 oz., use a soft catheter night and morning; if it amounts to 6 oz., use the catheter every eight hours; if it amounts to 8 oz., use the catheter every six hours (J. W. White). The patient should be taught how to use the catheter and how to keep it sterile. (For Methods of Disinfecting Catheters see article on page 1309.) The bladder is from time to time washed out with 3 gr. to the ounce of boric acid solution at a temperature of 100° F. Strychnin, electricity, ergot, and hexamethylenamin may be ordered.

True Paralysis of the Bladder.—Vesical paralysis results from a lesion of the nervous system causing paralysis of the motor nerves or of the motor paths of which they are prolongations (fracture of the vertebræ, spinal meningitis, syphilis of the cord, myelitis, and hemorrhage about or into the spinal cord). A traumatic paralysis comes on suddenly. Hysteria may be responsible for temporary palsy. If the detrusor muscles alone are palsied there is complete retention of urine. If the sphincter is paralyzed the urine dribbles constantly. Even when there is dribbling a quantity of urine is retained below the level of the internal meatus. In such a case there is incontinence with partial retention (the *overflow of retention* of Sir Henry Thompson). If the patient sits down or assumes the knee-chest position, he may empty the bladder by contracting the abdominal muscles. In cases of real retention the detrusors may be temporarily paralyzed. In such a case the sphincter may finally relax from fluid pressure, and atmospheric pressure or contraction of abdominal muscles may cause urine to dribble, the bladder remaining full (the *incontinence of retention* of the elder Gross). In some cases of vesical paralysis there is retention; in some cases, incontinence of urine. If the sensory as well as the motor path be involved in a lesion, the patient has no sensation to notify him of dribbling or of retention.

Treatment.—Treat the cause. Employ regular aseptic catheterization by a soft instrument. In some cases the bladder may be subjected to faradism (one electrode in the bladder and one on the perineum or on the abdomen above the pubes). Kilvington ("Brit. Med. Jour.," 1907, vol. i) pointed out that the nerve-supply of the bladder and rectum is from the second and third and sometimes also from the first sacral nerves. He suggested treating some otherwise incurable cases of vesical paralysis by anastomosing a nerve root above the lesion to certain sacral nerves below the lesion. Bird did the first operation, but it failed. Frazier for Mills (see page 831) performed intradural anastomosis of the last lumbar nerve to the third and fourth sacral nerves. The patient was much benefited ("Jour. Amer. Med. Assoc.," Dec. 21, 1912).

Foreign Bodies in the Bladder.—The term "foreign body" is, at best, a poor one, since a stone is a foreign body. The term, however, is generally used to designate material held within the viscus and of purely extraneous origin. A great variety of foreign bodies have been removed from both the male and female urinary bladder. We have seen a lead-pencil, hair-pins, a willow twig, a glass rod, and a piece of chewing gum removed. Stellwagen removed an open safety-pin. Lippincott removed a nut-pick. Corwitz and Lowa removed chewing gum, as well as portions of catheters and filiform bougies. For reports of foreign bodies found in the bladder the reader is referred to text-books upon genito-urinary diseases.

Most of the foreign bodies are found in the bladders of masturbators. In them the glans penis or the clitoris has become so inured to friction that they must seek deeper for sensation, consequently men resort to titillation of the verumontanum and posturethra, and women, to irritation of the vesical neck. The object used to stir sensation may slip from the grasp and pass backward into the bladder. The careless introduction of a filiform bougie is a real danger. Always test the filiform for defects and for tensile strength before using it. If you use the Gouley catheter, see that the tip through which the filiform must lace is not sharp or square, else it may shear off a portion of the bougie. All foreign bodies sooner or later induce cystitis. Every foreign body, if allowed to remain, will become encrusted with urinary salts and constitute a nucleus for stone formation.

Diagnosis, Symptoms, and Treatment.—*Diagnosis* is made by the history, if given correctly, of the case. The stone-searcher, the *x*-ray, and the cystoscope are most useful in diagnosis. The *symptoms* are similar to those of stone in the bladder. The *treatment* is removal, with subsequent care of the resultant cystitis.

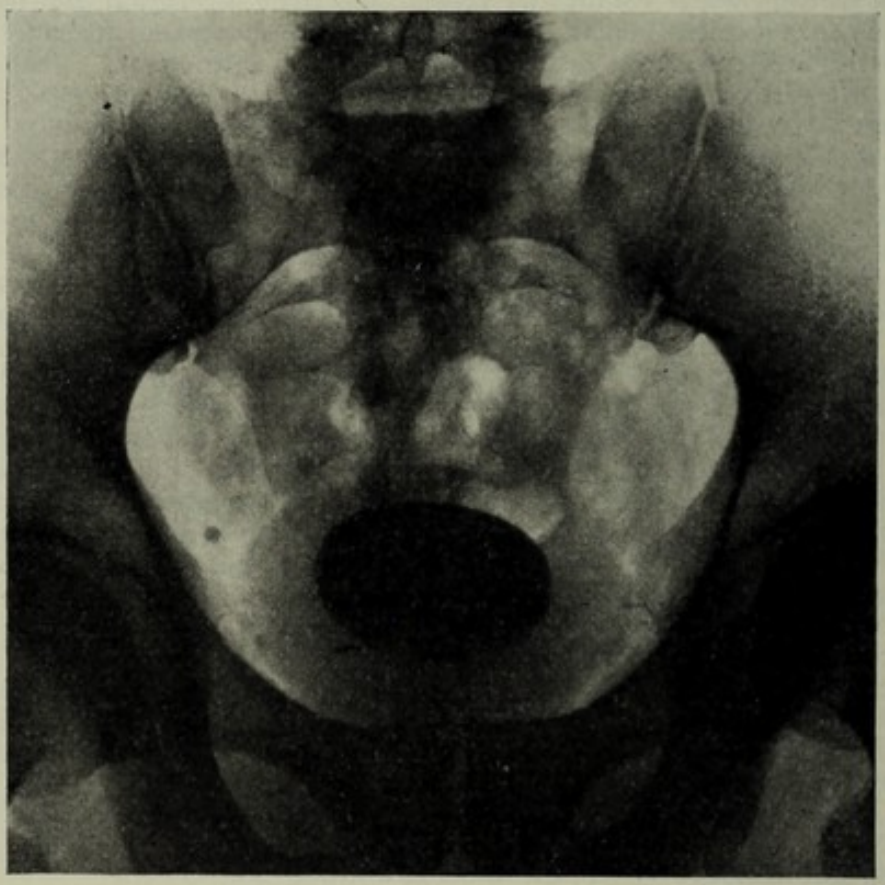


FIG. 1063.—Stone in the bladder.

Vesical Calculus, or Stone in the Bladder.—The salts normally in solution in the urine may become deposited as calculi and may be imprisoned in any portion of the urinary tract. The commonest primary calculi are those composed of uric acid, urates, calcium oxalate, or fusible phosphates. In 80 per cent. of cases primary calculi are composed of uric acid and urates. A primary calculus may become coated with another material (secondary calculus). The formation of uric acid and urate calculi is explained under Renal Calculus (see page 1280). Vesical calculi are usually renal calculi that have passed through the ureter and become enlarged by new accretions. New accretions from an alkaline urine will cause the formation of a secondary phosphatic stone. Phosphatic calculi may be formed in the bladder when chronic cystitis causes and maintains an alkaline urine. Uric-acid calculi are smooth, round or oval, and hard, but easily broken. On section they present the color of brick-dust and are marked by concentric rings. Their nuclei are dark by comparison. They are soluble in dilute potassium hydrate and in nitric acid. They are combustible and leave scarcely any ash. Urate of sodium and urate of ammonium often occur together in stones, and these calculi are not in rings, are not so hard as the uric-acid stones, and are fawn colored on section. Oxalate of lime stones are round, with many

projecting nodes like the mulberry, hence the term "*mulberry calculus*." They are very hard, and section shows the color to be brown or green, and that they possess wavy, concentric rings. This form of calculus is soluble in hydrochloric acid. The so-called fusible calculus of the early writers, which is composed of a phosphate of magnesium, ammonium, and calcium (*triple phosphate*), constitutes the commonest form of phosphatic stone and of large stone. It is light, soft, smooth and white, and shows no laminæ on section. Some rare forms of primary stone are composed of xanthin, cystin, indigo, urostealith, calcium phosphate or calcium carbonate, or blood concretions.

A stone having layers of different substances may be formed; for instance, there is often found a uric-acid center surrounded by phosphates, the latter surrounded by some uric acid or urates, and these again by phosphates. In some cases oxalate of lime alternates with uric acid, urates, or phosphates (Bowlby). Bowlby states that the alternating uric-acid and phosphatic layers are due to the altering reactions of the urine; that when the urine is acid uric acid is deposited on the stone, but when cystitis makes the urine alkaline the stone receives a phosphatic coat.

Anything that favors the formation of an excessive urinary deposit may cause vesical calculus, and among such causes are defective digestion, failure in processes of oxidation, excess of solids and nitrogenous elements in the diet, deficient exercise, etc. If to the urinary condition established by the above factors catarrh of the genito-urinary tract is added, pus or mucopus in the concentrated urine may induce stone. Urinary calculi are more common in children and infants than is generally supposed and often the condition is unrecognized. Thomas and Tanner ("Minn. Med. Jour.," March, 1922) collected 203 cases and 40 of them were under five years of age. Children are predisposed to uric-acid stones, and old people to phosphatic stones. In an old man with enlarged prostate and chronic cystitis a stone forms rapidly about any accidental nucleus. The nucleus may be phosphate crystals glued together by mucus, a blood-clot, uric-acid gravel, or a foreign body. Stone is rare in females because of the shortness, the large diameter, and the ready dilatability of the urethra. Stone is very rare in the negro. Gout, rheumatism, lithemia, enlarged prostate, vesical atony, urethral stricture, and catarrhal inflammation of the kidney, the ureter, and the bladder are predisposing causes.

Symptoms.—In not a few cases the vesical symptoms are antedated by an attack of nephritic colic. Hence the necessity for cystoscopy after renal colic if no stone has passed from the meatus, and the removal of any retained stone by the evacuator or the cystoscope and catcher. The severity of the symptoms of stone in the bladder depends more on the roughness of the stone than on its size. A small, rough calculus will produce intolerable anguish, whereas several large, smooth stones will cause but moderate pain. A patient with stone in the bladder complains of frequency of micturition, particularly in the daytime, the desire being sudden, uncontrollable, and invoked or aggravated by exercise. This symptom is more positive in youth than in old age. Pain of a sharp, burning character is experienced at the end of micturition due to the contraction of the empty bladder upon the stone or stones. It disappears gradually as urine enters and distends the bladder. The usual seat of this pain is the under surface of the head of the penis, a little behind the meatus, and the pain may continue for some time. By pulling on the penis to relieve this pain the prepuce of a child may become pendulous. The pain varies in severity, being much worse during an attack of cystitis and after exercise; it may be absent in encysted stone; it may be present early in a case, but almost disappear as a case progresses, and it is always worse in the young than in the old. Stone in chronic cases of atony and in cases of vesical paralysis causes neither marked pain nor frequency of micturition.[1] In a case of enlarged prostate pain *precedes* the act of micturition, in urethral stricture it *accompanies* it, and in stone, as already stated, it *follows* it (P. J. Freyer in "The Practitioner," Feb., 1898). The symptoms may be somewhat confused by the co-existence of vesical calculus and prostatic hypertrophy. Attacks of cystitis in a man with calculus are spoken of as *attacks of stone*. When a stone is small, it may during micturition roll into the urethral orifice, and so cause a sudden interruption of the flow of urine, the stream again starting when the patient changes his position. This symptom is seldom met with and is particularly rare in the old, the stone in them dropping into the sac back of the prostate and *below* the urethral orifice. Even if this symptom occurs, it is not conclusive, as a stalked tumor, a blood-clot, or a mass of pus or mucus may block the urethral orifice and cut off the stream. Hematuria may

[1] "American Text-book of Surgery."

or may not be noted; it is most usual after exercise, and occurs at the end of the urinary act, the first urine passed being clear, the later urine being blood-tinged, and at the end of the act some drops of pure blood emerging. It is not one of the earliest symptoms. When it occurs it puts the patient in a great fright. It does not appear suddenly and profusely, but as gradual and trivial bleeding and with micturition. Blood appearing between acts of micturition comes from either the urethra or prostate (P. J. Freyer). The bleeding from a bladder tumor is profuse and the urine is mixed with blood and blood-clots and tumor fragments. Bleeding from a tuberculous ulcer of the bladder often resembles the bleeding caused by stone. Pus or mucopus will be observed if cystitis occurs with calculus disease. Priapism occurs in some cases. Pain of a reflex nature may be felt in the rectum, in the perineum, or in some distant part.

The above symptoms, even if all be present, do not prove that an individual has a stone in the bladder. To prove the presence of a stone the object must be pictured by the *x*-rays, seen through a cystoscope, or be touched by a sound. Simple touching by a sound is not sufficient, the contact must be felt and heard. To sound a patient, have the bladder well filled with boric acid solution or salt solution, and place him recumbent, with the knees drawn up. Never sound a person while he is standing because of the danger of syncope. In an ordinary case in a male use a sound with a very slight curve (Fig. 1064); in a man with hypertrophied prostate use a sound with a short and decided curve. The caliber of a stone-sound is No. 13 of the French scale. The instrument is carefully boiled and anointed with lubricant. Examine the entire bladder systematically, and don't be sure a stone is present until contact with the sound is both heard and felt. The stone may be difficult to find, or it may elude the instrument entirely when it is encysted, when it rests in a diverticulum, when it is fixed to the roof or anterior wall of the viscus, or when it is crusted with lymph or blood-clot. In doubtful cases always insist on a second examination, giving ether if the first has been very painful. Occasionally, as Freyer pointed out in 1884, a small



FIG. 1064.—Thompson's calculus sound.

stone will be found by using a Bigelow evacuator, the current causing the calculus to knock against the tube. In many cases stone in the bladder may be detected by means of the *x*-rays (see Fig. 1063). Use the cystoscope in all cases of suspected stone. If a stone is fixed in a diverticulum or projects from the ureter, or is in a sac back of the prostate, it may be missed by sound and evacuator tube, but be shown by the *x*-rays and the cystoscope. I have seen 14 stones removed from a bladder that were not shown by *x*-rays. The study was made by a highly efficient man. These stones were uric acid and hence did not show. The outer layer of a calculus may be soft phosphate and the inner portion may be the harder uric acid, urate, or oxalate.

Stone in Females.—Calculus in the female is a rare complaint. In over 900 patients operated upon by Freyer for stone there were only 20 females. Pain and increased frequency of micturition, which are symptoms of stone in men and women, are in women so commonly caused by other conditions, notably by uterine disease, that the symptoms lack significance. A straight sound is used to examine a female for stone. If the surgeon is still uncertain after sounding, he uses a cystoscope or dilates the urethra and explores the bladder with his little finger.

Stone in children can occur at any age, and congenital cases have been placed on record. The uric-acid stone is most common. The symptoms are like those of the adult. The pain causes the male child to pull at the penis and the prepuce becomes pendulous. If in a child with stone the stream of urine may be blocked from time to time, the child strains to empty the bladder, and after a time a hernia may form or prolapse of the rectum take place.

Treatment.—In people predisposed to stone (for instance, by lithemia) the physician should foresee the danger and antagonize it. Insist on the urine being kept dilute by the freest use of distilled water and of milk, and reduce to a minimum the amount of alcohol, meat, sugar, and fat which is taken. Let the patient live chiefly on green vegetables, salads, bread, fruit, eggs, fish, poultry, weak tea or coffee, sterile water, milk, and, if desired, a little red wine. Continued purging does harm by con-

centrating the urine, though a laxative may be employed when indicated. Moderate open-air exercise is of immense importance, sunshine and fresh air being nature's correctives for a condition of imperfect oxidation power. If the urine be very acid order quantities of distilled water and give liquor potassii citratis, phosphate of sodium, or borocitrate of magnesium. If the urine be phosphatic and alkaline, order mineral acids and strychnin, or, what seems to be very efficient, hexamethylenamin. Hexamethylenamin is given in 5-gr. capsules four times daily. If the urine be filled with oxalate, use the mineral acids with an occasional course of phosphate of sodium. Travel and rest at the seaside or at some spa are often of service in all forms of calculous disease. Always endeavor to prevent cystitis, and treat it promptly when it does occur. When a stone is once formed it is an idle dream to think of dissolving it. An operation must be done. Some very small stones may be crushed while in view through the cystoscope by one of the several intravesical forceps, or removed by means of Young's grasping cystoscope, but in an immense majority of cases a very much more formidable operation is required. The operation selected depends upon the age, the state of the bladder and the prostate, the dilatability of the urethra, the kidney condition, the size and composition of the stone, and the number of calculi present (see Operations on the Bladder).

Bacteriuria or Bacilluria (see page 1284 *et seq.*).—Most urines contain bacteria which soon die. If the bacteria live and multiply the condition is called bacteriuria. When there is bacteremia, bacilli frequently enter the urine. Bacteremia is a common cause of bacteriuria. If bacilli are present in numbers the condition is called *bacilluria*. The variety and number vary greatly in different individuals. In typhoid fever typhoid bacilli may be found. In many cases of nephritis bacteria are present. In pulmonary tuberculosis, vesical tuberculosis, and renal tuberculosis bacilli may be found in the urine. In some cases numerous colon bacilli are found. They may seem to do no harm; they may cause nephritis; they may cause cystitis.

If a urine contains bacteria, inflammation of the genito-urinary tract may or may not exist, but even if it does not exist it is apt to occur at any time. In some persons the urine is found swarming with colon bacilli. Colon bacilli are capable of causing a very severe type of cystitis and nephritis. Bacterial urine explains many cases of urinary fever (see page 1356) Bacilluria is generally due to one of the several forms of colon bacillus or its congeners. It is most commonly seen in women, is often present in female children, may pass into a state of quiescence until marriage, when it may light up, producing what is termed a deflorization pyelitis. An autogenous vaccine will often do good, or lavage of the kidney pelvis with a ½ per cent. solution of silver nitrate. Constipation should be corrected and the administration of Bacillus acidolphus is perhaps beneficial. A primary focus of infection should always be sought for in the tonsils, bones, teeth, prostate, etc. In many cases a strepto- or staphylococcus is the underlying cause, and some observers, notably Rosenow, believe that the presence of the colon bacillus is secondary to the really potent germ. The intravenous injection of small doses of neo-arsphenamin will often benefit these cases; give four to six doses, beginning with a small dose, and gradually increasing it.

Bacteriuria and pyelitis are so intimately associated that I have interlarded in this paragraph remarks on the two subjects.

Cystitis.—Inflammation of the bladder is, as a rule, a complication of some other disease of the genito-urinary tract, but it may arise after exposure to cold and wet. Traumatism from a catheter, the presence of a stone, the spread of a urethral inflammation, pus infection, vesical tuberculosis or cancer, and the use of such drugs as cantharides, turpentine, alcohol, hexamethylenamin, and sandalwood oil in large doses may produce it. It appears not unusually during an exanthematous fever or in conditions of vesical paralysis; it often follows retention; frequently accompanies enlarged prostate and urethral stricture, and sometimes arises from concentration of urine or accompanies bladder growths. Acute cystitis causes discoloration and swelling of the bladder walls, and there is present a catarrhal discharge which is mixed with urinary elements, serum, mucus, often pus, and epithelial débris. Ulceration, sloughing, or false-membrane formation may occur. Chronic cystitis is an inflammatory condition always due to bacteria. We frequently speak of a chronic cystitis as due to stone in the bladder, hypertrophy of the prostate gland, or tumor of the bladder. These conditions do not cause chronic cystitis, but act by rendering the bladder vulnerable to micro-organisms. Among the causative organisms we may mention the Bacillus coli communis, the gonococcus, the B. tuberculosis, the B. typhosus, the Urobacillus liquefaciens septicus, and the various pyogenic bacteria (Leonard Freeman). The

Bacillus aërogenes lactis has been found (Luetscher in "Jour. Clinical Research," 1914, vii, i). These bacteria may gain entrance on instruments or by way of the ureter, urethra, the lymph-vessels, or the blood.

In chronic cystitis there is an enormous production of thick, sticky mucus and the urine becomes alkaline. The excessive secretion of mucus and the great number of bacteria convert the urea into carbonate of ammonium, and this product, being irritant to the bladder walls, makes the inflammation worse. In chronic cystitis the bladder is contracted and has very thick walls, and the mucous membrane is thick, edematous, congested, and filled with large veins. The bladder may be ulcerated or encrusted with urinary salts. The urine contains bacteria, triple phosphate, pus, blood, and mucus, the blood emerging with the last drops of urine. Pyelitis may arise as a result of chronic cystitis.

What was formerly called inflammation of the neck of the bladder is an inflammation of the vesical trigone and of the posterior urethra. It is now usually called *urethrocystitis* or *trigonitis*.

Symptoms of Acute Cystitis.—Great frequency of micturition, with the passage, at each act, of a very small quantity of urine; the desire to urinate is almost constant, and there is intensely painful straining (*tenesmus*). The pain is acute and scalding, and may be felt in the head of the penis, above the pubes, or in the perineum; it often runs into the loins and the thighs and radiates over the sacrum. Pain above the pubes indicates involvement of the fundus, and pain in the perineum and in the head of the penis points to inflammation of the bladder trigone. The urine, at first clear, loses its transparency, becomes full of thick mucus, and often contains a little blood or pus. The patient not unusually has some fever. A rectal examination causes violent pain. If retention arises, there will probably be a chill and high fever, and anuria may occur. The above symptoms are commonly due to trigonitis that becomes aggravated.

Treatment.—In treating acute cystitis endeavor to remove the cause. By allaying an irritation or removing an obstruction the bladder will often become able to empty itself of retained urine, which causes congestion of the bladder and thus renders infection probable, or the urine itself may be filled with bacteria. If cystitis arises after the administration of cantharides, put the patient in bed and give him liquor potassii citratis. If it arises after the use of a clean sound, order rest in bed, suppositories of opium and belladonna, diluent drinks, and ammonii benzoas or lupulin. If the inflammation is septic (as from the use of a dirty sound) or is very acute, put the patient in bed, keep him warm, and use a hot sand-bag to the perineum and hot fomentations or poultices to the hypogastrium. Hexamethylenamin is a valuable prophylactic if the urethra or bladder is to be subjected to instrumentation. Hot hip-baths may be used for cystitis. The hips should be elevated, and the bowels should be emptied by the administration of salines and by glycerin enemata. An exclusive milk-diet is desirable. The patient should drink copiously of sweetened water containing a few drops of aromatic sulphuric acid or of milk of almonds. We may sterilize the urine, if it be alkaline, by acidulating with acid sodium phosphate or benzoic acid and then administering hexamethylenamin in fairly large doses. Other remedies which may be of service in sterilizing the urine are quinin, boric acid, salol, borocitrate of magnesium, and salicylate of sodium. A valuable remedy consists of 15 gr. of salicylate of sodium and 15 gr. of benzoic acid, given three times a day in a little chloroform water. Paregoric is a useful drug. If the pain and straining still continue, order—

℞. Ext. hyoscyami..... gr. viij;
Ext. cannabis indicæ..... gr. viij;
Sacchar. alba..... gr. xlviij.—M.
Div. in pulv. No. xxiv.
Sig.—One powder every four hours.

Or,

℞. Camphoræ..... gr. viij;
Ext. cannabis indicæ..... gr. viij;
Sacchar. alba..... gr. xlviij.—M.
Div. in pulv. No. xx.
Sig.—One powder every three hours. (Von Zeissl.)

The two most active agents in acidifying alkaline urine are the acid phosphate of sodium and the benzoate of ammonium. Boric acid not only acidifies urine, but it is also antiseptic. Suppositories of extract of belladonna are of great value. Sup-

positories each of which contains 1 gr. of ichthyol are of service, and one may be used every four hours. Opium, unfortunately, constipates; when it is given, secure evacuations by the use of glycerin suppositories, by the administration of saline cathartics, or by the employment of enemata. If opium is necessary, it is given in suppositories each containing 1 gr. of powdered opium and $\frac{1}{6}$ gr. of the extract of belladonna and given every three or four hours. Hypodermic injections of morphin may be required. Wash the bladder out daily with warm normal salt solution or warm boric acid solution. This can be done through a soft catheter or, better, by hydrostatic pressure. If retention occurs, use a soft catheter. If much blood is passed, give internally the tinctura ferri chloridi and blister the perineum. In acute *urethrocystitis* (*trigonitis*) the instillation of solutions of nitrate of silver (5 to 10 gr. to the ounce) may do good. A very acute cystitis is rarely arrested within a week or ten days. In very severe cases relief may be obtained by injecting through a soft catheter some bland warm sterile olive oil. This prevents irritation by friction.

Symptoms of Chronic Cystitis.—This condition may be a legacy from acute cystitis or it may appear without any acute precursory phenomena. There will be found frequency of micturition, but not so great as in the acute form. There will be slight tenesmus and moderate pain from time to time, usually radiating toward the head of the penis. Constitutional symptoms may arise when kidney damage has become pronounced or sepsis has occurred from absorption. The urine is ammoniacal, fetid, and turbid; it is filled with viscid, tenacious mucus or with mucopus; it contains a great excess of phosphates, and occasionally clots of blood. The condition of chronic cystitis with the production of immense quantities of thick mucus is often called *chronic catarrh of the bladder*. Chronic cystitis may eventuate in the formation of stone or in the production of serious disease of the bladder, the ureters, and the kidneys. It is very apt to cause retention of urine.

Chronic Tuberculous Cystitis.—Chronic cystitis may be due to tuberculosis. Primary vesical tuberculosis is very uncommon. When it does occur it will often be found that it has been preceded by gonorrheal infection of the bladder. Most cases of vesical tuberculosis are secondary to renal tuberculosis or to tuberculosis of the prostate, seminal vesicles, or epididymis. Tuberculous epididymitis is an extremely dangerous condition often leading to miliary tuberculosis. It should be radically dealt with by epididymectomy when feasible. The patient should subsequently be closely watched for further manifestations of the disease. Some cases come on rapidly, many tubercle bacilli may be found in the urine. Other cases come on more gradually, and in them the urine may contain few tubercle bacilli. In many such cases no tubercle bacilli are found. The tuberculous products caseate and ulcers form or fibrous organization takes place. A cystitis for which no cause can be found, and which is accompanied by pyuria and severe and lasting pain, is possibly tuberculous. Pyuria is usually present, but in some cases the urine is perfectly clear. In some cases the patient has painful paroxysms of varying duration and feels well between the attacks. Finding tuberculosis of the kidney, prostate, seminal vesicle, or epididymis, increases the probability that tuberculous cystitis exists. The diagnosis is made by the cystoscope. Tuberculous ulceration is most common in the trigone and about the inner orifice of the urethra. A tuberculous ulcer is small. The adjacent membrane is not inflamed, but contains grayish-white nodules (Louis E. Schmidt, "Jour. Amer. Med. Assoc.," July 19, 1902).

Treatment of Chronic Cystitis.—In treating chronic cystitis remove the cause, if possible (get rid of a stone; evacuate at rather frequent intervals residual urine; dilate a stricture; and remove a tumor). For chronic cystitis certain remedies are taken by the mouth. Water is drunk in large amounts, also iron spring-water (Marienbad, etc.). Diuretics which make the urine alkaline must not be given in association with hexamethylenamin. Free diuresis by such waters is often valuable, but we must choose between diuresis so obtained and hexamethylenamin (J. W. T. Walker, Abstract in "Surg., Gynec., and Obst.," from "Clin. Jour.," 1915, xliv). Salol and boric acid, 5 gr. of each four times a day, are very valuable in certain cases. Salol in fluidextract of triticum repens may do good; so may chlorate of potassium, 10 gr. daily. Either borocitrate of magnesium, quinin, or salicylate of sodium with benzoic acid may often be used with benefit. A valuable combination to correct alkalinity and to exercise an antiseptic action consists of benzoate of ammonium and boric acid, 15 grains of each, given several times a day. Alum, tannic acid, uva ursi, copaiba, cubebs, buchu, and turpentine have all been recommended, and possibly may be of some benefit. Hexamethylenamin may prevent the development of bacteria in the urine

(Nicolaier) and it antagonizes the tendency to sepsis and urinary poisoning. It is given in 5- to 20-gr. capsules, from 3 to 4 being given daily in combination with acid sodium phosphate. Alkaline diuretics must not be given if hexamethylenamin is administered. Colon bacillus cystitis is treated by giving sodium benzoate and hexamethylenamin internally. In obstinate cases an autogenous vaccine should be made and given. In cases of chronic cystitis (even the tuberculous form) Stellwagen has had promising results from the following capsule: 3 min. of creosote, 6 min. of oil of sandalwood, 1 min. of oil of cinnamon, 1 gr. of pepsin. One capsule after each meal. Whatever remedy is used, see that the bowels move once a day and that the skin is active. Champagne and beer must be avoided. If residual urine gathers, a soft catheter must be regularly employed. If it is possible to introduce a catheter of considerable size, catheterization may be all that is needed in the case. In some cases of chronic cystitis the retention of a catheter from three to five weeks is of the greatest service. If the case is very severe, the bladder must be washed out daily with nitrate of silver (1 : 8000), boric acid (5 to 10 per cent.), carbolic acid (1 : 500), corrosive sublimate (from 1 : 20,000 to 1 : 5000), or permanganate of potassium (1 : 4000). If nitrate of silver or permanganate of potassium be used, first rinse out the bladder with distilled water. If any other agent be used, first wash out the bladder with either boiled water or normal salt solution. The daily injection of a 2 per cent. solution of ichthyol may prove useful. Collin uses a 1 per cent. solution of guaiacol carbonate in sterile olive oil. Some surgeons occasionally employ, at intervals of a number of days, strong silver solutions (30 or 40 gr. to the ounce). If a strong solution be used, after the drug flows away wash out the bladder with a solution of common salt. The bladder is usually washed out by attaching to the free end of a soft catheter, the other end of which is in the bladder, a tube which is connected with a graduated bottle, the force being obtained by elevating the reservoir (*fountain irrigation*). The bladder can be irrigated without using a catheter, the resistance of the compressor muscle of the urethra being overcome by the pressure of a column of water. The reservoir is raised to the height of 6 feet. The patient sits in a chair with the buttocks beyond the edge of the chair and the Valentine nozzle or one equally well suited is used to fill the bladder by hydrostatic pressure. The tip is inserted into the urethra, the clamp on the tube is loosened, and the patient is directed to take a deep inspiration. In a short time the bladder fills with water, the tube is removed, and the patient empties the viscus naturally. In some cases it is necessary to wait quite a while for the column of water to tire out the muscle. If the fluid will not enter, direct the patient to make efforts as in micturating, the pressure of the fluid on the anterior surface of the cut-off muscles being kept up. If this fails, direct him to urinate, and then the surgeon makes another attempt to get the fluid to enter. After a little practice a patient learns how to admit the fluid. The general belief today is that cystitis without very definite cause is rare. Always search for some obstructing medium.

Chronic trigonitis is treated by anesthetizing the bladder locally twice a week (by means of novocain) and by instilling from 30 to 60 minims of a 2 per cent. solution of nitrate of silver. Direct applications of a 5 per cent. solution can be made through a Kelly cystoscope. If a cyst forms it should be punctured. If the papillæ hypertrophy they should be curetted. In the male these procedures are carried out through an operating cystoscope; in the female through a Kelly tube (H. W. E. Walker in "Med. Record," 1916, lxxxix).

If the cystoscope discloses tuberculosis of the bladder and there is known to be tuberculosis of one kidney, cure of the bladder is impossible without preliminary nephrectomy. Collin advises the instillation of 30 min. of the following mixture into the bladder and posterior urethra: 5 gm. of guaiacol, 1 gm. of iodoform, 100 gm. of sterile olive oil. About 30 min. of this are injected once a day. Rovsing, of Copenhagen (Meeting of French Urologic Assoc. of 1910), uses, in tuberculosis of the bladder, a fresh solution of carbolic acid (3 to 6 per cent.). He injects from 25 to 50 c.c. through a catheter, allows it to remain in the viscus for two or three minutes, lets it run out, and repeats this procedure until the fluid emerges clear. This treatment is carried out at first every other day. When, on the intervening day, the urine remains clear the interval between treatments is lengthened. Rovsing claims to have cured 28 cases in from four to six weeks. During treatment he makes a cystoscopic examination every other week to determine the progress of the case. The injections are usually very painful and would be intolerable without a preliminary injection of a local anesthetic (25 c.c. of a 1 per cent. solution of eucain). Sometimes, in tuberculous ulcera-

tion of the bladder, curetting through a cystoscope is useful. In other cases the bladder must be opened, the ulcer curetted, and the viscus drained. We believe primary tuberculous cystitis is very rare, in fact, probably never seen. One must accept reports of cures of tuberculous cystitis with some doubt. Most patients have periods of relief followed by exacerbations, and my feeling is that many so-called cures by local treatment are either instances of undue optimism or are merely temporary affairs.

In genito-urinary tuberculosis a change of climate, for instance, to Southern California, is, after all, the best treatment. Heroic methods of treatment are often harmful and should be entered upon only after careful consideration.

In cystitis, and in *incrusted cystitis* particularly, injections of lactic bacillus or acidophilous cultures are very useful. We owe this knowledge to David Newman of Glasgow ("Lancet," Aug. 14, 1915). In this condition bacteria destroy the mucous membrane, phosphates are deposited, and the urine is very bloody and ammoniacal. The injections are made after the establishment of suprapubic drainage. Newman prepares the agent as follows ("Lancet," Ibid.): Dissolve 1 part of sugar of milk in 40 parts of sterile water, boil it for ten minutes, allow it to cool, add one tube of Oppenheimer's lactogen to 20 ounces of the solution, keep it under sterile conditions at a temperature of 70° F. for ninety-six hours, shaking occasionally. Before using the solution of bacilli wash out the bladder with a solution of permanganate of potash, beginning with a strength of 0.025 per cent. and gradually increasing to 0.1 per cent. If there is a great quantity of mucus present, first wash the bladder with a solution of potassium hydrate (1 oz. to a pint) then with sterile water until the fluid is neutral, then with the solution of bacilli.

The lactic bacilli destroy pyogenic organisms.

If the ordinary methods of treatment fail to cure chronic cystitis; if the bladder resents catheterization and irrigation; if in spite of irrigation the urine does not become clear; and if there are evidences of infection of the patient and breaking down of his general health, drain by perineal or suprapubic cystotostomy, and through the incision wash the bladder frequently and thoroughly. If a persistent cystitis is due to stricture which dilatation fails to cure, perform external perineal urethrotomy and employ perineal drainage.

Ulcer of the bladder may be due to injury, cystitis, tuberculosis, malignant tumor, or gonorrhea. A form of ulceration particularly common in anemic women is a solitary, punched-out ulcer (Louis E. Schmidt, "Jour. Amer. Med. Assoc.," July 19, 1902). Ulcers may be single or multiple. Some are non-indurated and superficial. Some are indurated and deep. Chronic ulcers are nearly always within the area of the trigone. Perforation may occur.

A perforation may occur into the peritoneal cavity or into the perivesical cellular tissue. In the former case, after the onset of marked hematuria, there are shock, abdominal pain, and peritonitis. In the latter case there is extravasation of urine or abscess formation.

Tuberculous ulcer is discussed on page 1323.

Schmidt (Ibid.) points out that gonorrheal ulceration is apt to be multiple, and causes severe pain and bloody, turbid urine. As a rule, when the bladder is ulcerated, the urine contains blood, blood-clots, or tissue débris, but the urine may be clear when there is a tuberculous ulcer or solitary ulcer.

Diagnosis is usually made by the cystoscope. In some cases it is made by exploratory suprapubic incision.

Treatment.—If there is one ulcer, or if there are a few ulcers, curet or excise with cutting forceps, through an operating cystoscope (Buerger), use irrigations, and keep the urine aseptic. In wide-spread ulceration perform suprapubic cystotostomy, curet the diseased mucous membrane, and insert a drainage-tube into the bladder. In some cases of malignant growth the cautery is used as a palliative measure. Perforation is treated as is rupture of the bladder (see page 1315).

Tumors of the Bladder.—These growths are usually said to be very rare, but in Guyon's statistics they are found to constitute 3.9 per cent. of all cases of genito-urinary disease. They are almost five times as common in males as in females. They are most frequently met with between the ages of fifty and sixty, although myxoma is met with in childhood only and sarcoma is most common in the young (Lincoln Davis in "Annals of Surgery," April, 1906). Persistent vesical irritation may, perhaps, be an element in causing tumor. Tumors of the bladder may be either innocent or malignant, the latter being the commonest. Innocent tumors which may arise from the bladder are papillomata or villous tumors, adenomata, mucous polypi (myx-

omata), fibrous polypi, myomata, and angiomata. A myoma may attain a great size (even that of a child's head). The common form is intravesical. There is an interstitial form and a peripheral form. Papilloma is far and away the most common form of innocent tumor. Cysts may also arise. Malignant tumors are sarcoma (comparatively rare) and carcinoma (encephaloid, rare; epithelioma, common). Munwes ("Ztschr. f. Urol.," Nov., 1910) collected 107 cases of sarcoma. Sarcoma begins in the submucosa. Papillary cancer and epithelioma are not unusually primary (Mandlebaum in "Surg., Gynec., and Obstet.," 1907). Primary carcinoma, like primary sarcoma, most commonly arises in or near the trigone. Any tumor of the bladder, innocent or malignant, will eventually cause death if allowed to remain. Papilloma is very apt to become cancerous.

Symptoms.—The innocent tumors rarely cause cystitis or irritation, though by obstructing the ureters or the urethra they may induce disease of the kidneys. Hematuria is almost invariably present at some time during the existence of a bladder tumor. It is apt to be profuse, and the urine contains blood, blood-clots, and perhaps fragments of tumor. The bleeding is intermittent, may occur even when the patient is at rest, and, except in malignant disease, is seldom preceded or accompanied by pain. Bleeding usually occurs at the termination of micturition, the first urine being clear and the last red or clotted. Often hemorrhage is the only phenomenon produced by a papilloma or a mucous polypus. Hemorrhage may occur from a myoma. Malignant tumors cause cystitis, and the urine contains mucus, blood, and pus. The growth may become crusted with salts from the urine. Cancer is decidedly and often horribly painful. In malignant disease the rectum usually becomes involved. Hydronephrosis may be caused. Metastases to the lungs are common. Ulceration may occur into the peritoneal cavity or rectum. A malignant tumor progresses much more rapidly than an innocent growth, although in vesical cancer metastases are not formed so early as in some other regions. Innocent tumors are felt with difficulty with the sound, but malignant tumors are easily felt. In some cases a tumor can be detected by a bimanual examination (a finger in the rectum and the fingers of the other hand on the abdomen). Make a careful study to determine whether or not a growth has infiltrated the prostate, the seminal vesicles, the rectum, or the perivesical tissues. Bleeding follows the use of a sound. There may be difficulty in starting the stream in micturition, there may be interruption or irregular halts in the stream. The latter condition is called *stammering of the bladder*. The urine should be examined microscopically to see if it contains villi, portions of fibroma, colonies of cancer-cells, or fragments of epithelioma. A cystoscope should be employed in order to reach a diagnosis. If the urethra is too narrow for the cystoscope, this channel must be dilated. If there be profuse bleeding, an irrigating cystoscope must be employed. In doubtful cases exploratory suprapubic cystotomy is advisable.

Treatment.—Some innocent tumors may be cured by high-frequency electrocoagulation. This method is very valuable. Some use the Oudin, some the d'Arsonval current. Various names are given to the method besides the one employed above, viz.: desiccation, fulguration, thermocoagulation, high-frequency cauterization. The application is made through a cystoscope. In extensive malignant growths, beyond surgical removal, electrocoagulation may be used to arrest bleeding and lessen pain (for a Collective Review of this method see Henry G. Bugbee in "Internat. Abstract of Surgery," Dec., 1915; also Report of Cases of Malignant Growths of the Bladder Treated by Resection and Radium, "Journal of Urology," vol. x, No. ii). (See p. 1468.) Papillomata are particularly amenable to this treatment. Some innocent tumors (for instance, peripheral myomata) are treated by suprapubic incision and removal of the growth and a portion of the bladder wall. A papilloma which recurs after electrocoagulation should be treated by excision with a portion of the mucous membrane and submucous tissue of the bladder wall. The perineal operation only enables the surgeon to reach and remove growths of small size, pedunculated growths, and growths near the neck of the bladder. (See Operations on the Bladder.)

Among the operations practised for malignant disease are *partial cystectomy* with resection of one or both ureters, partial resection of the bladder wall, removal of the growth without resection of the wall (a useless procedure), curetting (which is futile). Complete extirpation of the bladder (*total cystectomy*) for cancer has been performed by Bardenheuer, Héresco, Stellwagen, and others. Goldenberg reported 26 cases, with a mortality of over 60 per cent. It is usually done in two stages, in the first operation the ureters of a man being transplanted into the rectum, the ureters of a woman into the rectum or vagina. Héresco prefers skin implantation in the hypo-

gastric region because the ureters can then be catheterized and the pelvis of each kidney can be disinfected. About three weeks later the bladder is removed. The adjacent lymph-nodes along the internal iliac vessels and in front of the sacrum must be removed in all cases. The space left by removing the bladder is drained through the perineum. The surgeon should bear in mind that vesical scirrhus and adenocarcinoma are practically always secondary growths, and if he cannot remove the primary growth he should not extirpate the bladder. The complete procedure has been carried out successfully at one operation (Tuffier and Dujarier, "Rev. de Chir.," April, 1898). Some surgeons prefer preliminary double lumbar nephrostomy; others transplant the ureters to the skin surface (they are palliative operations). The operation of complete extirpation is of questionable value. In most cases it has proved a fatal failure. Munwes ("Ztschr. f. Urol.," Nov., 1910) reported 69 radical operations for sarcoma. Only 3 patients lived for more than a brief time.

In Rafin's collection of 30 cases of cancer there were 17 deaths. One case was alive five years after operation, 1 fifteen months, and 1 seven months after. Watson's table of 25 cases of cancer shows 14 deaths and only 2 of the survivors were alive and free from recurrence after three years.

Complete extirpation should be employed only when cancer involves the bladder extensively. I agree with Berg ("Annals of Surgery," Sept., 1908), that if less than one-third of the bladder is involved the operation should be partial cystectomy with implantation of the ureters into the portion of bladder remaining. The surgeon removes the anatomically related lymphatic area and always bears in mind that vesical adenocarcinoma and scirrhus are secondary growths. Partial cystectomy saves the performance of the fatal operation of transplanting the ureters as is ordinarily done, or the questionable operation of lumbar nephrostomy with all of its unpleasant consequences. In Rafin's collection of 96 cases there were 21 deaths (a mortality one-half that of complete cystectomy); 50 cases were traced—5 were well over three years and 16 over six months (Berg, Ibid.). Henry Morris lays down the following rule: "When an infiltrating growth is felt, *per rectum* or *per vaginam*, or with the sound, to be involving a large surface of the bladder wall, to be infiltrating its coats, especially in the neighborhood of the ureters and neck of the bladder, no operation whatever should be proposed unless the hemorrhage is copious or the symptoms of cystitis severe, and then an incision for palliative purposes only should be made" (Treves's "System of Surgery").

Many surgeons content themselves in vesical cancer with suprapubic cystotomy, removing the growth and a portion of the bladder wall. If removal be not possible, they curet, cauterize, and drain. Radium and the *x*-rays may be of service to prevent recurrence after an operation for cancer, and in inoperable growths. After cystotomy for irremovable cancer of the bladder radium is sometimes left in the bladder for several hours.

Before attempting operations upon the bladder a careful examination should be made either by the cystoscope or the *x*-ray. Preferably by both. Cystoscopy cannot always be done, and when it is unsatisfactory then make a cystogram; it may save the surgeon much trouble and prevent embarrassing situations. Encysted stones have been missed by able surgeons. Diverticula have greatly complicated operative technic and other complications have often defeated the operator's skill. Follow the above rule, and when a complication is known beforehand the surgeon must be on his guard as to prognosis of end-results.

It is often impossible to judge the extent of involvement of surrounding structures and contiguous and distant lymph-nodes. Therefore it is a wise procedure to make an exploratory laparotomy, mobilize the bladder without opening it, and pass the hand behind the viscus. If the lymph-nodes are well defined, hard, and extend well up along the course of the great vessels, operative attempts at removal will be futile. It is better to back out and close up and trust to providence and deep penetrating cross-fire of massive *x*-ray dosage, possibly radium, and, of course, morphin for pain. If the bladder were opened it might not heal, and a suprapubic fistula would only add to the poor soul's tortures. Radium may do good, but it also often increases the suffering with no material benefit.

Operations on the Bladder.—Lateral Lithotomy.—*Lithotomy* is the removal of a stone from the bladder. *Lateral lithotomy* is an operation which was once a glory of surgery, which has been almost abandoned, but which is still at times employed by surgeons, especially for stone in children. This operation should not be performed if the stone is over 2 inches in its short diameter; it is rarely justifiable if the stone weighs 3 oz. or more (Cage); and it must not be performed for encysted stone,

or on a person with a deep perineum, a narrow pelvic outlet, or an enlarged prostate. For one week before the operation keep the patient in bed, wash out the bladder daily with hot boric acid solution, and administer salol and boric acid by the mouth, 5 gr. of each four times a day. The night before the operation give a saline, order a hot bath, and have the perineum, the scrotum, the buttocks, and the inner sides of the thighs shaved, cleansed. and dressed antiseptically. In the morning an enema is to be given. At the time of operation the bladder should contain several ounces of boric acid solution. The instruments required are a lithotomy knife, a straight probe-pointed bistoury, a grooved staff, a stone-sound, stone-forceps and scoops, a tenaculum, an aneurysm needle, a fountain-syringe, curved needles and a needle-holder, hemostatic forceps, a tube with chemise (see Fig. 244), a Paquelin or electric cautery, a Clover crutch, and a lithotrite.

Place the patient upon his back, anesthetize him, and find the stone by sounding. If the stone is not discovered by the sound at that time, *do not operate*. Place the buttocks so that they project beyond the edge of the table, introduce the staff into the bladder, flex the legs and thighs, and fasten the patient in the lithotomy position by means of a crutch. During the first incision the handle of the staff is held toward the belly; after the first cut the staff is set perpendicularly and is hooked up under the pubes. An incision is made, starting just to the left of the raphé of the perineum and 1¼ inches in front of the edge of the anus, and passing downward and outward to between the anus and the ischial tuberosity, but one-third nearer the former than the latter. In the adult this incision is 3 inches in length. The first incision is superficial and does not reach the staff, but it is this incision which may cut the rectum. After making the first cut the nail of the left index-finger feels for the groove of the staff, the staff is hooked up, the knife is entered into the groove and is pushed into the bladder, and as it is withdrawn the wound is enlarged. As the knife enters the bladder there is a gush of fluid. The finger follows the knife and stretches the wound, the staff is withdrawn, and the stone is felt for and extracted with forceps. Liston showed years ago the value of keeping the finger in the wound. This maneuver retains some water in the bladder, and as a consequence causes the stone to rest upon the tip of the finger, and when the forceps are introduced they at once come upon the stone. In withdrawing the stone make traction in the axis of the pelvis, and do not rotate the calculus until it is entirely out of the prostatic urethra. Wash or scrape away débris or incrustation from the wall of the bladder, see that no other stone is present, syringe out the viscus with warm salt solution, insert a tube, apply antiseptic dressings around the tube, and put on a T-bandage. The end of the tube which is external to the dressings is fastened to the tails of the T-bandage. A rubber cloth is put on the bed, under the body and legs, and the patient's buttocks rest upon a mass of old linen, the scrotum being raised on a pad. The knees are bent over pillows. Change the linen as soon as it becomes wet. Remove the tube in forty-eight hours. The urine begins to come by the urethra from the eighth to the twelfth day. In children the incision is not so long, it is dilated by forceps instead of by the finger, and no tube is required. In lateral lithotomy the prostatic and membranous portions of the urethra are opened, the prostate gland is partly divided by the knife, and the wound is dilated by the finger. One objection to the operation is that it is possible to cut the rectum, and another is that inflammation may occlude the ejaculatory ducts and cause sterility (as it probably did to Samuel Pepys).

Suprapubic Lithotomy.—This operation is the removal of a stone through an opening above the pubes. It is in many instances the preferable operation. The mortality of this operation is higher in children than that of lateral lithotomy; in adults and in individuals beyond middle life the mortality is decidedly less than is that following the lateral operation. It is the preferred cutting operation for the removal of multiple calculi, for very hard stones, for stones above 2 inches in their short diameter, for calculi in men with enlargement of the prostate, for foreign bodies incrusted with sediment, when the perineum is deep, when the pelvic outlet is narrowed, for encysted stones, for calculi associated with a vesical tumor, and when the urethra will not permit the use of a lithotrite. Before doing the operation determine the carrying capacity of the bladder when the patient is not anesthetized. This gives the safe limit of distention. Under an anesthetic the bladder will receive 3 or 4 more ounces than the safe amount. The patient is prepared as for lateral lithotomy, except that the pubes are shaved, and the lower part of the abdomen and the upper part of the thighs are disinfected. During the operation the penis is kept wrapped in a piece of antiseptic gauze.

In performing the operation place the patient in the Trendelenburg position. It is necessary to distend the bladder and raise it in order to have the prevesical space uncovered by peritoneum. In most cases this is accomplished by distention of the bladder and the Trendelenburg position. In a very few cases in which the bladder holds very little fluid a rectal bag may be used to lift the bladder. If a rectal bag is to be used an assistant oils it and pushes it (empty) above the sphincters before the bladder has been filled. It is filled after the bladder has been injected. Draw off the urine with a soft catheter, wash out the bladder with a solution of silver nitrate (1:8000 to 1:5000), and inject the bladder with a like solution. In a child under the age of five inject 3 to 4 oz.; in an adult it is usual to inject 10 to 12 oz. Withdraw the catheter and tie a tube around the penis to prevent the escape of fluid. After injecting the bladder with fluid, if the viscus is not well lifted, inject the rectal bag with water and clamp its tube with forceps. In a child inject from 2 to 4 oz. of warm water into the rectal bag; in an adult inject 10 oz. Bristow suggested the injection of air into the bladder. Some surgeons simply inject air by means of a catheter and a brass syringe or a Davidson syringe. Air injection is not recommended if fluid can be used. In operating on an air-distended bladder there is greater danger of trauma, shock, and postoperative bleeding. If air be injected, a rectal bag is never used, and the patient is placed on his back rather than in the position of Trendelenburg. The best method of injecting air is that of F. Tilden Brown,[1] by means of a bicycle pump. A catheter is introduced, the bladder is washed out, the catheter is fastened to a bandage, the bicycle pump is attached, the operation is proceeded with, and when the transversalis fascia is exposed the bladder is filled with air, the soft catheter is clamped, and the bladder is opened. Make a 3-inch longitudinal incision in the median line of the hypogastric region, terminating over the symphysis. When the prevesical connective tissue is reached push it up with a gauze-covered finger slowly and gently and with a sweeping motion. In close association with this tissue are the prevesical fat and peritoneum. Any roughness may be responsible for disaster. If the peritoneum should appear, push it up. Hold the wound edges apart by retractors. The large veins are seen, giving the bladder a blue color. Avoid these veins if possible, but even if they should be cut, bleeding will usually cease when the bladder has been opened and the rectal bag has been emptied and removed. Clamp bleeding vessels. Pass a stay suture of strong silk on each side of the contemplated incision in the bladder. Catch each suture by a hemostat and let it hang. Open the viscus in the middle line above, and cut toward the pubes. Explore the bladder, remove the stone or stones, scrape away incrustations, ligate bleeding vessels outside the bladder, and irrigate the viscus with hot saline solution. Introduce a double tube into the bladder, and attach to its external ends long tubes to siphon off the urine. The bladder can be drained very satisfactorily by a siphonage apparatus (Fig. 1065). Suture the muscles and fascia at the upper part of the wound. Dress with dry antiseptic gauze and a rubber-dam, the dressings and binder being split to go around the tube. Catch the urine which siphons over in a bottle containing some antiseptic fluid. Change the dressings as often as they become wet. Take out the tubes in four or five days, and allow the wound to heal by granulation. The patient may get up in two weeks. Many Continental surgeons advocate immediate suture of the bladder after incision. Albert, Vincent, Bassini, DeVlaccos, and others advocate



FIG. 1065.—Cathcart drainage. The Y-tube is of glass and is darkened in order to be shown against a white background.

[1] "Annals of Surgery," Feb., 1897.

immediate suture. The suture material should be catgut. After suturing, a catheter passed along the urethra is kept in the bladder to drain the viscus. Immediate suture may be employed in patients of any age, but should not be used if the urine is very septic or if pyelonephritis exists. In some cases the attempted closure will fail; in others it will only partially succeed; in others it will prove successful; but even if it only partially succeeds it will tend to prevent dissemination of urine in the prevesical cellular tissue. The chief causes of death after suprapubic lithotomy are septicemia, secondary hemorrhage, cellulitis, peritonitis, and suppression of urine. Statistics are growing better every year.

Crushing of the Vesical Calculi.—Crushing and evacuation are now done in one sitting, the old operation of Civiale, which required repeated crushings, being obsolete. In every case of suspected stone (as before stated) the cystoscope should be used.

Contraindications to Litholapaxy.—Papilloma, malignant tumor, projecting prostatic lobes, encysted stone, and diverticula.

Litholapaxy (*Bigelow's operation*, or *rapid lithotrity*) is the operation for removing a stone from the bladder in one sitting by thoroughly crushing the stone and completely washing away the fragments. This operation is wonderfully successful if done by an expert. In the United States few of us do it sufficiently often to learn how to perform it with great rapidity, certainty, and safety. It is the best operation in most cases if performed by a very skilful man. It is the operation in the majority of cases for the specially trained surgeon to select, but the general surgeon will have better results in certain difficult cases by suprapubic lithotomy than by litholapaxy. Sir H. Thompson says this method is suited to 29 cases out of 30. Litholapaxy should be employed if the bladder will hold at least 4 oz. of fluid and is in a fairly healthy condition: if the urethra is tolerant and permits freely the passage of instruments; if the stone is not too hard, does not weigh over $2\frac{1}{4}$ oz., and is not over 2 inches in diameter. It is not suitable for multiple calculi, for large and hard calculi, for encysted stones, or for a patient with marked enlargement of the prostate gland, with vesical atony, or with cystitis. An easily dilatable stricture need not prevent the surgeon doing litholapaxy. The stricture can first be dilated, and later Bigelow's operation can be performed, but firm, gristly strictures demand a cutting operation. If the urethra is intolerant to instrumentation, the patient being prone to febrile attacks when it is attempted, cut instead of crushing. An individual laboring under kidney disease will do better after this operation than after cutting (Cage). In diabetes, locomotor ataxia, and conditions of exhaustion patients are best treated by Bigelow's operation, unless cystitis exists. The older views are quoted above. Today the question is looked upon differently. I believe the safest and sanest method is that of suprapubic opening. The shock is less, the trauma much less severe, and the after-results better. Crushing of stones is not often done in this country. If I personally were the patient and had to choose between the two methods, cutting or crushing, I would elect to be cut unless an expert on crushing were accessible.

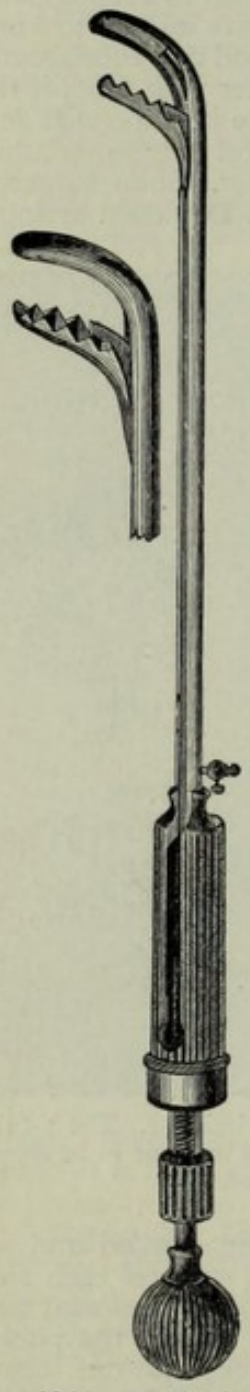


FIG. 1066.—Bigelow's lithotrite.



FIG. 1067.—Thompson's lithotrite.

The Indian surgeons have had the most admirable results from litholapaxy. It has often been claimed that such results were due to racial peculiarities of the patients and various factors regarding their habits, diet, etc. The fact, however, that some of these very surgeons have returned to England and repeated their triumphs in London shows how large a part masterly dexterity played in obtaining success.

J. A. Cunningham ("Brit. Med. Jour.," Aug., 1887) reports upon 10,073 Indian cases of litholapaxy. The mortality was 3.96 per cent.

Cabot, of Boston, in 116 cases had but 4 deaths, and 2 of these were due to pneumonia.

The preparation of the bladder is the same as for lithotomy. Be sure to measure the stone, and to ascertain also whether a lithotrite can readily be introduced and manipulated. The instruments required are a stone-sound (see Fig. 1064), lithotrites (several sizes, Figs. 1066, 1067), an evacuating bulb and tubes (straight and curved, Fig. 1068), soft catheters, a glass irrigator to inject the bladder, and instruments in case the surgeon is forced to cut. The patient is anesthetized and is placed upon his back, a pillow is inserted under the pelvis, and he is well wrapped up. The urine is drawn and a measured amount of warm boric acid is allowed to flow into the bladder. This plan is better than having the patient retain his urine, as in the latter case there

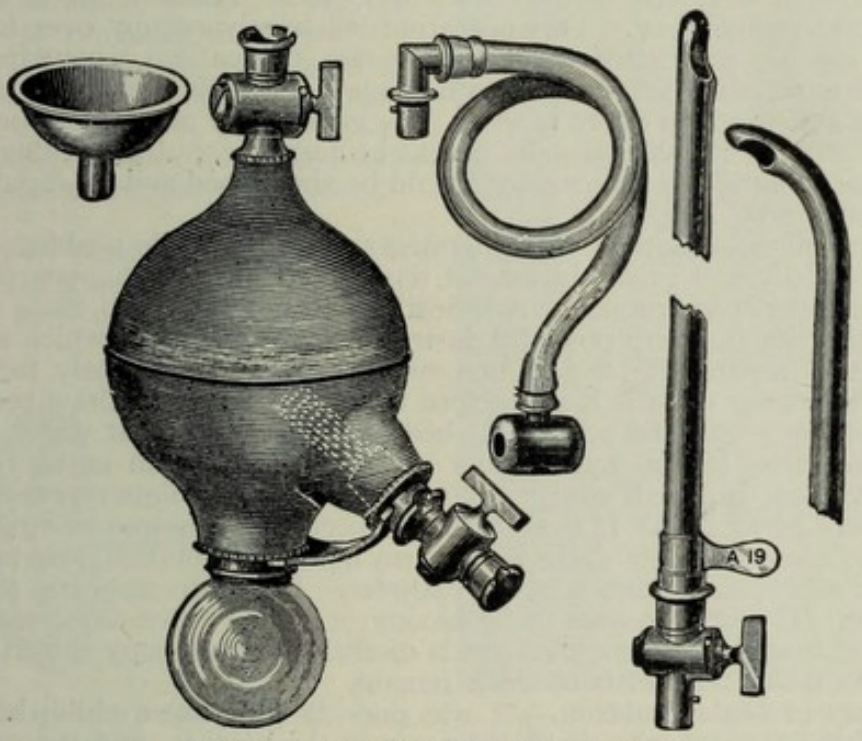


FIG. 1068.—Bigelow's latest evacuator.

is no certainty as to the amount of fluid in the viscus. It is well to introduce at least 5 or 6 oz. of fluid, if possible. If the bladder will not hold 4 oz. the operation is unsafe (Thompson). The lithotrite, preferably the instrument of Bigelow (Fig. 1066), is introduced, the handle being gradually raised to a vertical position as the penis is drawn up on the shaft, but not being depressed until the instrument has passed by its own weight into the prostatic urethra. Thompson's plan for catching the stone is as follows: After introducing the lithotrite, let its lower end rest for a few seconds on the bottom of the bladder, so that currents will subside; then draw back the male blade, wait a moment, close the blades, and in almost every instance the stone will be caught. If the stone is caught, press firmly to see that the calculus is well held, lock the instrument, and break the foreign body by screwing. When resistance suddenly ceases the stone has either slipped or has been crushed; if crushed, the blades should have been felt forcing through the stone and the calculus should have been heard to break. When resistance ceases catch and crush again as above directed. Rapid movements with the lithotrite are improper, as they establish currents which are apt to push away the stone. If the above maneuver does not catch the stone, see if the calculus is near the neck of the bladder. Pull the instrument close to the vesical neck, and open it, not by pulling the male blade, but by pushing the female blade. If the operator still fails

to catch the stone, or if, after crushing, a large fragment knocks against the evacuator, and this fragment cannot pass, conduct a careful search: turn the blades to the right side, open, and close; then to the left side, open, and close; next turn the point around behind the prostate, open, and close. After catching a stone with the lithotrite, turn the instrument very slowly, so as to detect the catching of the bladder wall if it has occurred, and crush the stone in the middle of the bladder with the blades up. After crushing several times, proceed to evacuate. Fill the aspirator with warm saline fluid. Insert an evacuating catheter (Fig. 1068), its point being in the center of the bladder (this procedure is called evacuating catheterism), let the fluid and fragments run out, and attach the aspirator to the catheter; turn the valve, and compress and relax the bulb so that an ounce or more of fluid is forced in at each squeeze, the compression coinciding with expiration. The débris falls into a bulb, and the pumping is continued until the fragments cease to pass, whereupon the point of the catheter is pushed against the floor of the bladder and another trial is made. If fragments which cannot gain exit are felt knocking against the tube, withdraw the evacuator, crush again, and again use the aspirator. When no more débris comes away and no more fragments are felt, withdraw the tube and carefully sound the bladder. Keyes advises the operator to seek for a final fragment by listening with a stethoscope while pumping at the bulb and searching the bladder with the tube. The amount of blood usually obscures a cystoscopic view. This operation will rarely occupy over forty minutes, though Bigelow has protracted it for three hours, the patient recovering. A serious complication is severe bleeding, due to damage done with the instrument or to the presence of a tumor which easily bleeds. The injection of moderately hot water or of adrenalin solution (1 : 10,000) usually checks hemorrhage, but if bleeding is dangerous in amount the operation of litholapaxy should be abandoned and suprapubic lithotomy should be performed.

If clogging of the lithotrite with fragments occurs, forcible pushing of the blades together repeatedly will probably amend it; but it will never happen if the surgeon uses a proper form of instrument. A lithotrite with a fenestrated blade will not lock. Bigelow's lithotrite is a very powerful instrument, the blades of which will not lock. If the blades of a lithotrite should become forcibly and hopelessly locked, make a perineal section, clear out the blades, close them, and then withdraw the instrument.

After-treatment.—Put the patient to bed, apply a bag of hot water to the hypogastrium, and give him a hypodermic injection of morphin as he recovers from ether. Give a hot hip-bath every night, and administer liquor potassii citratis in moderate doses every day. If urethral fever occurs, use quinin and morphin, wash out the bladder several times daily with warm boric acid solution, and tie in a rubber catheter. If retention occurs, use the catheter. If cystitis appears, treat as in an ordinary case. The urine ceases to be bloody in two or three days, and the patient may get up in a week. Before the case is discharged cystoscopy should be practised to be certain that no fragments of stone remain.

Litholapaxy in Male Children.—It was once taught that a child, because of the small size of the bladder, the small diameter of the urethra, and the readiness with which the mucous membrane is lacerated by even slight violence, is a poor subject for crushing. Lateral lithotomy is known to be eminently successful when performed upon children. The elder Gross did this operation upon 72 children, with only 2 deaths. Keegan, however, has persuaded the profession that rapid lithotrity is perfectly applicable to children. He shows that the bladder of a child of even less than two years of age is quite large enough to allow the surgeon to manipulate an instrument; that the mucous membrane is in no danger if the operator is careful, and that the urethra is by no means so small as was supposed. The urinary meatus must often be incised, and after doing this, Keegan states, there can be passed in a boy of from three to six years a No. 7 or 8 lithotrite (English), and in a boy of from eight to ten years a No. 10 or even No. 14. It is, however, just to state that the operation is more delicate than a like procedure on older persons, and that no one is justified in doing it who has not had considerable experience in adult cases. Furthermore, it should be noted that Keegan's mortality by this operation has been 4.3 per cent., while Gross's mortality from lateral lithotomy on children has been under 3 per cent.

Special points relating to litholapaxy on male children are as follows: use well-fenestrated lithotrites; have a stilet to punch out the fragments blocking the evacuator, and crush the stone to a fine mass. There can usually be employed a No. 8 lithotrite and a No. 8 evacuating tube (English scale). My own feeling is strongly against crushing operations in children. In this country few of us have had the experience

in adults which justifies us in undertaking it. I have seen it done successfully, but I believe that the perineal or suprapubic cutting operation are the ones of choice.

Operation for Stone in Women.—If the stone be small, give the patient ether, place her in the lithotomy position, dilate the urethra by the uterine dilator until it admits the index-finger, and remove the stone by the finger, the scoop, or the forceps. If the stone is found to be too large to pass, crush it by a lithotrite and get rid of the débris by the evacuator. Large stones (2 oz.) may require suprapubic lithotomy. Vaginal lithotomy is never required. If done, it is very likely to leave as a legacy a vesicovaginal fistula. In female children dilate the urethra, crush the stone, and evacuate.

Cystotomy or Cystostomy.—These terms mean the opening of the bladder. If the opening be made for diagnosis or treatment and be then closed or allowed to close, the operation is a cystotomy. If the wound be deliberately kept open it is a cystostomy. The bladder may be opened for drainage, for diagnosis, for the removal of stones or tumors, or for the treatment of ulcers. This opening may be done by (1) a suprapubic cut (as in suprapubic lithotomy), (2) a lateral perineal cut (as in lateral lithotomy), or (3) a median perineal cut (as in median lithotomy).

The operation may be completed in one sitting, or the bladder may be only exposed, the opening of it being delayed for several days until it becomes adherent to the margins of the wound (Senn's operation).

A sinus may persist after suprapubic cystotomy, but usually the wound heals unless it be kept open by some expedient.

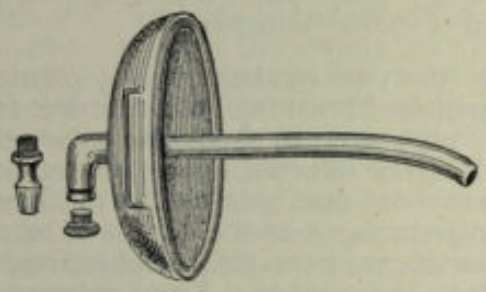


FIG. 1069.—Stevenson's suprapubic drainage-tube.

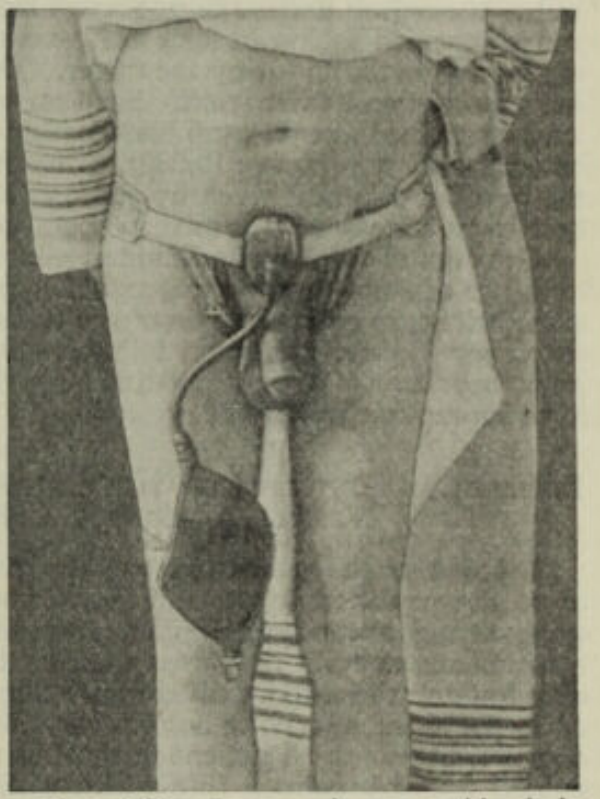


FIG. 1070.—Stevenson's suprapubic drainage-tube in place and attached to a receptacle for urine.

The effects of suprapubic drainage are very beneficial in cases of chronic cystitis associated with hypertrophy of the prostate gland, the urine being foul. Drainage causes the urine to become clear and the mucous membrane of the bladder to become normal. If the opening be made as a permanent drain, there will usually be incontinence, as the new channel has no sphincter action (Dandridge). Figures 1069 and 1070 show tubes for prolonged drainage.

Suprapubic Cystotomy (or Cystostomy).—The operation is employed to allow the surgeon to explore the bladder, to treat an ulcer, to provide drainage, or to remove a tumor. If the operation be for calculi, it is known as suprapubic lithotomy (see page 1328). After the bladder is opened its interior can be illuminated by the rays of an electric lamp, which is fastened with a mirror to the forehead of the operator. If an ulcer be found, it is scraped with a curet or a spoon. Most cases of tumor require suprapubic cystotomy. It is true that a small single growth at the vesical neck is accessible by median cystotomy, but the area for manipulation is very narrow and the growth cannot be seen. Every large growth, all cases of multiple tumors, and all cases of tumor in individuals with great depth of perineum or with enlarged prostate require suprapubic cystotomy, an operation which allows one to feel and to see the growth, which gives room for manipulation, and which permits thorough exploration of

the entire bladder. The patient is put in the Trendelenburg position, if water distention be used; but he is placed horizontally, if air distention be employed. After opening the bladder, as for stone (see page 1328), hold the edges of the incision apart by means of a speculum or by retractors, and reflect the electric light into the wound. Growths when seen can be twisted off, a pair of forceps holding the base and another pair being used to twist, but after removal by twisting they will always recur unless the base and the mucous membrane about the base be removed. Broad malignant growths may require partial cystectomy. If bleeding be severe, check it by pressure, by hot water, by a 1 : 10,000 solution of adrenalin chlorid, or even by the actual cautery. In some cases the wound is allowed to heal rapidly. In others the bladder is drained for a considerable time. In some it is kept open permanently. Permanent drainage is desirable in some cases of enlarged malignant prostate. Stevenson's tube (Figs. 1069, 1070) may be employed for permanent drainage.

Median Cystotomy (or Cystostomy).—The same incision is made in the perineal raphé for median cystotomy as for median lithotomy. A grooved staff is introduced and is hooked up under the pubes; an incision is made into the membranous urethra, and is extended backward for ¾ inch, and a finger is carried into the bladder. If searching for a growth, find it by the finger. The usual rule has been to catch it in Thompson's forceps and twist it off. Such an operation is totally inefficient. Soft growths may be scraped away. Stop bleeding by digital pressure or by injections of hot water or adrenalin chlorid (1 : 10,000). Median cystotomy does not allow anything like the freedom of access given by suprapubic cystotomy, and the latter operation is the best for tumor cases. The median operation may be used for drainage.

Growths in the Female Bladder.—It was long the custom to dilate the urethra as in a case of stone, and scrape, twist, or pull the growth away or ligate it. This plan is inefficient, as by it the base of the tumor is not removed. It is usually best, if high frequency electrocoagulation fails or will evidently be useless, to perform a suprapubic operation. If the growth is large or if there are multiple growths, always perform suprapubic cystotomy.

Diseases and Injuries of the Urethra, Penis, Testicle, Prostate, Seminal Vesicle, Spermatic Cord, and Tunica Vaginalis

Injuries of the penis and urethra may arise from traumatism to the perineum or to the penis, from cuts and twists, from the popular "breaking" of a chordee, from tying string around the organ, from forcing rings over it, from the passage of instruments, or from the impaction of calculi. Violence inflicted upon an erect penis may fracture the corpora cavernosa. The writer saw one man with a glass rod broken off in the canal, he having been in the habit of introducing it at the dictate of morbid sexual excitement. A patient in the Insane Department of the Philadelphia Hospital pushed over his penis a ring which ulcerated into the urethra. These injuries are treated on general principles. It is often difficult to locate the encircling body, especially when it is a small rubber band, as it lies at the bottom of a deep sulcus, but always make a most careful search. For this purpose I use an incus hook, which will usually fit into the groove where the constriction is.

Perineal Bruises.—If the perineum be bruised without rupture of the urethra, the perineum and scrotum swell and become discolored; water is passed with difficulty because the extravasated mass of blood in the periurethral tissues compresses the canal more or less; the water is not bloody; and there is severe pain and much shock. Some authors include under rupture those cases in which laceration of the spongy tissue occurs, without involvement of the mucous membrane or of the fibrous coat, but they are properly contusions.

Treatment of Bruises and Wounds.—Place the patient in bed and establish reaction, and when reaction is complete employ opiates for the relief of pain. Apply an ice-bag to the perineum. If, notwithstanding these measures, swelling continues, introduce a catheter, tie it in, and make pressure upon the perineum by a firmly applied T-bandage or by a crutch braced against the foot-board of the bed. A very efficient method of controlling bleeding from the bulb is that used and devised by Stellwagen. A belt is placed about the waist of the patient and rubber tubing is passed from in front down over the belly, crossing the perineum and returning up the back to the belt where it is fastened. Such a sling is passed upon each side. The slings cross the perineal pad and by applying the proper tension to the tubing and fixing it to the belt at that tension the pressure necessary to control the bleeding can be continuously

applied. This appliance is much more comfortable than the crutch, for it permits freedom of motion to the patient. Even when swelling is slight, retention of urine may occur from projection of a submucous blood-clot into the canal of the urethra. In some cases it may become necessary to incise the perineum and evacuate the blood-clot. After twenty-four hours have passed, if hemorrhage has ceased, substitute a hot-water bag for the ice-bag, and empty the bladder every six hours by a soft catheter. Occasionally, though rarely, an abscess forms. *Punctured wounds of the urethra* require ordinary dressings. *Incised wounds of the urethra*, when longitudinal, are closed by suture. Healing is rapid and ill consequences are not to be feared. Stricture does not follow. When the wound is transverse, introduce a catheter, suture the wound over the instrument, and remove the catheter at the end of the third day. If a catheter cannot be introduced, employ sutures, but at the first evidence of extravasation open the wound, and if drainage is not free perform external perineal urethrotomy.

Rupture of the Urethra.—By this term is meant a lacerated or a contused wound of the urethra, destroying partially or entirely the integrity of the canal. A lacerated wound may be induced by fracture of the cavernous bodies during erection, the symptoms being severe hemorrhage, intense pain, retention of urine, and inability to pass an instrument; infiltration of urine occurs, and gangrene is a common result. The writer has seen 1 case of rupture of the penile urethra due to a man's slipping while shaving, the penis being caught in a partially open drawer, the drawer being shut by his thighs coming against it. Stellwagen operated upon a case of rupture of the urethra due to violence induced by a blow upon an erect penis. Also on one in a child caused by an instrument. Rupture, however, is almost invariably located in the perineum, and it arises when the urethra is suddenly and forcibly pressed against the arch of the pubes by a blow, by a kick, or by falling astride a beam or a fence-rail or on a wagon wheel. Falling astride causes at least half of all cases. (See Kidd's 41 cases in Abstract by "Amer. Jour. Med. Sci.," March, 1922.) Retention of urine due to stricture may lead to rupture and extravasation of urine. The lesion of urethral rupture consists, in some cases, of laceration of the spongy tissue and the mucous membrane, a cavity being formed which communicates with the canal, and which fills with urine during micturition. In other cases not only the spongy tissue and the urethral mucous membrane are rent asunder, but the fibrous coat is also torn, the canal opening directly into the perineal tissues, in which a huge cavity forms, a cavity that fills with blood and later with urine and pus. The urethra may be torn entirely across, but in most cases a small portion at least of its circumference is uninjured. Rupture never occurs primarily and alone in the prostatic urethra. Some think it is extremely rare in the membranous urethra unless due to pelvic fracture. I believe that it occurs not unusually in the membranous urethra. When we recall that this is the fixed portion of the tube we should expect rupture here rather than elsewhere. It is very unusual in the penile urethra. The seat of rupture in the great majority of cases is in the region of the bulb. Very rarely is the skin broken. The surgeon must always be upon his guard for a type of rupture of the urethra seen behind old strictures where an ulceration probably exists, and because of pressure a slight leakage occurs which in reality is a ruptured urethra. It at least produces a similar chain of symptoms and often is seen in old alcoholics.

The **symptoms** of rupture of the fixed urethra are considerable pain, aggravated by motion, pressure, and attempts to pass water; decided shock; in some cases micturition is still possible, blood preceding and also discoloring the stream, for some blood usually runs into the bladder; retention of urine quickly arises; in a vast majority of the cases retention is absolute from the very first, and it is due to the interruption in the integrity of the canal and to the occlusion of the channel by blood-clots. Bleeding, which is usually free, lasts for several hours, some little blood generally appearing externally from the meatus, and much being retained in the perineum, inducing progressive swelling. The presence of a large swelling is regarded as evidence of urethral rupture. The blood and urine effused in the perineum may extend under the fascia to the penis and scrotum (Fig. 1071). The swelling soon becomes reddish, purple, or even black, pressure upon it is apt to cause blood to run from the meatus, and it is enlarged when attempts are made to urinate. After a time, if the surgeon does not act, the urine fills the perineal cavity and widely infiltrates, and there ensue gangrene, sloughing, and sepsis, life being endangered or fistulæ being left as legacies. The course of the extravasated urine will often enable one to locate the seat of injury. In rupture of the membranous urethra, if uncomplicated, the urine remains between

the two layers of the triangular ligament until a channel is opened for it by sloughing or by the knife. When extravasation occurs behind the posterior layer of the ligament the urine finds its way to the perineum in the neighborhood of the anus. When the rupture is in front of the anterior layer of the ligament the urine, directed by the deep layer of the superficial fascia, finds its way into the scrotum and up on the belly, but does not pass into the thighs (Fig. 1071). A contusion is distinguished from a rupture by the facts that in the former the perineal swelling is not very extensive and does not enlarge on attempting micturition, while in the latter it is extensive and does enlarge on attempting to pass water. Furthermore, contusion does not cause urethral hemorrhage, while rupture does. A contusion sometimes, but not often, prevents the passage of a catheter; a rupture almost always, but not invariably, does so. The mortality from severe rupture with extravasation is about 14 per cent. (Kaufman).



FIG. 1071.—Rupture of the urethra and extravasation of urine.

Treatment.—In some very rare cases it is possible to suture the urethra, and this procedure should be carried out when possible. In order to suture, perform suprapubic cystotomy and also make a perineal section. Find the proximal end of the ruptured urethra in the perineum by passing a catheter from the bladder into the urethra (*retrograde catheterization*). Suture by way of the perineum and with silk. The sutures pass through all of the coats of the urethra. The roof of the canal is sutured first, then a steel sound is introduced from the meatus, and the urethra is sutured around the instrument. The sound is withdrawn and the bladder is drained above the pubes by Cathcart's siphon as illustrated in Fig. 1065 or by a double tube. In recent cases of ruptured urethra the usual treatment is as follows: Immediately perform median perineal section and turn out the clot; trim off lacerated edges; find the proximal end of the urethra, pass a catheter from the meatus into the bladder, and leave it *in situ* until healing has begun around it. If the catheter cannot be passed from the meatus, open the bladder above the pubes and find the proximal end of the torn urethra by retrograde catheterization. In retrograde catheterization we push an instrument from the bladder into the wound and use it to guide a catheter from the meatus into the bladder. When rupture occurs back of a stricture it is a good plan to excise the cicatricial tissue. In cases with extravasation make a median incision and numerous transverse cuts to secure drainage for areas of retained urine or pus. Then at once perform suprapubic cystotostomy. Drain suprapubically and from the perineum for about two weeks, by which time sloughing tissue will have separated. Then find the posterior urethra by retrograde catheterization and do a perineal operation to repair the damaged urethra. The wound is packed with iodoform gauze, and the bowels are tied up with opium for a few days. Some surgeons strongly disapprove of the custom of retaining the catheter, believing that the instrument does no real good, as urine is certain to get between the catheter and the walls of the urethra. They think it is quite enough to stuff the wound with gauze, the patient urinating through the wound for the first few days, after which time a catheter is used at regular intervals. Whatever method is employed, healing will require from six to eight weeks, and the patient must, during the rest of his life, from time to time, introduce large-sized bougies.

Foreign Bodies in the Urethra.—These bodies may be calculi; bodies introduced by injury, as shot, bone, etc.; bodies entering from a fistulous opening into the rectum; or bodies introduced from the meatus, as broken bits of catheters, straws, pins, etc.

The **symptoms** and **treatment** vary with the size and the nature of the body. Sometimes there are almost no symptoms; at other times there are found great pain, re-

tention of urine, and hemorrhage. Examination is made by the urethroscope, by feeling carefully with a finger in the rectum, and by searching very gently with a sound, taking care not to push the body back. In some cases the body can be removed by aid of the urethroscope. Employ this plan if possible. If it is not possible, try the following plan: If the bladder is well filled with water when the body becomes impacted, inject a little oil into the meatus, close the lips with the fingers, and direct the patient to attempt forcibly urination, the surgeon opening the meatus when the urethra is widely distended, the foreign body being often forced out. If this maneuver fails, and the foreign body be impacted in the pendulous urethra, prevent its backward passage by at once tying a rubber tube around the penis. Try to squeeze the body out, and, if unsuccessful, endeavor to catch it with a wire loop, with a scoop, or with the long urethral alligator forceps. If these methods fail, cut down upon the body and remove it, dividing any existing stricture. If it be lodged just back of the meatus, meatotomy will permit extraction. If a hairpin is in the canal, the ends of the pin are almost always pointing to the meatus; to prevent them catching on attempted withdrawal, the penis must be squeezed to approximate the ends of the pin, and when they are adjacent a part of a silver catheter is slipped over to retain them in this position, when the pin can be extracted. If this fails, drag the penis against the belly, by rectal touch force the sharp ends of the pin out through the integument, cut one end off, and then withdraw the other. An ordinary large-headed pin is forced out in the same way, and when the head is turned externally it is extracted by way of the meatus. If a hard or sharp foreign body be lodged in the prostatic urethra, do not catch it with an instrument or try to drag it forward. To do so would be apt to tear the membranous urethra. It is better to push it into the bladder and remove it later by cutting or, if it be a stone, by crushing (H. Hartmann in "La Presse Méd.," July 24, 1901). If a lithotrite loaded with fragments be caught in the urethra, the surgeon must perform a perineal section, to enable him to clean and close the blades. After the blades have been closed the instrument may be easily withdrawn.

Urethrorrhea is not urethral inflammation, but is a condition of sensitiveness of the urethra and oversecretion of the glandular elements. It may be due to masturbation, sexual excess, and also, as Sturgis points out, to withdrawal during sexual intercourse, and to ungratified sexual passion. This condition is often met with in young men who are engaged to be married and undergo strenuous courting without sexual gratification. A somewhat enlarged boggy prostate has been termed the "lover's prostate." A drop or two of transparent mucus is found at the meatus in the morning, and a considerable amount may flow away while straining at stool or upon the diminution of an erection. This flow at stool is often called *defecation spermatorrhea*. This discharge stains, but does not stiffen linen (Sturgis). The discharge contains mucus, mucous corpuscles, epithelial cells, but no gonococci or pus-organisms. The patient may be well in all other respects, but in many cases there are neurasthenic symptoms, sexual weakness, or even impotence. It is well to explain to the patient that the overaction of the muciparous glands is nature's effort to facilitate the passage of the fluid of the orgasm and to alkalinize an acid urethra which would inhibit the activity of spermatozoids. Quacks fatten on these unfortunates. This condition may be readily distinguished from prostatorrhea by the absence of Böttcher's crystals (see page 1364) and from that very rare condition, spermatorrhea, by the absence of spermatozoids.

Treatment.—In an uncomplicated case improvement or cure will follow the abandonment of evil habits and the systematic passage of steel sounds. If complications arise, they must be treated.

Urethritis, or Inflammation of the Urethra.—Urethral inflammations can be divided into two classes: (1) *simple* or *non-specific*, in which infection is due alone to pyogenic cocci (particularly the Bacillus coli communis, Micrococcus catarrhalis, diphtheroids, and the Staphylococcus pyogenes), and (2) *specific*, in which the gonococcus is present.

Non-venereal, non-specific, pyogenic, or **simple urethritis** may be due to several causes, such as traumatism, great acidity of the urine; alkalinity and phosphaturia; chancre in the urethra; contact with menstrual fluid, leukorrheal discharge, the discharge from malignant disease of the uterus, ordinary pus, or acrid vaginal discharge; the passage of instruments; the administration of irritant diuretics; strong injections; worms in the rectum; a febrile malady; venereal excess and masturbation; the passage or impaction of foreign bodies, and papillomata of the urethra. A temporary and mild urethritis sometimes accompanies early syphilitic eruptions. Simple urethritis

is less severe and prolonged than gonorrheal urethritis, though clinically in the early stage the physician cannot invariably distinguish between the two forms without microscopic studies. The diplococci of gonorrhea are never found in the discharge of simple urethritis, although there may be numerous other diplococci. In medico-legal cases testimony is not admitted as to the presence or absence of diplococci, as many judges do not admit that their presence proves or their absence disproves gonorrhea. In the non-specific inflammation pus is not always present, many cases stopping short of pus formation after a varying period of catarrh, but any catarrh may become purulent. A simple urethritis may be caused or may be prolonged for an indefinite period by the presence of large amounts of oxalate in the urine or the existence of the uric-acid diathesis (see Gouty Urethritis).

Treatment.—Seek for the cause and remove it. Correct any abnormal condition of the urine by means of suitable diet, drugs, and mode of life. Mild astringent injections are useful. It may be necessary to flush the urethra repeatedly with a solution of silver nitrate (1 : 8000) or permanganate of potash (1 : 6000).

Traumatic Urethritis.—The onset of pain in traumatic urethritis is coincident with the introduction of the foreign body. The discharge, which may be bloody, mucous, mucopurulent, or purulent, comes on within twenty-four hours.

Treatment.—If the inflammation be slight, prescribe diluent drinks, paregoric, a saline, or the following:

℞. Tinct. belladonnæ..... f℥ss;
Sodii bromid..... ℥iv;
Tinct. opii camphorat..... f℥j;
Syrupus zingib..... f℥ss;
Aquæ destil.....q. s. ad. f℥vj.—M.
Sig.—A tablespoonful every six hours.

If the inflammation be severe, put the patient to bed, apply hot fomentations to the perineum, give diluent drinks, employ suppositories of opium and belladonna, and watch for fever and other complications.

Gouty Urethritis.—This condition first manifests itself in the posterior urethra, not in the anterior, as does clap. Its symptoms are great vesical irritability; pain on urination; discharge, usually scanty, associated with uric acid in the urine and perhaps joint symptoms of gout. The *treatment* comprises dieting and the usual remedies for gout. Purgatives are given freely, and full doses of colchicum, the salicylates, urotropin, or the alkalies; hot baths, low diet, diluent drinks, and diaphoretics are indicated. A chronic discharge from the prostatic region is apt to linger; for this there is nothing better than the usual gouty remedies and saline waters with copaiba, cubebs, or sandalwood oil. In many cases it is necessary to flush the urethra once a day with a solution of silver nitrate (1:8000).

Eczematous Urethritis.—Berkley Hill states that this disease is very obstinate, is probably associated with gout, and is met with in adults of full habit or who are beer-drinkers and who have eczema of the surface of the body. He states also that the glans penis near the meatus is red and tender, and that the interior of the urethra is in the same condition. Pain is constant, and it is aggravated by micturition. The discharge is scanty. The *treatment* comprises injections of cold water or irrigation with iced water, and internally the administration of arsenic with the alkalies.

Tuberculous urethritis is due to a tuberculous ulcer, which is most apt to be seated near the vesical neck. There is a little pain on micturition, but there is intense pain at one spot on passing a bougie. The discharge is slight and at times bloody. The bladder is very irritable, and severe cystitis arises and persists. The *treatment* includes warmth, nutritious diet, and cod-liver oil, curetment, and local applications of iodoform through a urethroscope, and living as much as possible out-of-doors. The climate of southern California is peculiarly well suited to these cases. The bladder is washed out once a day with boric acid solution. Iodoform emulsion is injected daily. Tuberculin may prove of value. After a time the surgeon will probably be forced to drain by perineal or suprapubic cystostomy (see Tuberculous Cystitis, page 1323). It is always of the greatest import to find the original focus of infection. We are led to believe there generally exists such a focus and that the urethral condition is secondary.

Pyogenic Chancroidal Urethritis.—This condition is sometimes seen in association with chancroid of the urinary meatus.

Pyogenic Urethritis of Urethral Chancre.—A urethritis may occur with urethral chancre.

Pyogenic Syphilitic Urethritis.—A temporary and mild urethritis sometimes accompanies early syphilitic eruptions.

Examination of a Patient in Whom a Urethral Discharge Exists.—Learn accurately the history. Obtain some of the discharge and examine an unstained slide and a slide stained for gonococci. In some cases take cultures. Learn the amount of the twenty-four-hour urine and study a sample chemically and microscopically, being sure to determine the amount of urea. Learn if the discharge discolors or stiffens linen; if it is only found in the morning; if it simply glues the lips of the meatus together; if it is seen during the day; if it is noted particularly or only after sexual excitement or straining at stool. Inquire as to pain, frequency of micturition, passage of blood, nocturnal emissions, manner of urinating, etc. In many cases insert a finger in the rectum, feel the prostate and vesicles, massage them, and see if discharge appears at the meatus after stripping the penis. If discharge does appear, collect a specimen and examine it. In some cases it is necessary to pass a sound. Carefully cleanse the meatus, glans, prepuce, and urethra before passing a sound. Cleanse the meatus, glans, and prepuce with a 1 : 6000 solution of corrosive sublimate. Irrigate the urethra with boric acid solution and fill and clean the urethra with emulsion of iodoform and glycerin (5 per cent.), and after using the instrument irrigate again with boric acid solution (Valentine's method). Examine the urine by the three-glass test.

The Three-glass Test (*Valentine's Plan*).—Take as many 3-oz. tubes as are required to receive all the urine from the bladder. The first tube contains the washings from the anterior urethra; the second and other tubes, additional material from the bladder; the last tube contains material expressed from the posterior urethra, prostate, and seminal vesicles. This rule is only approximately true; too much reliance should not be placed upon it. Very often the first urine will contain shreds that are from the prostatic sinuses. Examine the urine and the sediment in the first two glasses and in the last glass. Note particularly if *shreds* are present. The shreds of gonorrhea are white in color and of variable length. They are composed of pus-corpuscles and of epithelial cells which have undergone fatty degeneration. Some of these shreds form in the ducts of Cowper's glands, some in the glands of Littre, some in the prostatic sinuses, some in the utricle, some in the folds around the verumontanum, and some are from inflammatory patches along the entire length of the urethra. A 1 per cent. solution of methylene-blue injected into the anterior urethra will stain the urethral shreds, while those from the bladder will not be stained by it.

Gonorrhea (Clap; Specific Urethritis; Tripper; Venereal Catarrh).—Gonorrhea is an acute inflammation of the genital mucous membrane, nearly always of venereal origin, due to the deposition and multiplication of gonococci in the cells of the membrane and a mixed infection with the cocci of suppuration. The disease is inaugurated by gonococci. After a few days or more secondary pyogenic infection develops and complications may result from the gonococci or from the bacteria causing the mixed infection. The disease attacks with the greatest ease surfaces covered with squamous epithelium. The gonococci enter into and multiply in the superficial epithelial cells and pass between the deeper cells, where they lodge and multiply as the superficial cells are cast off. The pus from the urethra contains epithelial cells with gonococci on or inside of them, and also pus-cells with gonococci within them as a result of phagocytosis. Cultures are made with difficulty. Gonococci do not stain by Gram's method, but stain best with a weak, watery solution of an anilin dye. These bacteria are said not to be pathogenic to animals, although some observers deny this assertion. Gonorrhea is one of the most common and widely disseminated diseases. Probably one-half of all sterile women and many sterile men have been rendered so by this disease. It is responsible for not a few cases of abortion, for an enormous majority of female pelvic diseases, and it causes many cases of blindness by infection of children's eyes during delivery.

Gonorrhea in the Male.—In the male clap begins within the meatus and fossa navicularis and extends backward perhaps throughout the length of the urethra. The mucous membrane swells and becomes hyperemic, and there is a discharge, first of mucus and serum, and then of pus. In severe cases the discharge is bloody (*black gonorrhea*) or green. During the acute stage the entire penis swells and the corpus spongiosum becomes infiltrated with inflammatory exudate. An interesting fact is that gonorrhea may induce mild septicemia without demonstrable complications, the condition causing, according to Thayer ("Amer. Jour. Med. Sci.," Nov., 1905), a continued fever

which, perhaps, lasts a number of weeks. In true gonorrheal septicemia the blood must contain gonococci (*gonococcemia*). In the case recorded by Thayer and in the one recorded by Blumer and Hayes, and in the one recorded by Stellwagen ("Therapeutic Gazette," April 16, 1910), cultures were obtained from the blood. Gonorrhea may produce grave septicemia with systemic complications. It tends particularly to attack serous membranes or other endothelial structures (joints, pericardium, endocardium, pleura, tendon sheaths, intima of vessels, etc.). Among the complications are gonorrheal arthritis, myelitis, bursitis, poliomyelitis, and multiple neuritis. Phlebitis may arise. Mild endocarditis may arise or severe endocarditis may occur, identical symptomatically with ulcerative endocarditis due to other bacteria. In 6 reported cases of endocarditis gonococci were obtained by cultures from the blood *intra vitam* (Thayer, Loc. cit.). Cerebral embolism may result. Cerebrospinal meningitis can occur (fluid obtained by lumbar puncture contains gonococci).

Gonorrheal rheumatism is discussed on page 598. Gonorrheal peritonitis is rare. Infection of the peritoneum through the blood is very rare. The majority of cases of gonorrheal peritonitis occur in women and are due to direct extension from the Fallopian tubes. A child may contract gonorrheal ophthalmia during delivery, and any person may develop it by getting gonococci into the eyes.

Symptoms of Acute Inflammatory Gonorrhea in the Male.—The period of incubation of gonorrhea is from a few hours to two weeks. The usual period is from three to five days, when symptoms of the *prodromal stage* or *stage of onset* begin. The patient notices on arising a drop of thin fluid which glues the lips of the meatus together, and he feels some heat and itching or tickling about the meatus or in the navicular fossa. There may be uneasiness or actual pain unconnected with micturition, and there is sure to be scalding pain on micturition. The meatus is red and swollen, has a glazed appearance, may be covered with a little mucopus, and the lips are glued together by the discharge. It may be possible to squeeze out a drop or two. Even so early the fluid contains gonococci. The urine appears clear, but on shaking some flakes are noted. They are epithelial cells. Within forty-eight hours the *first stage*, the *florid stage*, the *acute stage*, or the stage of increase, becomes established. The meatus is now red, swollen, and everted (*fish-mouth meatus*); the entire glans may be red and swollen; if the prepuce is long, it becomes swollen, reddened, and constricted, and in many cases very edematous; the lymphatics at the frenum and on the dorsum of the penis may be red, swollen, tender, and cord-like; micturition causes severe pain (*ardor urinæ*), which is due to distention of the inflamed urethra and to stinging by the acid urine. Bumstead thus described the act of micturition in acute gonorrhea: "During the act the patient involuntarily relaxes the abdominal walls, holds his breath, and keeps the diaphragm elevated in order to diminish the pressure on the bladder and lessen the size and force of the stream" ("Venereal Diseases," by Robt. W. Taylor). Because of the narrowing of the canal the stream of urine becomes narrow, weak, twisted, forked, or is delivered in little bursts or drops. Retention may result from spasm of the muscles. For a week or more the acuteness of the symptoms increases (first stage). When the acute or florid stage is fully developed (second stage) the entire urethra is inflamed from the meatus to the triangular ligament; there is constant uneasiness or actual pain in the penis and perineum, increased by walking and by sitting down suddenly or carelessly. Insomnia is common; *chordee* occurs, especially when the patient is warm in bed. By "chordee" is meant a condition of painful erection in which the penis is markedly bent. The rigid infiltration of the corpus spongiosum keeps it from stretching to accommodate itself to the enlarged corpora cavernosa, and, in consequence, the organ curves. There is frequent micturition, with tenesmus and a profuse creamy discharge, which is yellow, greenish, or even bloody. The discharge soils and stains the victim's linen and may crust upon the linen, the meatus, or the glans. The commonest complications of this stage are *balanitis* (inflammation of the mucous membrane of the glans penis), *balanoposthitis* (inflammation of the surface of the glans and the mucous membrane of the prepuce), *phimosis* (thickening and contraction of the foreskin, so that the glans cannot be uncovered), and *paraphimosis* (catching and fixation of the retracted prepuce behind the corona glandis, with such swelling of the glans and prepuce that it is impossible to bring the prepuce forward over the glans). This is a dangerous condition and it should be reduced at once. In the *second* or *stationary stage*, which lasts from the end of the first week for an uncertain time, the acute symptoms of the first stage continue. The most common complications of this stage are *peri-urethral abscess* or *phlegmon* (infection of a urethral gland or of submucous structures), *folliculitis* (inflammation of the follicles of Littre), hemorrhage, retention

of urine (which is rare), gonorrheal arthritis, lymphangitis, and diminutive bubo on the dorsum of the penis (*bubonulus*), solitary and painful bubo of the groin, which may suppurate, *Cowperitis* (inflammation of Cowper's glands), inflammation of the prostate or of the bladder, trigonitis, gonorrheal ophthalmia, and *chordee* (painful erection with downward bending of the penis). The second stage lasts for an uncertain time, when the acute symptoms decline and the discharge grows thinner and less profuse. In the *third* or *subsiding stage* the symptoms gradually abate, the discharge becoming scantier and thinner, and finally drying up. This stage is of uncertain duration, and in it there may occur *epididymitis*, or inflammation of the epididymis. Among possible complications we may mention peri-urethral abscess or phlegmon, Cowperitis, cystitis, prostatitis, bubonulus, folliculitis, gonorrheal arthritis (see page 598), infective endocarditis, tenosynovitis, pyelitis, purulent ophthalmia, perichondritis, and peritonitis. It must always be borne in mind by the student that the complications of gonorrhea are variably classified as those of anterior urethritis and those of posterior urethritis, but the complications may arise during any of the so-called stages, for the organisms may be carried back through some faulty manipulation, or in the very severe types the complications may appear early in the disease. An ordinary case of genuine gonorrhea lasts from six to ten weeks. Even a case limited to the anterior urethra lasts from four to five weeks.

Examination for Gonococci.—Every urethral discharge should be examined for gonococci in order to make a positive diagnosis. This examination is made several times during the progress of the case, so as to determine when the organisms disappear. Many non-gonorrheal conditions are due to cocci strongly resembling gonococci. Free pus and numerous cocci usually mean gonorrhea. So do complications. The examination of the smear is not absolutely conclusive. Cultures are conclusive. If there be a free discharge, fluid for examination can be easily obtained. If the discharge be scanty or occasional, have the patient partially empty the bladder. Then the surgeon massages the prostate and urethra and smears fluid on the slide. Then the patient empties his bladder into two glasses. Each specimen is to be centrifuged and examined for pus (Keyes, "Amer. Jour. Med. Sci.," Jan., 1912). The taking of a smear and its examination are easy. Place a drop of discharge upon a cover-glass, lay another cover-glass over this, and slide the glasses apart. Dry and fix the slides in the flame of an alcohol lamp. Bring the cover-glasses in contact with a saturated solution of methylene-blue in 5 per cent. carbolic acid water. The staining material is allowed to remain in contact with the slides for five or ten minutes, the glasses are washed with water, are then placed in a solution of 5 drops of acetic acid to 20 c.c. of water, and kept there "long enough to count one, two, three slowly," and are again washed with water. Examination with the microscope shows the gonococci stained blue.[1] In doubtful cases, especially when the microscope fails to show gonococci, make cultures. Cultures must be made in suspected gonorrhea in a child, from the fluid of an inflamed joint, from the discharge in gleet or purulent ophthalmia, and from the blood in obscure infections.

Subacute or **catarrhal gonorrhea** develops in men who have previously had gonorrhea, as a result of prolonged or repeated coition or of contact with menstrual fluid or leukorrheal discharge. There is profuse mucopurulent discharge, but very little pain on micturition, and seldom chordee or marked irritability of the bladder. In these cases the cause should be sought for in the prostate and seminal vesicles. In our experience they are generally at fault.

Irritative or Abortive Gonorrhea.—In this disease the symptoms, which are identical with those of beginning clap, do not increase, but disappear within ten days.

Chronic Urethral Discharges.—Chronic urethral catarrh, which may follow gonorrhea, is characterized by the occasional presence of a drop of clear, tenacious liquid. This discharge becomes more profuse as a result of sexual excitement or the abuse of alcohol.

The persistence of a small amount of milky discharge, because of localization of inflammation in one spot or the production of a granular patch or a superficial ulcer, characterizes *chronic gonorrhea*. There is some scalding on urination; erections produce aching pain; there are pain in the back and redness and swelling of the meatus. All the symptoms are intensified by sexual excitement, by coitus, by violent exercise, or by alcoholic excess. In all of these cases it is well to carefully examine the prostate and vesicles. An endoscopic study may help greatly and should always be done.

Gleet.—If a chronic gonorrheal urethritis lasts over ten weeks it is called gleet.

[1] Schutz's method, as set forth by R. W. Taylor in his work upon "Venereal Diseases."

In gleet the lips of the meatus are stuck together in the morning, and squeezing them discloses a drop of opalescent mucopurulent fluid (the *morning drop*). During the day the discharge is rarely found. The discharge is yellow or has a yellowish hue; it stains the linen distinctly, and contains pus shreds, epithelium, and at times gonococci. The urine is clear and contains pus, gonorrheal shreds, and comma-shaped hooks. The discharge is not obviously purulent, and contains amyloid corpuscles. There are frequency of micturition, pains in the back, and dribbling of urine, and a bougie may find a stricture of large caliber, or at least will discover that the urethra is rigid from inflammatory infiltration. A discharge may be maintained by *chronic prostatitis*. In this condition there are frequency of micturition; a sense of weight or dull pain in the perineum; diminished projectile force of the stream of urine; there is often a tendency to sexual excitement and premature emission. In *prostatorrhea* a milky discharge gathers in the urethra during sleep and flows during muscular effort or while the patient is at stool. The linen is stained but slightly and the lips of the meatus are not glued together on waking. There is a history of masturbation or sexual excess. The condition is not aggravated particularly by alcohol or sexual intercourse. In chronic anterior urethritis there is a discharge from the meatus or sticking together of the lips in the morning. In chronic posterior urethritis there may be no discharge of pus from the meatus. If the three-glass test be made, it will be found that in a case of chronic anterior urethritis only the first portion will be cloudy and show shreds; if there be posterior urethritis of not very long standing, both portions will be a little clouded, the first containing clap-shreds, the last hook-shaped shreds. The glass tests are notably fallacious. In a very chronic case neither sample will be cloudy, but the first portion will contain shreds. In gleet the rigidity of the urethra causes the retention of small quantities of urine back of the thickened areas after each urination. This retained urine decomposes and adds to inflammation. Indulgence in alcohol, sexual excitement, or sexual intercourse aggravates the condition.

Treatment of Acute Gonorrhea.—*General Care.*—Wash the hands after touching the parts and dry them upon *individual towel*, which is not used upon the face. Wear a suspensory bandage. Avoid violent exercise, especially bicycle riding, and also exposure to dampness. Moderate exercise is allowable. The patient must not only refrain from sexual intercourse, but must not permit himself to indulge in sexual excitement, and must not drink a drop of liquor, malt, vinous, or spiritous, unless he be a heavy or a regular drinker, in which case we should permit the moderate use of a well diluted rye or Scotch whisky. Some men become actually ill without their regular daily stimulants and such men should have them in moderation. Some surgeons permit the moderate use of claret to all patients. At least twice a day wash the penis for five minutes in a cup of warm water containing 1 dram of salt. Passing the urine while the penis is immersed in warm fluid lessens ardor urinæ. Cut a small opening in a square piece of old linen, slip the linen over the glans, catch it back of the corona, and bring the ends forward with the prepuce. Never permit the cotton or linen to stick fast and plug up the lips of the meatus. If the lips tend to become sealed up, grease them with sterile vaselin. If the glans be completely naked, pin the foot of an old stocking upon the undershirt, put absorbent cotton in the toe, and place the penis within this bag. Never tie or fasten any material about the penis. Gauze bags, in which the penis can be suspended, can be bought at small cost and should be burned when soiled. The patient should drink freely of plain water or of water containing a little bicarbonate of sodium. He should obtain one bowel movement every day.

Diet and Instruction List (Dr. T. C. Stellwagen, Jr.).—*Meats.*—May have white meat of chicken, boiled fish, lamb.

Must not take beef, beef steak, veal, pork, liver, kidney, etc.; nor salt fish, meats, smoked, canned, or potted foods.

Vegetables.—May have rice, hominy, string beans, fresh peas, beans, baked potatoes (sweet and white), lentils, etc.

Must not take rhubarb, tomatoes, asparagus (Guitéras's rule. See Begg in "Phila. Med. Jour.," June 7, 1902), lemons, oranges, limes, or preserved fruits.

Drinks.—Nothing but plain water and milk.

Must not take alcoholic beverages or carbonated drinks.

Must not take salt, spices, condiments, cheese, or pickles.

Desserts.—Only of the simplest kind, made from milk and eggs, and take them sparingly.

General Rules.—Put on a suspensory bandage and wear it in conjunction with a piece of linen or a bag to catch discharges.

Wash the hands after handling the parts, and keep the fingers away from the eyes.

Keep the linen from contaminating the family wash. This rule applies particularly if baby girls are in the household.

Wash the organ frequently in warm salt water (1 teaspoonful of table salt to 1 glass of water).

When urination causes burning, immerse the organ in a basin of warm water and allow the urine to flow.

Keep the body warm and free from chilling.

Should not go about on rainy or snowy days without ample protection.

Should go to bed early.

Must not take cold baths. Should take warm baths.

Should not eat between meals—it is unwise to overload the stomach.

Should drink freely of plain water or milk.

Should urinate when the desire comes.

Should keep away from females socially and sexually—and all other exciting influences, such as erotic sights, thoughts, and literature.

Must keep bowels loose.

A smoker should decrease the consumption of tobacco.

Never put pieces of cotton over the end of organ, as cotton so used prevents the free drainage of discharge. Should the lips of the opening seal together, wash clean in warm salt water and grease with vaselin.

A tea or coffee drinker may have a small amount once daily, but it will be better not to partake of either.

Should the patient be using an injection and find that the desire for urination becomes frequent at night, he must stop the injection and consult his physician.

The injection is never to be forced into the urethra; it is to be introduced gently, and the bladder is to be empty when an injection is given.

Do not carry heavy burdens, crank automobiles, or drive them.

Remember that rest is of great importance.

Abortive treatment may be tried if the case is seen early. The use of strong solutions of powerful germicides has been abandoned because of the great pain they produce and the inevitable subsequent crippling of the urethra.

Abortive treatment is applicable to specially selected cases only, and even then usually fails. It should never be used after the gonococci have invaded the submucosa, but only during the prodromal stage, when it is hoped that the germs are upon and not in the mucous membrane. This stage usually lasts but a few hours, seldom over forty-eight. The patient generally presents himself after this period has passed. When the symptoms as described in the prodromal period prevail, the abortive treatment may be tried, after explaining to the patient that it will cause some pain and discomfort and in the end may fail or even aggravate the inflammation.

Germicides may be used and with some chance of killing the infection, for as yet the organisms are growing upon the superficial strata of epithelium much as a sod of grass upon soil. When the deeper structures have been invaded it is folly to attempt to abort the disease.

The abortive method advocated by White and Martin and which has proved successful in Prof. Hiram Loux's Clinic in a limited number of selected cases is as follows: After urination 4 drops of a 4 per cent. solution of eucain are injected into the urethra, after which 2 drams of $\frac{1}{4}$ per cent. solution of protargol are instilled and retained for three minutes. The injections are repeated every two hours while awake.

Each time the bottle is half emptied it is replenished with sterile water to its full capacity, until the end of the third day. If successful, recovery is accomplished in about seven days. Should a mucoid discharge persist an antiseptic astringent injection is employed to complete the cure. During the treatment the patient must be kept at rest. The diet should be bland and light and the usual balsamic remedies are administered. If the symptoms become hyperacute, stop the treatment at once and give a sedative.

Another abortive method is the use of hot retro-injections of corrosive sublimate solution (1 : 20,000), 2 pints being run through the urethra once a day. If in seventy-two hours the symptoms are not greatly improved, abortive treatment should be abandoned. Recent studies render it almost certain that there is no real abortive treatment. Abortive treatment, to be efficient, would have to be carried out before the gonococci penetrated the epithelial cells; in other words, would need to be instituted before the distinct symptoms of the disease appear. Janet says that we must

alter our conception as to what constitutes abortive treatment, and he doubts if a case of true gonorrhea has ever been really aborted.[1] The method of irrigation with solutions of permanganate of potassium is really a prophylactic treatment. Janet applies his treatment as evidences of trouble present themselves, and before acute symptoms appear, and claims that in most persons the disease can be arrested in from eight to twelve days. The same plan of treatment is useful in a well-developed case.

Irrigation in Gonorrhea.—Irrigation can be used in an incipient or in a well-developed case. Janet's method is as follows: An irrigator is filled with a warm solution of permanganate of potassium (1 : 4000). The patient after emptying his bladder is

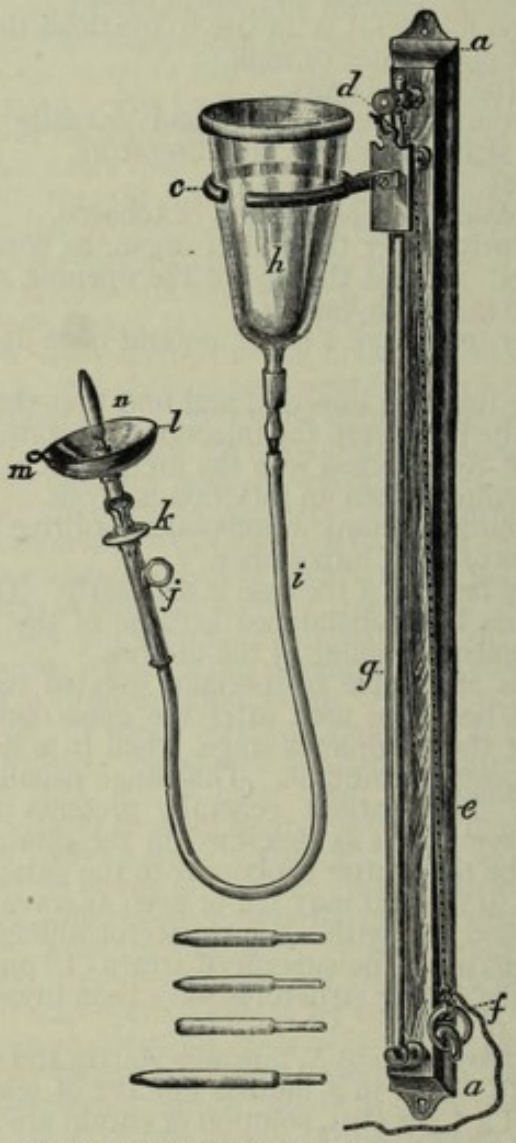


FIG. 1072.—Valentine's urethral and intravesical irrigator: *a*, Board with attachments to be screwed to wall; *c*, open collar; *d*, pulley; *e*, cord; *f*, ring to suspend ercolator; *g*, brass rod; *h*, percolator; *i*, rubber tube; *j*, ring for fourth finger; *k*, flange to graduate pressure; *l*, shield; *m*, ring to suspend shield; *n*, nozzle attached.

seated upon a chair and his sacrum rests upon the extreme front edge of the chair (Valentine's position). The reservoir is joined to a glass nozzle by a rubber tube. The nozzle is introduced into the meatus, and the fluid is permitted to run gradually at first, with full force later. In anterior trouble the fluid is allowed to run out of the meatus by the side of the nozzle. The anterior urethra is always irrigated first, the reservoir being 2 feet above the chair.

In posterior urethritis, after the anterior urethra has been irrigated, the reservoir is raised from 6 to 7 feet above the penis, the meatus is held tight about the nozzle, and the fluid overcomes the force of the compressor muscles of the urethra and the bladder sphincter and enters the bladder. If the muscles do not quickly relax, con-

[1] "Ann. d. mal. d. org. gén.-urin.," 1896, p. 1031.

tinue the hydrostatic pressure for several minutes, when relaxation will usually occur; but if it does not do so, tell the patient to breathe slowly and deeply, and to make efforts at urination (Valentine's plan). When the bladder is full the tube is withdrawn and the patient micturates. This procedure is practised once or twice a day for five or six days, or even longer, and the strength of the solution is gradually increased up to 1 : 1000. It has been claimed that after one or two weeks of this treatment gonococci permanently disappear in the majority of cases. Figure 1072 shows the ingenious and very useful irrigator devised by Ferd. C. Valentine, of New York. Valentine[1] has constructed the table shown below, which is of use to a practitioner who wishes to employ irrigations with permanganate of potassium in the treatment of acute gonorrhea. I followed the method set forth in this table in a great number of cases, and regarded it as an extremely useful systematic plan.

First day, first visit.	Anterior irrigation	1 : 3000
First day, 7 P. M.	Anterior irrigation	1 : 4000
Second day, 9 A. M.	Anterior irrigation	1 : 3000
Second day, 7 P. M.	Anterior irrigation	1 : 4000
Third day, 9 A. M.	Intravesical irrigation	1 : 6000
Third day, 7 P. M.	Anterior irrigation	1 : 5000
Fourth day, 9 A. M.	Intravesical irrigation	1 : 5000
Fourth day, 7 P. M.	Intravesical irrigation	1 : 5000
	Anterior irrigation	1 : 2000
Fifth day, Noon.	Intravesical irrigation	1 : 5000
Sixth day, Noon.	Intravesical irrigation	1 : 5000
Seventh day, Noon.	Intravesical irrigation	1 : 5000
Eighth day, 9 A. M.	Intravesical irrigation	1 : 5000
	Anterior irrigation	1 : 3000
Eighth day, 7 P. M.	Intravesical irrigation	1 : 5000
	Anterior irrigation	1 : 2000
Ninth day, 9 A. M.	Intravesical irrigation	1 : 4000
	Anterior irrigation	1 : 1000
Ninth day, 7 P. M.	Intravesical irrigation	1 : 4000
	Anterior irrigation	1 : 1000
Tenth day, 9 P. M.	Intravesical irrigation	1 : 4000
	Anterior irrigation	1 : 1000
Tenth day, 7 P. M.	Intravesical irrigation	1 : 5000
	Anterior irrigation	1 : 500

For full directions regarding this method see Valentine's book, "The Irrigation Treatment of Gonorrhea." If a stricture exists, it is not advisable to employ this treatment. Excellent results can be obtained by irrigations with fluid containing silver nitrate (1 : 12,000 to 1 : 8000).

When a patient is treated by irrigation, after the entire subsidence of acute symptoms, a thin, colorless discharge may persist. This can be cured by the use of astringents. Two or three times a day an astringent is injected by means of a ½-ounce syringe. Dalton's formula is very useful: Zinc oxid and lead acetate, of each, ½ to 3 gr.; tincture of catechu, from 10 to 30 min.; glycerin, from ½ to 1 dram; and water to make 1 oz. Ultzmann's formula is: Zinc sulphate, 16 gr.; pulverized alum, 8 to 12 gr.; carbolic acid, 3 gr.; and water to make 4 oz.

Many writers oppose the irrigation treatment, claiming that it increases the liability to complications, especially prostatic inflammation, and enhances the danger of recurrence. I believe in the method. I do not think it shortens materially the duration of the disease, but do believe that it mitigates its intensity, makes the patient much more comfortable, and quickly causes the discharge to become mucopurulent. That it increases complications and the danger of reinfection is very doubtful. Much of the trouble which has followed its use has been due to raising the reservoir to too great a height.

Irritative gonorrhea will subside in a few days. The above directions should be followed, and the anterior urethra should be washed out several times daily with diluted peroxid of hydrogen, or irrigated once a day with a hot solution of permanganate of potassium (1 : 4000). In *catarrhal gonorrhea* at once order injections (1 gr. to the ounce of sulphate of zinc; or zinci sulphas, 8 gr.; plumbi acetas, 15 gr.; water, 8 oz.; or 5 gr. of sulphocarbolate of zinc to 1 oz. of water; or White's prescription of 1 dram each of acetate of zinc and tannic acid, 8 drams of boric acid, 6 oz. of liq. hydrogen peroxid). For injecting use a blunt-pointed hard-rubber syringe of a capacity of

[1] "The Irrigation Treatment of Gonorrhea."

3 or 4 drams. Let the patient urinate and then sit on a chair, his buttocks hanging over the edge; throw a syringeful of the solution into the urethra and let it run out at once, and throw in another syringeful and hold it in from three to five minutes.

In *ordinary acute gonorrhea* we follow an old rule when we order balsams. The common custom is to give 2 capsules three times a day, each capsule containing 5 gr. of salol, 5 gr. oleoresin of cubebs, 10 gr. balsam of copaiba, and 1 gr. of pepsin. Clinical observation indicates that the balsams are of distinct value in gonorrhea. When used early, the discharge tends to become mucopurulent and the acute symptoms usually soon begin to subside (S. Behrmann in "Dermatologisches Centralblatt," Berlin, Nov. and Dec., 1901). Many practitioners will not use balsams until the third week. Bacteriologic studies indicate that copaiba, when eliminated in the urine, has a certain amount of power in inhibiting the growth of gonococci, but that cubebs and oil of sandal have not such power. Yet oil of sandal is more useful than copaiba as a remedy. Salol is distinctly germicidal, hence it is given with the balsams. In a case treated by balsams an astringent injection is usually employed. The injection is used two or three times a day, immediately after micturition. As the inflammation subsides the strength of the injection should be gradually increased. A good plan is to order an 8-oz. bottle and eight 1-gr. powders of sulphate of zinc. Direct the patient to fill the bottle with water, in which one powder is dissolved; when this is used dissolve 2 powders in a bottleful of water, and so progressively increase the strength. When the discharge ceases stop the injections gradually. Whenever a syringeful is taken from the bottle a syringeful of water is put into the bottle, and thus pure water is soon obtained, at which point injection is discontinued. If a simple astringent injection causes much pain, use a sedative injection—2 drams of boric acid, 8 gr. of aqueous extract of opium, and 8 oz. of liquor plumbi subacetatis dilutis. I have had about as much success with the above simple method as with the most complicated plans. Complication and complexity are not criterions of usefulness.

Protargol, metallic silver combined with a protein, is a yellow powder soluble in water, the solution not being acted on by light. It is a non-irritant germicide. Neisser, after demonstrating the presence of the gonococcus, administers protargol by injection, the first injections being of a strength of 0.25 per cent., the strength gradually increased to 0.5 per cent., and finally to 1 per cent. In the beginning he orders three injections a day, each injection being retained from fifteen to thirty minutes; after several days, when the symptoms improve, he gives only one or two injections a day, and these are continued for ten days after gonococci disappear from the discharge. After protargol is abandoned an astringent injection should be used for a time. Some surgeons use a 1 : 1000 solution of protargol, and irrigate the anterior urethra and flush the bladder twice a day.

The following injection is of ancient lineage, but still useful:

℞. Hydrarg. chlor. corros..... gr. ½;
Zinci sulphocarbolas..... ℥ss;
Acidi boraci..... ℥ij;
Acidi carbolici..... ♏xv;
Boroglycerid (25 per cent.)..... f℥ij;
Aquæ destil.....q. s. ad. f℥vj.—M.
Sig.—Inject. Dilute if it causes much pain.

When all symptoms of clap have disappeared, any injection in use is gradually diluted. Whenever a syringeful of the fluid is taken from the bottle, a syringeful of water is put in. When the fluid becomes pure water the injection is discontinued. Balsams are stopped by gradual diminution in the number of daily doses. For three weeks after the entire disappearance of all symptoms alcohol is forbidden and sexual indulgence is prohibited. Should a relapse occur the patient is at once placed upon treatment as for the acute stage, and when the stage of decline again ensues he is placed again on antiseptics and astringents. Relapses are caused by a localized lesion or lesions in the anterior or posterior urethra, hence as soon as all acute symptoms subside an endoscopic examination is to be made and proper treatment is to be applied to any localized lesion. If during the treatment of gonorrhea a complication develops, local treatment of the urethra is at once discontinued and constitutional treatment suited to the new condition is prescribed.

If the early stage of gonorrhea is marked by violent inflammatory symptoms (chordee, hemorrhage, severe pain, swelling, profuse purulent discharge), local treatment of the urethra is contraindicated.

If the invasion is hyperacute, no local treatment of the urethra is permissible until the disease assumes the character of ordinary gonorrhea.

Not unusually gonorrhea passes into a low grade of anteroposterior urethritis that proves most rebellious to treatment. This condition is especially common when too stimulating a treatment has been used. A mild astringent injection should be used three times a day. Every second or third day an injection of nitrate of silver (1 : 4000) should be given. If the silver salt sets up an acute inflammation the treatment recommended in the acute stage of gonorrhea is given until the symptoms abate.

A valuable plan in rebellious anteroposterior urethritis is daily irrigation of the anterior urethra with a warm solution of permanganate of potassium (1 : 6000), followed by direct intravesical injection (page 1134) or by the passage of a soft catheter and the filling of the bladder with a like solution. The patient empties his bladder after the catheter is withdrawn and thus flushes the entire urethra with the permanganate. The strength of the solution is gradually increased up to 1 : 2000.

Weiss used corrosive sublimate (1 : 20,000) in the manner just described. It is said to be particularly valuable in cases of bacterial contamination, the gonococci having disappeared. In all cases in which the discharge persists the endoscope should be used to determine the condition of the anterior and posterior urethra. The prostate and seminal vesicles should be examined and their secretions studied for the presence of pus-cells or even gonococci. It is also most essential to rule out the secondary infections by other organisms than the gonococcus. In many of these intractable discharges the use of an autogenous vaccine combined with local treatment may do good. A stock polyvalent vaccine with the offending organism prevailing will often answer. It must always be remembered that a clear urine may be present, but the prostate or vesicles, or both, may be grossly affected. Also a kidney may be responsible for the trouble and should at least be ruled out in intractable cases. I have seen an apparently chronic urethral discharge cured by lavage of a kidney pelvis.

Treatment of Complications.—*Ardor urinæ* is relieved by urinating while the penis is immersed in hot water and by administering alkaline diuretics. *Chordee* requires a bowel movement in the evening, and sleeping in a cool room, under light covers, and on a hard mattress; bromid of potassium is given several times daily, and a considerable dose is given at night; it may be necessary to use suppositories of opium and camphor or to give hyoscyamin. *Balanitis* requires frequent washing of the head of the penis and prepuce in warm salt water, drying with cotton, and dusting with borated talc, stearate of zinc or boric acid, and subnitrate of bismuth (1 : 6). *Balanoposthitis* requires soaking in hot water, and injections of black wash under the prepuce until edema of the foreskin subsides, and then cleanliness and the application of a drying powder. *Phimosis* requires soaking the penis in hot water, and injections of hot water beneath the foreskin, followed by black wash. If this fails, circumcision must be performed. If *paraphimosis* occurs, grasp the head of the penis with the fingers of the left hand, squeeze the blood out, and try to push the head back, while with the right hand the penis is pulled upon as if the surgeon intended to lift the individual by the organ. If this fails, cut the collar on the dorsum with scissors; or, what is better, for it gives free exposure, incise each side of the prepuce between the middle of the dorsum and the frenum. *Bubo* requires the application of iodin, ichthyol, or blue ointment, the use of a spica bandage, and rest. If a bubo suppurates, it must be opened or aspirated. *Acute posterior urethritis* is treated by rest, and if the symptoms are severe, by rest in bed. If the balsams do not irritate, they are given; if they do, they are withdrawn. Hexamethylenamin or salol is given and the patient is placed upon a milk-diet with orders to drink largely of flaxseed tea. Alkaline fluids do harm by favoring ammoniacal decomposition of the urine. Injections and irrigations are abandoned. Pain and vesical spasm are controlled by suppositories of opium and belladonna. If retention of urine occurs, have the patient urinate while in a hot bath; if this fails, use a soft catheter. *Acute vesiculitis* is treated as is acute prostatitis. Chronic vesiculitis is considered on page 1362. *Pyelitis* is treated by rest in bed, hot baths, wet cupping of the loin, milk-diet, diuretics, the drinking of a large quantity of bland liquid, and the administration of salol or hexamethylenamin, and in some cases lavage of the kidney pelvis through a ureteral catheter with one of the silver preparations (1 : 15,000 of nitrate of silver), and injections of neo-arsphenamin or autogenous vaccines. *Folliculitis* is treated by rest and the application of a hot-water bag to the perineum (if that be the part involved). If pus forms, evacuate by incision. Later the follicle may be dissected out or destroyed by cauterization. If the follicle opens into the urethra it may be cauterized through an endoscope. *Peri-urethritis* is treated by rest and hot

applications. If pus forms, an incision must be made. If the abscess is permitted to break into the urethra, rest and hot fomentations may be used, but at the first sign of urinary extravasation make an external incision. *Cowperitis* is treated in the same way as peri-urethritis. Gonorrheal rheumatism is considered on page 598. *Acute prostatitis* and *cystitis* require confinement to bed, a milk-diet, the use of diuretics, hot applications to the perineum and hypogastrium (bags of hot sand), hot sitz-baths, suppositories of opium and belladonna or of ichthyol, leeching the perineum, the discontinuance of balsams and injections, and the administration of hexamethylenamin or salol. Heat can be applied by means of a stream of warm water which circulates through a metal instrument introduced into the rectum. *Abscess of the prostate* requires instant incision. In *retention of urine* the patient should try to pass the urine while in a hot bath; if this fails, a soft catheter is used. After relieving the bladder put the patient to bed and apply hot sand-bags as for acute prostatitis. *Chronic prostatitis* requires cold hip-baths, cold-water enemata, deep urethral injections, massage of the prostate, plain diet, avoidance of alcohol and overexertion, insistence on counterirritation of the perineum, and the relief of stricture or phimosis. Great benefit is occasionally derived from passing a grooved, soft bougie covered with blue ointment or with a 1 per cent. ointment of silver nitrate. If *epididymitis* arises, put the patient to bed, abandon injections, shave the hair from the groin, leech over the cord, elevate the testicles, and early in the case apply an ice-bag. Drainage of the epididymus by puncture is often done (Hagner). Give a cathartic, a fever mixture, and suitable doses of bromid of potassium and morphin. The local application twice a day of 20 drops of guaiacol in 1 dram of cosmolin or olive oil may give relief. When swelling lingers, *after tenderness subsides* strap the testicle with adhesive plaster. A lingering case is benefited by the internal use of iodid of potassium and the local application of ichthyol. In *gonorrheal ophthalmia* secure a watch-crystal over the unaffected eye, put the patient in a darkened room, rub the infected conjunctival sac with cotton soaked in a 2 per cent. solution of silver nitrate, wash out the affected eye repeatedly with hot boric acid solution, keep the pupil dilated with atropin, leech the temple, and give purgatives. Always send for an ophthalmologist.

When is Gonorrhea Cured?—It is said that Ricord declared: "We know when clap begins, but God alone knows when it ends." When actual discharge ceases a patient considers himself cured, and yet he may have residues of infection which are liable at any time to awaken into activity and produce anew an acute condition. Gonococci are frequently retained in the urethral glands and follicles or in areas surrounded by indurated mucous membrane. Gonococci may linger in these haunts for many months, some say for years. Keyes, however, maintains that they never persist in the male urethra over three years and that in 90 per cent. of cases, with or without treatment, they disappear within one year (Edward L. Keyes, Jr., in "Amer. Med. Sci.," Jan., 1912). It is customary to consider a man well when, after he has been without treatment for one week, shreds and pus disappear from the urine, when an examination of expressed mucus on three successive days fails to find gonococci, and when there has been no discharge for ten days. Furthermore, we must be sure that the prostate, Cowper's glands, and the seminal vesicles are free from disease. Never declare a man well under three months from the start of the disease unless gonococci are positively absent from the urine and the expressed discharge.

If a patient has "no morning drop," has been apparently well for three or four months, has no pus in the morning urine or in the expressed secretion of the urethra, prostate, and seminal vesicles, we can, without making cultures, affirm that he is well (Keyes, Ibid.).

Keyes also maintains that a man with a "pearly morning drop" who passes a urine containing pus-shreds, but who has no free pus in expressed secretions, is probably free from gonorrhea.

Treatment of Chronic Gonorrhea and of Chronic Urethritis Following Gonorrhea.—The first thing to do is to determine the *cause* of the prolongation of the discharge. This usually can be done by a careful study of the history of the case followed by a searching examination of the prostate, vesicles, urethra, kidneys, and the ducts and glands that are allied with the genito-urinary tract.

Exploration of the urethra is inaugurated by inspection and external palpation. Palpation detects induration, peri-urethritis, follicular abscess or inflammation, Cowperitis, etc. The prostate and seminal vesicles are examined by a finger in the rectum . The interior of the urethra is explored by a soft bougie-à-boule. On withdrawing this instrument the shoulder catches in any contracture. It is to be borne in

mind that a large steel sound can often be introduced with ease when the bougie-à-boule makes it evident that a contracture exists. The emergence of the instrument is arrested by a patch of thickening, a granular area, a zone of epithelial proliferation, a papilloma, or a stricture. In fact, anything which lessens the urethral caliber interferes with the withdrawal of the bougie-à-boule. It does not do to conclude that

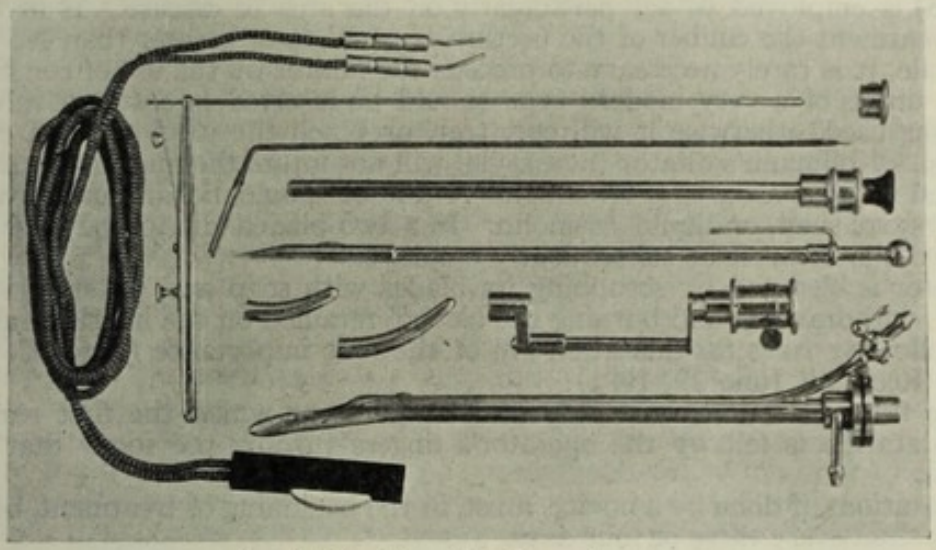


FIG. 1073.—Wassidlow's urethroscope.

stricture exists simply because some lessening of caliber is appreciated. The bougie-à-boule finds its chief use in exploring the anterior urethra. If introduced into the deep urethra its emergence will be normally checked as its shoulder comes against the posterior layer of the triangular ligament. In the hands of the inexperienced operator the bougie-à-boule will often mislead.

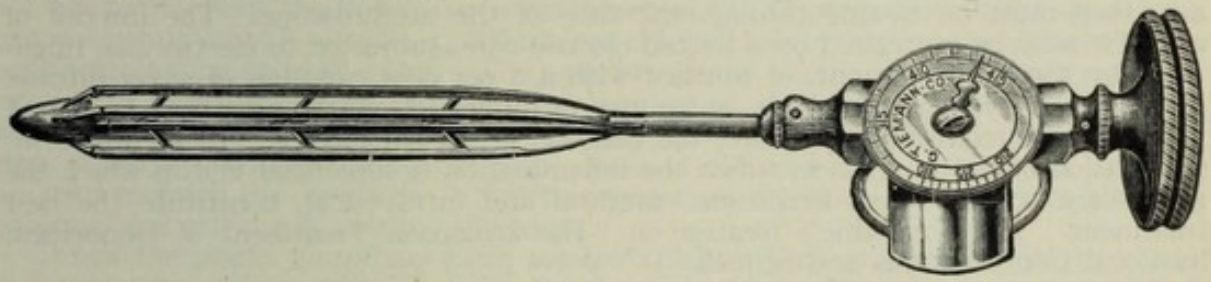


FIG. 1074.—Kollmann's anterior dilator.

In most cases the diagnosis is only certainly determined by the use of the urethroscope (Fig. 1073). This instrument has been perfected of recent years and is now an absolutely essential part of our armamentarium.

When the cause of a discharge is once determined, rational treatment can be instituted, and to determine the cause the electric urethroscope is indispensable. An

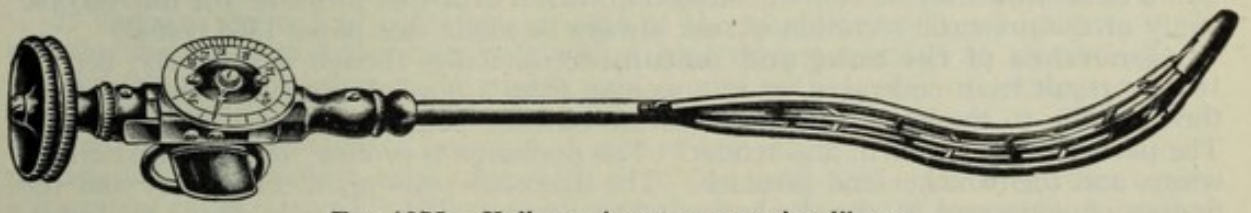


FIG. 1075.—Kollmann's anteroposterior dilator.

erosion of the mucous membrane or a granular patch requires touching from time to time with a solution of silver nitrate (1 or 2 per cent. or even much stronger). These applications are made through the tube of the urethroscope. A stricture or an infiltration is treated by gradual dilatation. This combines pressure and massage. If the caliber of the urethra be less than No. 21 of the French scale, conical steel sounds are used twice a week. If there be much hyperesthesia they are retained but a brief time; but as hyperesthesia diminishes the period of retention is lengthened, until an

instrument can be kept in place without causing severe suffering for ten or fifteen minutes. It is not desirable to use cocain. Its use is not free from danger and, further, it obtunds the sensibility so that undue violence may be used, and it increases post-operative inflammation. Before and after using an instrument the urethra must be cleansed by irrigation with salt solution or permanganate of potassium.

When the urethra becomes tolerant to instrumentation, a special dilator (Figs. 1074, 1075) is employed to act particularly on the area of disease. If in the beginning of treatment the caliber of the urethra is equal to or greater than No. 21 of the French scale, it is rarely necessary to precede the dilator by the use of conical sounds. A dilator unless of a very modern type should be inserted in a sterile rubber cover before being used, otherwise it will cut, tear, or pinch the urethra when closed and withdrawn. Kollmann's dilator (new style) will not injure the mucous membrane and can be used without a cover (Fig. 1074). A dilator should be lubricated with lubrichondrin, synol soap, or liquid cosmolin. If a two-bladed dilator be used at first, a four-bladed dilator must be subsequently employed.

A dilator is cleansed by scrubbing its blades with soap and water, placing them in alcohol, withdrawing, and burning the alcohol retained on the instrument.

The following rules for dilatation are of the first importance (Ferd. C. Valentine in "Med. Record," June 29, 1901):

1. The first dilatation must stop at that point at which the first resistance to further dilatation is felt by the operator's fingers turning the screw that separates the blades.

2. Dilatations, if done by a novice, must, in the beginning of treatment, be repeated no oftener than every three or four days.

3. Each dilatation in point of time must reach no greater duration than two minutes over that of the preceding session.

4. No dilatation must exceed one-half number (French Charrière scale) above the number attained at the next prior séance, regardless of any lack of resistance that may be present. The mechanical dilators are capable of doing great harm. They must be used very gently.

Glandular and follicular infiltrations may be cured by the dilator. If they are not, they must be treated through the tube of the urethroscope. The interior of a follicle may be cauterized by a heated electric wire, subjected to electrolysis, fulgurated by the Oudin current, or touched with a 3 per cent. solution of silver nitrate. A thickened crypt, gland follicle, or an area of induration may be slit by a knife. A polyp can be removed by a snare, the cautery, or special forceps. In a chronic inflammation of the urethra, in which the inflammation is superficial and in which the glands are not involved, irrigations, urethral and intravesical, constitute the best treatment. (See Valentine's treatise on "The Irrigation Treatment of Gonorrhea, its Local Complications and Sequels.")

In any lingering case of gonorrhea examine the urine, and direct suitable treatment for oxaluria, lithemia, or phosphaturia, if any one of these conditions exists. Such morbid states of the urine are occasionally responsible for great prolongation of the inflammation. In some cases a discharge is kept up by inflammation of the seminal vesicles. In spite of what some clinicians teach, it seems certain that the prostate and seminal vesicles are more often at fault than any other portion of the genito-urinary tract. Careful microscopic study should be directed to them, and since it is known that a clear urine may be seen in connection with a catarrhal prostate, the microscopic study of the prostatic secretion should always be made (see pages 1363, 1364).

Gonorrhea of the anus and rectum occasionally, though very rarely, occurs. It may result from pederasty, or in a woman from a flow of infectious material from the genitalia to the anus. It causes severe burning pain, aggravated by defecation. The parts are red, swollen, and tender. The discharge is profuse, being at first cream white, and then thicker and greenish. The diagnosis rests upon the history and the finding of gonococci in the discharge. The disease rarely extends above the anus. I have seen one undoubted case of rectal gonorrhea. Stellwagen has seen 3 cases of gonorrhea of the rectum.

Treatment.—If the anus only be involved, spray it several times daily with peroxid of hydrogen, wash with salt solution, irrigate with permanganate of potash (1 : 4000), dust with talc powder, and interpose a piece of iodoform gauze between the inflamed surfaces. An ulcer, a fissure, or an excoriation is touched with lunar caustic. If the rectum becomes involved, secure a daily bowel movement and irrigate the rectum twice a day with boric acid solution or permanganate of potassium (1 : 4000).

Gonorrhea of the Mouth.—This is a very uncommon malady. It occurs in infants more often than in older people. Infection in infants may take place during birth if the mother has gonorrhea. The symptoms are those of violent stomatitis. The diagnosis is suggested by the condition of the mother and is proved by finding gonococci in the discharges from the mouth.

Treatment.—Wash the mouth frequently with boric acid solution, and swab the diseased areas at intervals with a 1 per cent. protargol solution.

Gonorrhea of the Nose.—It is alleged that this condition can arise, but an absolutely authentic case does not seem to be on record.

Gonorrhea in the Female.—There is much dispute as to the parts infected. Some observers maintain that the vaginal epithelium never contains gonococci and that gonococci found in a vaginal discharge have come from the cervix or uterine canal. Beyond a doubt, however, when young women who have not born children contract gonorrhea the vulva and vagina usually suffer. In older women and in women who have born children the vaginal tissues are altered and the cells are not nearly so prone to infection; hence in such subjects the vagina usually or at least often escapes. The initial infection is in many cases in the cervical canal, in some in the vulva or urethra. No matter what part has been first attacked, other parts usually become quickly involved in the acute process. The urethra is involved in almost every case. Chronic gonorrhea is prone to linger in the urethra, in the glands of Bartholin, in the cervical canal, or within the uterus or in the Fallopian tubes. The great danger of gonorrhea in the female is the development of ascending infection of the lining membrane of the uterus, which may reach the tubes, ovaries, and peritoneum.

When infection occurs during pregnancy or when pregnancy occurs during infection of the cervical or uterine canal, abortion may take place. Again, a pregnant woman may not abort, but may go on to term and the child may receive a conjunctival infection during delivery and rapidly develop purulent ophthalmia.

In some cases when pregnancy occurs during the existence of gonorrhea the disease seems to pass away, and yet the child gets conjunctival infection during delivery or the mother subsequently develops pus-tubes.

Treatment.—Place the patient in bed during the acute stage of the disease, give hot hip-baths, keep the bowels open by means of saline purgatives, insist on a fluid diet consisting chiefly of milk, and flush out the urethra by having the patient drink considerable quantities of water. The external genital organs should be sprayed with peroxid of hydrogen every two or three hours, and after spraying should be dried with absorbent cotton and dusted with equal parts of starch and powdered oxid of zinc, or with powdered stearate of zinc. Pads of cotton fixed in place by a bandage are used to catch the discharge. If urethritis exists in this stage, we may give alkalies, balsams, and astringent urethral injections.

When the acute symptoms have somewhat abated an attempt should be made to prevent ascending infection from the cervical canal. The mucous membrane of the canal may be curetted away or be destroyed by pure carbolic acid or nitrate of silver. A wiser plan is to paint the cervical canal daily with iodin, painting the vaginal portion of the cervix at the same time with the same drug. The vagina is irrigated twice a day with a warm solution of permanganate of potash (1:4000) and is lightly packed with iodoform gauze. When the vulva particularly is involved, treat that part by applying acetate of aluminum (2 per cent.) locally or paint the vulva with silver solution (40 gr. to 1 oz.). If the vulvovaginal gland suppurates, incise it.

If vaginitis exists and continues in spite of the treatment suggested above, wash out the vagina every two hours, first with 1 pint of hot solution of bicarbonate of sodium, next with 1 pint of hot water, and finally with 1 pint of astringent solution (1 teaspoonful of lead acetate, 1 teaspoonful of zinc sulphate, 1 teaspoonful of alum, or 4 teaspoonfuls of tannin to 1 pint of hot water). As the attack subsides, use vaginal suppositories, each containing 5 gr. of tannic acid. In some cases apply solutions of silver nitrate (1:200) and insert tampons of ichthyol (8 per cent.) moistened with boroglycerid (Le Blonde).

In chronic cases of urethritis use strong solutions of silver nitrate and irrigate the urethra and bladder with silver nitrate (1 : 8000).

For *uterine gonorrhea* observe the same general management. Swab out the uterus with dilute tincture of iodin or nitrate of silver and insert tampons of iodoform gauze.

Gonorrhea in Children.—Male Children.—This disease is not very common. When it affects children under twelve it is usually due to some abandoned and diseased female having brought the child's penis in contact with her sexual organs.

It may result from introducing infected materials into the penis. The symptoms are similar to but more acute than those met with in an adult. The finding of the gonococci is clinical but not absolute legal proof of the existence of gonorrhea, and it is to be remembered that boys may suffer from catarrhal urethritis as a result of introducing irritants, from balanoposthitis, or from overacid urine. Legal proof is afforded by the growth of the suspected micro-organisms on artificial blood-serum.

The *treatment* consists in confinement to bed during the acute stage, bland drinks, light diet, etc. Circumcision is necessary if phimosis exists.

Female Children.—Gonorrhea is more common in female children than in male children, and the vagina is involved as well as the vulva and urethra.

A female child may suffer from catarrhal inflammation of the vulva, as a result of the contact of foul urine or feces, of the presence of seat-worms, or of neglect of bathing. In such a case the vagina and urethra escape. Involvement of the vagina and urethra strongly suggests gonorrhea. A recently born child or a young infant may acquire gonorrhea directly from a diseased mother, or indirectly, by pus upon linen, from the mother's fingers, etc. A diseased nurse may infect the baby. Older children who have ceased to nurse may get the disease from infected linen, bathtubs, etc., and may by these means infect child after child in an institution. Now and then the disease arises by a man or woman deliberately bringing the child's private parts in contact with his or her own diseased organ.

The disease is acute; the urethra, vulva, and vagina are usually involved; the discharge is profuse, purulent, and often bloody. During the first day or two the discharge exhibits leukocytes but not gonococci, and the normal flora of the urethra disappear; later gonococci appear (Harmsen, "Zeit. f. Hyg. u. Infektionskr.," 1906, vol. iii). Microscopic examination of the discharge is absolutely necessary. Dry cover-slip preparations are made so as to obtain clap-shreds from the discharge. An attempt should be made to obtain cultures. The gonococcus is very difficult to maintain in culture; it must be frequently transferred, and it grows best in an incubator at a temperature of 36° C. No attempt is made to grow it upon ordinary culture-media. The finger may be sterilized and punctured, blood thus obtained being smeared upon ordinary agar. Upon this composite material growth can be obtained. Animal blood-serum is not a good medium, but human blood-serum is (Lehmann and Neumann). Human blood-serum is obtained by opening a vein or from a fresh placenta.

Lehmann and Neumann ("Atlas and Principles of Bacteriology") find the following a satisfactory medium: Agar, containing 1 per cent. peptone and 5 per cent. glycerin, which has been liquefied and cooled to 50° C., is mixed "with one-half its volume of ascitic fluid or the fluid from ovarian cysts." Plate cultures and streak cultures should be made. This excessive care in proving the presence of the gonococcus is imperatively necessary in female children because of the medicolegal questions which may arise in such a case and also because of the danger there is of the victim infecting other persons.

Surgeons are apt to be doubtful about the diagnosis in many supposed cases of gonorrhea in female children. The clinical picture may simply be that of catarrhal vulvovaginitis; it may be that of gonorrhea. The finding of the gonococcus is regarded as conclusive from a clinical standpoint, but not from the legal point of view. Again, as Taylor points out, in some cases in which the clinical evidence and microscopic findings seem to prove the existence of gonorrhea no proof can be obtained that the condition is of venereal origin, and in some cases in which everything indicates that the disease began as a catarrhal vulvovaginitis, a condition seemingly identical with gonorrhea has arisen. Obtaining a culture of gonococci is conclusive. The treatment consists in taking every care to prevent diffusion of the infection to others and to the patient's own eyes. She is put to bed, given frequent baths, and fed upon milk, etc. Irrigations of bicarbonate of sodium are employed, followed by protargol (1 : 5000, according to White and Martin). Later, astringent injections are indicated. In institutions for the care of children the most rigid precautionary measures against contamination are necessary. I have seen an epidemic started from one case that involved practically the entire household of girls.

Gonorrheal Arthritis (see page 598).—The treatment of this grave complication resolves itself into an attempt to control the disease at its original points of infection; supportive treatment and the use of internal remedial measures, such as phylacogens, vaccine, and certain combinations of drugs either in the colloidal state or otherwise.

The one drug that has stood the test of time is syrup of the iodid of iron administered in massive ascending doses. We have frequently given 200 drops three times

daily to arthritic cases. Of course, the clinician must be ever watchful when using such large doses.

Phylacogens have been used with some success and at times with brilliant results, but I have seen them do harm, and in most instances they have failed. The vaccines we have seen do good and use them, but they have not accomplished the results in our hands that have been reported by others. There is no specific treatment for gonorrheal arthritis, and it may be said that the individual who becomes so afflicted and is permanently cured is indeed fortunate. Dr. J. E. McDowell of the Jefferson Clinic has had excellent results from the use of the combination of colloids of iodin, sulphur, and others as suggested by McDougle and used by him in the Lock Hospital, London.

I have had some brilliant results from the use of a colloidal iodin. This is given intravenously in massive doses. Care must be exercised to prevent obliteration of the vein.

Focal areas of infection must be drained in the chronic cases; this particularly applies to the seminal vesicles. We have seen rapid cures produced by seminal vesiculotomy.

When the vaccines were used in the venereal clinic of the Jefferson Hospital they did not produce the happy results that some clinicians have reported.

Stricture of the urethra, or narrowing of the urethral caliber, is divided into *inflammatory*, *spasmodic*, and *organic*. The so-called *inflammatory* or *congestive* stricture is not a stricture, but is an inflammatory swelling of the mucous membrane.

Spasmodic stricture does not exist alone, but complicates organic stricture, a hyperesthetic urethra, or an inflamed bladder.

Organic stricture is a fibrous narrowing of the urethra, due, as a rule, to chronic gonorrheal inflammation or to traumatism. True organic stricture is very rare in children, but can occur. Abbe reported a case of impassable stricture in the deep urethra of a male child two and one-half years of age, due to urethral gonorrhea. There were also two strictures of the anterior urethra. External urethrotomy was performed. Traumatic strictures occur in the bulbous or membranous urethra, and are due generally to force applied to the perineum, the urethra being squeezed between the subpubic ligament and the vulnerating body. Strictures resulting from gonorrheal inflammation occur in the penile, bulbous, or membranous urethra. Stricture never forms in the prostatic urethra except as a result of traumatism. Recent non-traumatic strictures are soft and are easily distended. Old strictures and traumatic strictures are very dense. A *resilient stricture* is one which contracts quickly after dilatation. The nearer a stricture is to the meatus, the more fibrous it is.

A *congenital* stricture is congenital narrowness of a portion of the urethra, usually the portion near the meatus. The more fibrous a stricture is, the more it narrows the urethra and the less dilatable it will prove. A stricture may be annular (forming a ring around the urethra), tubular (surrounding the urethra for a considerable distance), or bridle (when a band crosses the urethra from wall to wall). A stricture of large caliber will admit an instrument larger than a No. 15 French sound. A stricture of small caliber will not admit a No. 15 French sound. An impassable stricture will not admit the passage of any instrument. "Impassable" is more or less a relative term. A stricture may be impassable when an anesthetic is not used, and passable when the patient is anesthetized, or may be impassable to one surgeon, but passable to another. Impassability is often a temporary condition due to spasm or to inflammatory edema about an organic stricture. The term "impermeable" as applied to some strictures is misleading. There are impermeable strictures, but they are not often seen, for any stricture that permits a drop of urine to pass is not impermeable. It may be impassable to instruments, but passable by urine. In those cases where urethral caliber is destroyed and where all urine passes through sinuses there is absolute impermeability.

Symptoms and Results of Stricture.—There is usually a history of repeated attacks of urethritis. There may exist a chronic discharge, the amount of which is variable. There is a feeling of weight in the perineum and soreness of the back, and frequency of micturition is complained of. Hypochondriacal tendencies are usual. In a deep stricture there is difficulty in starting the stream in micturition. In most cases the stream is small, twisted, and forked. There is often interruption or "stammering" of the stream, and it dribbles long after the conclusion of the act, so that the penis must be "milked" before it is returned within the clothing. The urethra back of a stricture dilates, a pouch forms, drops of urine collect and decompose, and in the

mucous membrane or the parts adjacent there results a chronic inflammation which may go on to ulceration or to periurethral abscess. A urinary fistula follows the opening externally of a periurethral abscess. Retention of urine may occur, not from actual obliteration of the tube by the growth of the stricture, but from closure of the lumen of the urethra by muscular spasm and from edematous swelling in the neighborhood of the stricture. Edematous swelling may be due to cold, wet, venereal excitement, the use of alcohol, overexertion, etc. Spasm of the muscles results, and contact of the urine increases the spasm, and spasm with edema of the mucous membrane closes the urethra. Spasm may exist in the urethra itself and in the muscles of the neck of the bladder, but is only a temporary condition. In old strictures the bladder is hypertrophied and often fasciculated, and is very liable to cystitis. The diagnosis of stricture and of its location is made by the use of exploratory bougies. In this examination the author follows to a great extent Ramon Guiteras's[1] plan which is as follows: Have the patient pass urine into two glasses. Examine the urine for clap-shreds. Cloudiness in the first glass shows that urethral discharge exists. Cloudiness in the second glass points to cystitis. The patient is placed recumbent with his shoulders elevated, and the urethra is washed out with warm salt solution or boric acid. Bulbous sounds are inserted, beginning with No. 15 French. If this passes with ease, take a larger size and note where strictures are situated by the catch on withdrawal. If No. 15 does not pass, use a smaller size. Remember that the posterior layer of the triangular ligament catches a bulbous instrument on withdrawal. If the meatus be too small to permit of exploration, enlarge at the inferior end by a curved bistoury, cutting from within outward. After cutting the meatus bleeding is arrested with styptic cotton, and a piece of absorbent cotton is tucked into the cut. After each act of micturition the patient inserts a fresh bit of cotton, and after three days the urethral examination may be proceeded with.

Treatment.—A stricture of large caliber in the deep urethra requires gradual dilatation. A steel bougie is introduced every fifth day, the size being gradually increased. Never anoint a bougie with vaselin, as it may become a nucleus for a stone in the bladder; use liquid cosmolin, glycerin, synol soap, or lubrichondrin. Before passing an instrument the patient urinates and his urethra is washed out with salt solution or boric acid solution. Glans, meatus, and urethra are cleansed as directed on page 1339. The sound is rendered sterile by boiling before using. Gradual dilatation can be effected by the use of the dilator of Oberlaender, the tube being distended to the extent of 3 mm. every fifth day. If after dilatation there be urethral spasm, pain, or very frequent micturition, suspend the treatment for a number of days and order each night a hot hip-bath and a dose of paregoric. During gradual dilatation the patient should not use alcohol, should refrain from sexual excitement, should avoid cold and damp, and should take internally capsules containing boric acid and salol. It is rarely necessary to dilate above No. 32 French. After the surgeon finishes treatment he teaches the patient to use an instrument and directs him to pass it once a month, because gradual dilatation rarely cures a stricture, and if dilatation be permanently abandoned contraction will probably occur. Strictures in the pendulous urethra, if soft, are treated by gradual dilatation; if fibrous and contractile, by internal urethrotomy. For fibrous stricture in or near the bulb external urethrotomy should be combined with internal division. External urethrotomy secures drainage, and by performing it we greatly lower mortality. In performing internal urethrotomy prepare the patient carefully; for several days before the operation give salol and boric acid by the mouth, and wash out the bladder repeatedly with boric acid solution. Be thoroughly aseptic. Anesthetize the patient. Before cutting irrigate the urethra with warm normal salt solution, and after cutting irrigate again, pass a rubber catheter into the bladder, and tie it in. These precautions will prevent urethral fever. In cutting the stricture insert the Otis dilating urethrotome and cut on the roof. Do not overdistend the urethra, simply fix it well with the dilator before cutting. Overdistention allows the knife to cut too deeply and may result in a subsequent deformity when the organ is erect.

Stricture of the meatus requires incision by a knife and the use of a meatus bougie until healing is complete. Strictures of small caliber in front of the membranous urethra require gradual dilatation and, if this fails, internal urethrotomy or divulsion. Internal urethrotomy can be performed with the urethrotome of Maisonneuve (Figs. 1076, 1077) or the Otis-Wyeth instrument (Fig. 1078). The instrument of Maisonneuve is shaped like a sound, has an interlocking groove upon its surface, and into this groove

[1] "Med. Record," Nov. 14, 1896.

a shaft carrying a triangular knife can be inserted. The staff is screwed to a guide, the guide is carried into the bladder, and the staff follows it. The point of the staff is carried to the prostatic urethra and the guide curls up in the bladder. The penis is held upon the stretch, the blade is inserted, and pushed down through the stricture. This instrument cuts the stricture, but not the healthy urethra. Stricture within 1 inch of the meatus is divided on the floor of the urethra. A deeper stricture is divided on the roof, except at or near the bulbomembranous junction. In such a stricture

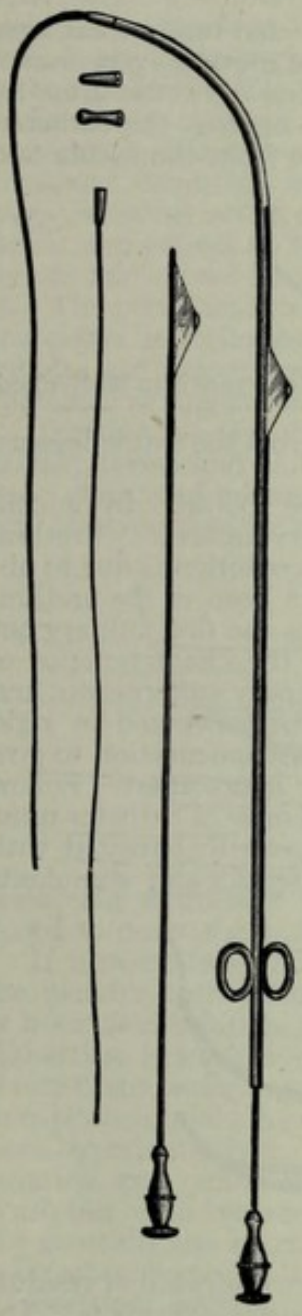


FIG. 1076.—Maisonneuve's urethrotome.

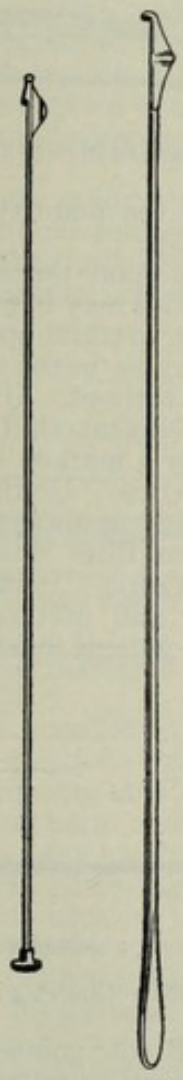


FIG. 1077.—Horwitz's modification of Maisonneuve's urethrotome.

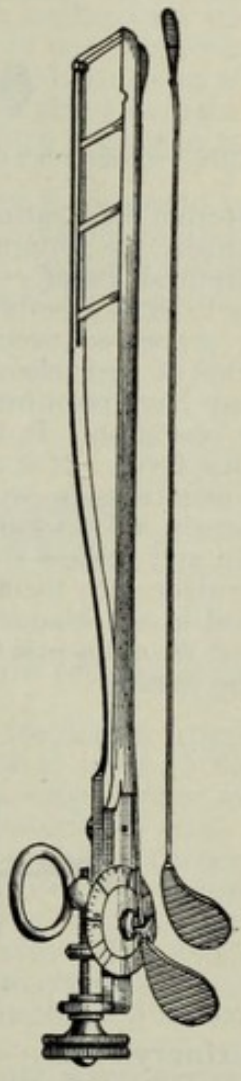


FIG. 1078.—Otis's dilating urethrotome.

the roof is divided by internal urethrotomy and the floor by external urethrotomy. In using a urethrotome do not overdilate or cut deeply. To do so will cause deformity of the penis. The best method for treatment of small caliber strictures in the deep urethra is combined internal and external urethrotomy. In strictures of the deep urethra, if only a filiform bougie can be introduced, the bougie may be left in place, and in a day or two another can be slipped in beside it, until in a few days the channel becomes passable to a metal bougie. A tunnelled catheter can be slipped over the filiform bougie, both be withdrawn, and a metal bougie passed. A tunnelled and grooved staff

can be carried in over the bougie and external urethrotomy performed. Thompson's dilator (Fig. 1079) can be carried in over the filiform and the stricture divulsed. What is known as *modified rapid dilatation* consists in first dilating, as described above, by the Thompson dilator and then introducing the powerful dilator of Gross to distend the urethra to the limit. This operation tears and lacerates rather than dilates and has been practically abandoned. In impassable stricture of the deep urethra perform external perineal urethrotomy without a guide (the operation of Wheelhouse). Cock's operation is also very efficient, but should not be attempted by one unaccustomed to its technic.

If a perineal fistula exists, dilate, divulse, or cut the stricture and retain a catheter in the bladder for forty-eight hours. After this period dilate the urethra every fourth or fifth day by a metal instrument. Every morning and evening draw the urine by a soft catheter, introduce boric acid solution into the bladder, remove the catheter, and let the man empty his bladder naturally. A part will flow from the fistula and



FIG. 1079.—Thompson's divulsor may be carried in over a filiform and the stricture is to be divulsed.

a part from the meatus. Day by day the quantity which comes from the fistula lessens, and finally the abnormal opening heals.

Urethral Fever.—Any operation upon the urethra may be followed by a chill owing to shock (urethral shock), and this may be followed by a nervous fever. Urethral fever proper is toxemia following a urethral operation. The condition is due to absorption of toxic elements which may be in the urine, may have been in the urethra, or may have been introduced from without. It usually follows the first urinary act after operation. It begins with a violent chill and presents the characteristics of a septic fever. It is accompanied by a marked tendency to urinary suppression, and may eventuate in septicemia or pyemia. Urethral fever can be prevented by rigid antisepsis. If a subject is sensitive it is always wise before instrumentation to give quinin and salol, 5 grains of each, in three doses about three hours apart. Follow or combine with them a dose of paregoric. If this fever should arise, a catheter must be tied in the bladder, the bladder and urethra must be repeatedly irrigated with aseptic or antiseptic fluids, and the patient must be given antiseptics and stimulants by the mouth.

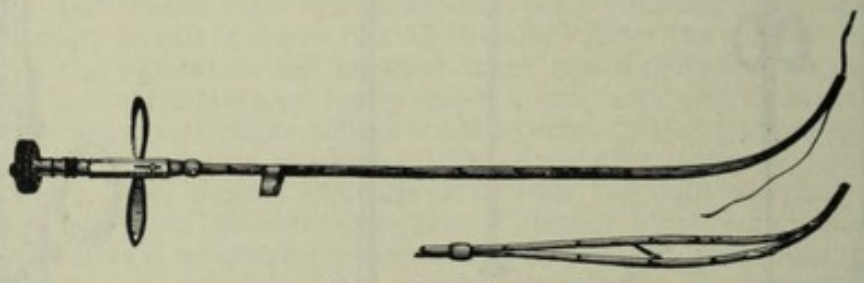


FIG. 1080.—Gouley's divulsor.

Urinary Fever.—Sir Benjamin Brodie pointed out that the withdrawal of residual urine in a case of enlarged prostate may be followed by very serious symptoms. The condition is spoken of as urinary fever, and was said to be due to the sudden and complete emptying of a bladder which had become accustomed to retaining permanently a considerable quantity of urine. Modern studies prove that urinary fever is due to infection of the bladder and kidneys, and not simply to the sudden withdrawal of all of the urine from the bladder, although such a procedure leads to vesical congestion and probably favors infection. The bacteria most often found are pyogenic cocci, colon bacilli, and micro-organisms which cause putrefaction and decomposition of urea.

The condition does not arise promptly, suddenly, and violently, as does urethral fever, but begins rather insidiously after several days. Mr. C. Mansell Moullin[1] thus describes the condition.

[1] "Lancet," Sept. 10, 1898.

"So far as the broader features are concerned, the symptoms that present themselves in these cases are remarkably uniform. They do not begin at once. Nearly always some few days elapse before there is anything to excite suspicion. Then the urine becomes cloudy, though it may still retain its acid reaction. A small quantity of albumin, more than can be accounted for by the amount of pus that is present, makes its appearance. Under the microscope there are a few hyaline casts, perhaps a blood-corpuscle or two, numerous pus-corpuslces, and myriads of bacteria. The specific gravity is lower than it ought to be, and is lower than it was before the catheter was used. The total amount passed in the twenty-four hours may either increase until it is as much as 7 or 8 pints, or diminish until it scarcely reaches 20 oz. There is seldom any definite rigor, but there may be numerous slight chills. The pulse grows more rapid and feeble. The tongue becomes red and dry. There is complete anorexia. Delirium sets in at night, and in a considerable proportion of cases the symptoms rapidly grow worse and worse until, at the end of a few days, the patient sinks into a semi-comatose condition from which he seldom rallies. Postmortem there are all the signs of recent acute cystitis and pyelonephritis. The mucous membrane lining the pelvis and calices of the kidney, the ureters, and the bladder is swollen and stained by old and recent hemorrhages, and here and there a thin layer of pus is adherent to it. The pelvis and the ureters are dilated, the apices of the pyramids are eaten away, the cortex is shrunken and hard, the capsule is adherent, and in places between the tubules are minute collections of pus differing in shape and outline according to the anatomic arrangement."

Treatment.—Aseptic catheterization is imperatively necessary if we would avoid urinary fever; and as the urethra contains some of the causative organisms, the prepuce, glans, and meatus should be washed with soap and water and irrigated with boric acid or permanganate of potassium solution, and the urethra should be irrigated with

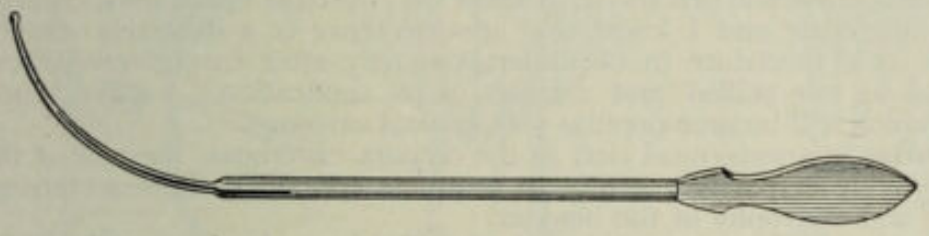


FIG. 1081.—Syme's grooved staff.

boric acid solution or permanganate of potassium before the sterile catheter is introduced to draw the urine.

If urinary fever arises, it may be possible to control it by frequently irrigating the bladder with warm normal salt solution, solution of nitrate of silver (1:8000), or boric acid solution, and by administering stimulants, diuretics, diaphoretics, saline cathartics, hexamethylenamin, salol or boric acid, quinin, and nutritious food. In severe cases perform suprapubic cystostomy for drainage. There is always a tendency to suppression in urinary fever, hence we must assist the kidneys in every way possible. Give hypodermoclysis, a small blood transfusion, caffein and sodium benzoate in combination, and generously irrigate the colon by means of a large return-flow irrigator. Wash out with bicarbonate of soda solution until the return flow comes away clear. We generally use several gallons for this purpose. Lavage of the stomach should be done when vomiting is a complication.

Perineal section is external perineal urethrotomy. There are three methods—the operation of Syme, of Wheelhouse, and of Cock.

Syme's Operation.—This operation is employed if a stricture is very contractile, if dilatation fails to cure, or if urethral instrumentation invariably causes pronounced urethral fever. The patient is anesthetized, Syme's staff (Fig. 1081) is introduced, and the surgeon makes an incision in the midline of the perineum and exposes the staff just above the shoulder of the instrument. The knife is carried along the groove and divides the stricture. After cutting, a catheter is passed into the bladder from the meatus and is retained for several days, and the wound is dressed antiseptically. After the retained catheter has been abandoned a catheter must be used every six hours until the urine passes by way of the meatus only. During the rest of the patient's life a full-sized sound should be passed at monthly intervals.

Wheelhouse's Operation.—This operation is employed for the treatment of imper-

meable stricture. Wheelhouse's staff (Fig. 1082) is passed into the urethra until it blocks on the stricture. The perineum is incised down to the staff and in front of the stricture. The edges of the cut urethra are held apart by forceps, the surgeon seeks for the opening through the stricture, passes a Wheelhouse probe through it, divides the stricture, carries into the bladder from the wound an instrument known as Teale's probe gorget (Fig. 1083) to dilate the canal and furnish a solid floor to facilitate the introduction of a catheter. With the gorget in place a rubber catheter is carried from the meatus into the bladder. The gorget is removed and a catheter, passed from the meatus, is tied in place. After three or four days the catheter is removed and is then passed frequently. The perineal wound is, of course, dressed antiseptically.

Cock's Operation.—This operation opens the urethra back of the stricture without the aid of a guide and relieves retention of urine. The surgeon introduces into the rectum the index-finger of the left hand, and the tip of the finger is rested upon the apex of the prostate gland. The surgeon incises the median line of the perineum. When the point of the knife is felt to be near the finger the handle is lowered slightly, the blade



FIG. 1082.—Wheelhouse's staff.

is placed a little obliquely, and the urethra is opened. A catheter is passed into the bladder from the wound and retained for a time, and the stricture is subsequently treated.

For a dissertation upon excision of stricture of the urethra the reader is referred to the article by Granville McGowan, "The Treatment of Urethral Stricture by Excision," "Journal Urology," vol. x, No. 6, p. 435. I believe excision is the proper procedure in some cases, and practise it. I know that the older operations do cure strictures when carefully done, and I know that urethrectomy is a definitely dangerous procedure. It is a procedure to be undertaken only after careful preparation of the patient and by one skilled and trained in its application. I don't think it is an operation which will become popular with general surgeons.

Epispadias is a congenital cleft in the corpora cavernosa, the roof of the urethra being completely or partly absent. In complete epispadias there are absence of the pubic arch and exstrophy of the bladder.

Partial epispadias may sometimes be remedied by a plastic operation.

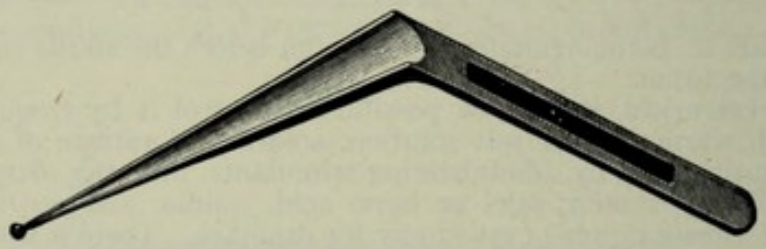


FIG. 1083.—Teale's probe gorget.

Hypospadias is a congenital cleft in the floor of the urethra. In the penile form the meatus opens on the floor at some point between the scrotum and the end of the glans penis, the channel in front of the meatus being a gutter and not a tube.

Hypospadias of the glans is the most common form. In this condition the urethra has no floor as it passes beneath the glans, the site of the urethra is indicated by a groove, and the foreskin is absent below. Partial hypospadias requires no treatment except possibly dilatation or incision of the meatus. People who suffer from it are very prone to develop chronic urethral inflammation. In hypospadias of the penis the ill-developed cord-like corpus spongiosum draws the penis toward the scrotum. In this variety of the deformity the penis is very short.

In complete hypospadias the opening of the urethra is back of the scrotum in the perineum, the penis is dwarfed and bound down, and looks not unlike a clitoris; the scrotum is divided into two portions, a gap existing between them, and in many cases the testicles have not descended. Such individuals are occasionally mistaken for females. In the penile, complete forms of hypospadias a plastic operation should be performed between the eighth and tenth years of age. Such an operation, unfortunately, may fail. Hypospadias is rare in women, but it may occur. In such a case

the urethra opens into the vagina. Figures 1084–1086 show the ingenious operation successfully practised by Carl Beck for penile hypospadias.

There have been many operations devised for the cure of this deformity. Some of them are sound in theory, most are unsurgical, and, unfortunately, most of them fail. I am certain that the first consideration must be the correction of the deformed or bound-down penis, known as clubbed penis. After this has been accomplished then the problem of correction of the urethral defect can be considered. The more I see of hypospadias surgery the more I am certain that the urinary flow must be cared for by a suprapubic drainage.

Never make the grave mistake of persuading the parents of the boy into consenting to the operation; tell them the full truth; let them distinctly request its performance, and don't promise a successful result. Always have a witness present at this conversation or, better still, put it in writing and keep an attested copy of the letter.

Chancroid (*soft chancre; the local venereal sore*) is an ulcer, usually of venereal origin. The name "chancroid" was introduced by Clerc, who believed that a soft sore resulted from inoculating a person already syphilitic with the products of a hard sore.

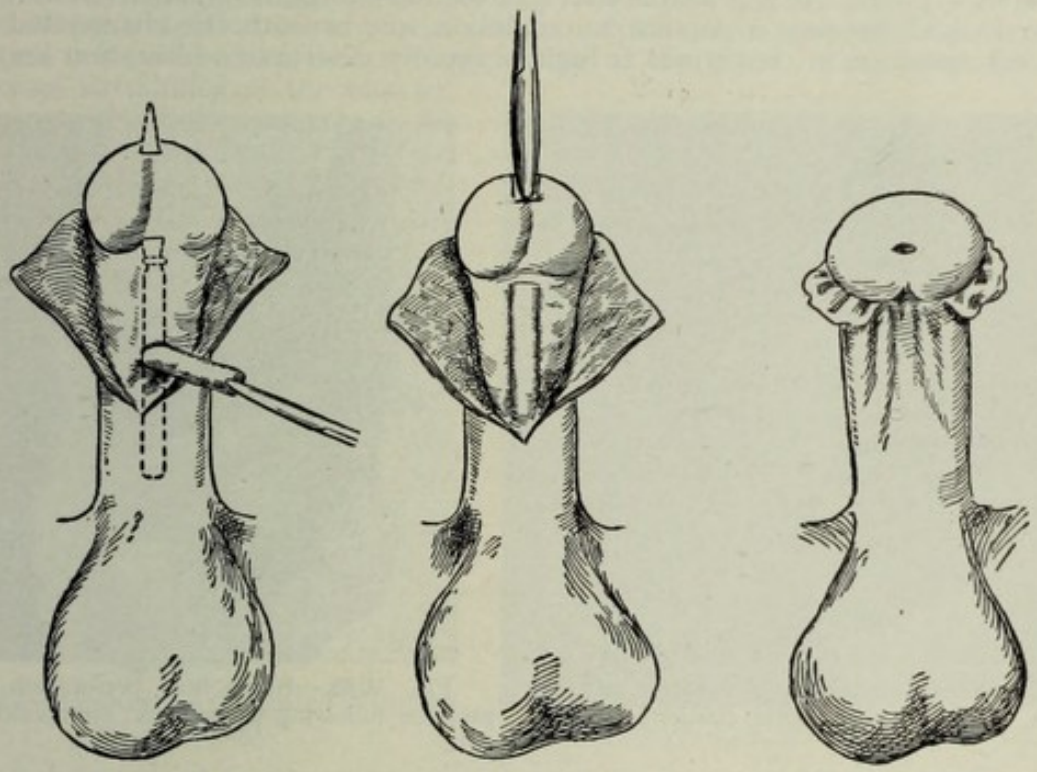


FIG. 1084. FIG. 1085. FIG. 1086.

FIGS. 1084–1086.—Beck's operation for penile hypospadias.

He further held that when a soft sore arose the syphilitic poison lost its infective properties, and "could be transmitted as a soft sore to a healthy person, and not cause general infection."[1] The chancroidal ulcer is not connected with the syphilitic poison, but is developed by inoculation with the bacterium of Ducrey. Until recently it was believed that a chancroid was not produced by a special poison, but arose after inoculation with inflammatory products or irritating secretions. It seems to have been proved, however, by Krefting and Colombini that the organism discovered by Ducrey in 1889 is the real cause. This organism is grown on a medium of fresh blood and bouillon or in "unmixed human blood." (See Lincoln Davis, "Observations On the Distribution and Culture of the Chancroid Bacillus," "Report of Research Work," 1902–03; Division of Surgery of the Medical School of Harvard University.) As a rule, chancroids are of venereal origin, and result from contact with other chancroids, pus, mucopus, or areas of ulceration. A chancroid appears soon after intercourse, usually within five days, always within ten days. It is first manifested by a pustule which ruptures and discloses an ulcer. This ulcer has sharply defined and undermined margins; it looks "punched out"; the base is gray and sloughy; the discharge

[1] "Syphilis," by Alfred Cooper.

is profuse, purulent, foul and auto-inoculable, and causes fresh chancroids by flowing over the parts. The area around a chancroid is red and inflamed, and considerable pain is apt to be complained of. The original chancroid spreads and new sores appear. The edge of a chancroid is rarely indurated unless caustics have been used or there is mixed infection with syphilis. Inflammatory induration fades gradually into the tissues, but the induration of a hard chancre is sharply defined. Fournier says that a chancroid may have a hard base if the sore is located in the sulcus back of the glans, on a lip of the meatus, or on the lower border of the prepuce of a man with phimosis, or when the ulcer is inflamed. The surgeon should always ask if the sore has been cauterized and how it has been treated. When a chancroid after a time displays marked and sharply outlined induration it points to mixed infection with chancroidal and syphilitic organisms. Chancroids are not followed by constitutional symptoms, but are apt to be accompanied by painful inflammatory buboes which are prone to suppurate. In hospital practice about 30 per cent. of patients with chancroids develop buboes. The bubo may be either unilateral or bilateral. In the majority of cases the adenitis of chancroid is due to the absorption of toxins alone and the pus may be entirely free from bacteria. Cases have been reported in which non-indurated sores were followed by syphilis. It is probable that a mixed infection existed, and that induration was overlooked, because a papular initial lesion was beneath the chancrodial ulcer. When inflammation in chancroids is high, a rapidly destructive ulceration known as



FIG. 1087.—Buttonhole perforation of the prepuce following phagedenic chancroid (Horwitz).



FIG. 1088.—Buttonhole perforation of the prepuce following phagedenic chancroid (Horwitz).

phagedena may arise (Figs. 1087 and 1088), but this process is more common in syphilitic sores.

Treatment.—Ordinary cases of chancroid are treated by spraying with peroxid of hydrogen, drying with cotton, touching each sore first with pure carbolic acid and then with pure nitric acid, and dressing with black wash or dusting with iodoform or with calomel. The carbolic acid causes momentary pain and then anesthetizes the sore so that nitric acid does not cause pain. Every few hours the patient soaks the penis in hot salt water (a teaspoonful of salt to a pint of water), sprays the sores with peroxid of hydrogen, dries with cotton, and dresses with black wash or dusts with iodoform or with calomel. As soon as granulation begins the sores should be dressed with 1 part of ointment of nitrate of mercury to 7 parts of cosmolin. Mild cases do well without cauterizing, peroxid of hydrogen being frequently used and a drying powder being employed. In chancroids with phimosis slit up the foreskin, smear the raw edges of the wound with pure carbolic acid, and treat the ulcers by cauterization. A regular circumcision usually fails because of infection of the stitch-holes. Phagedena requires the internal use of iron, quinin, and milk-punch, and the local use of powerful caustics (bromin or nitric acid or even the actual cautery). In some cases continuous antiseptic irrigation is valuable. When a bubo first begins, order rest, apply iodin or an ointment of belladonna and ichthyol, and make pressure by a spica bandage of the groin. Some surgeons advise the injection of 20 to 40 min. of

a solution of carbolic acid (10 gr. to the ounce), but I have never seen any benefit from it. Some inject a 1 per cent. solution of bichlorid of mercury, but the proceeding causes intense pain. Welander recommends the injection of a 1 per cent. solution of benzoate of mercury. I have had no experience with this method. If the bubo persists, though it does not suppurate, it should be completely excised. If pus forms, several methods of treatment are open to us: aspiration, injection with a solution of carbolic acid, squeezing out the acid and injecting 10 per cent. ointment of iodoform and glycerin, and sealing the opening with collodion (Scott Helms). Hayden makes a puncture, squeezes out the pus, washes out the cavity with peroxid of hydrogen, and then with corrosive sublimate solution, injects warm iodoform ointment, and dresses with cold, moist, corrosive sublimate gauze to set the ointment. Otis, Fontain, Perry, and others commend this plan. We have sometimes found it to succeed. If the above-mentioned plan fails, if it is not used, or if an ulcer or sinus exists, incise, curet, cauterize with pure carbolic acid, cut away hopelessly infiltrated skin, and pack the wound with iodoform gauze. In some cases it will be necessary to extirpate fragments of gland.

Phimosis is a condition of the prepuce that renders retraction over the glans impossible. It is usually congenital, but it may arise from inflammation. Congenital phimosis causes retention of sebaceous matter, which decomposes and lights up inflammation and the prepuce is apt to grow fast to the glans. Congenital phimosis may induce irritability of the bladder, incontinence of urine, prolapse of the rectum, and various nervous symptoms.

The **treatment** is *circumcision*. Asepticize the parts. Grasp the foreskin and the mucous membrane by two pairs of forceps, draw the prepuce forward, catch the skin (at the point it is desired to cut) horizontally between the arms of the handle of a pair of scissors, and cut off the redundant prepuce. Retrench the excess of mucous membrane by trimming with scissors $\frac{1}{4}$ inch from the glans, stitch the skin to the mucous membrane with catgut, and dress with sterile gauze (Fig. 1089).

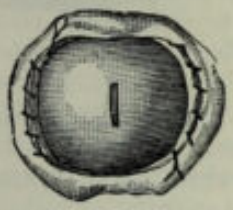


FIG. 1089.—Circumcision completed (Esmarch and Kowalzig).



FIG. 1090.—Cancer of penis (Horwitz).

Fracture of the penis, which is a laceration of the cavernous bodies with extravasation of blood, occurs occasionally during coition and also from crushing.

The **treatment** consists of cold and bandaging to arrest bleeding, and in some cases incisions to let out clot.

Gangrene of the penis arises from phagedena, from tying constricting bands around the organ, from fracture with excessive hemorrhage, and from paraphimosis. If extensive, it requires amputation. Always make a very careful search for a constricting band where one is suspected. I have seen them missed because they embed so deeply in the penis. An incus hook will help, and I have made a routine procedure to examine the groove very carefully, for I missed such a constricting rubber band upon the penis of a boy.

Cancer of the penis (Fig. 1090) is commonest in persons with phimosis. Penile cancer is practically never seen in Jews. It may develop from a syphilitic scar or ulcer or from venereal warts. I have seen one case of Paget's disease of the glans penis. Cancer developed. It has been claimed that contact cancer of the penis may develop as a result of intercourse with a woman suffering from cancer of the cervix uteri. The inguinal glands on both sides are involved early and the deep glands in the inguinal canals are usually involved (J. H. Cunningham, Jr., in "Trans. Amer. Assoc., G. U.

Surgeons," 1914). In a limited epithelioma of the foreskin circumcision is performed and the glands of the groin are removed; if a well-developed cancer affects the glans amputation of the penis is imperative and removal of the inguinal glands is absolutely necessary. Certain recent superficial cases without glandular involvement may apparently be cured by fulguration.

Amputation of the Penis.—Ricord advised cutting off the organ by a single stroke of the knife, making four slits in the mucous membrane of the urethra, and stitching each of these flaps to the skin. Treves splits the skin of the scrotum along the raphé, separates the halves of the scrotum down to the corpus spongiosum, passes a metal catheter down to the triangular ligament, inserts a knife between the corpus spongiosum and the corpora cavernosa, withdraws the catheter, cuts the urethra across, detaches the urethra from the penis back of the triangular ligament, cuts around the root of the penis, divides the suspensory ligament, detaches each crus from the pubes, slits up the corpus spongiosum ½ inch, stitches its edges to the rear end of the scrotal incision, introduces a drainage tube, ligates the vessels, and sutures the wound. In cancer cases a much more extensive operation should be done, involving removal of the crura and glandular excision (see Bickham's "Operative Surgery," vol. v., page 687).

Seminal Vesiculitis.—Inflammation of the seminal vesicles is due to the extension of a gonorrheal inflammation, to a pyogenic process, or to tuberculosis. The symptoms vary greatly because in some cases the vesiculitis is associated with trigonitis, in others with prostatitis, in others with urethritis.

Acute vesiculitis is made evident by frequent and painful micturition, pains in the anus, rectum, and perineum, and possibly the hip-joint, back, and thighs. The cords and epididymes are painful and tender and epididymitis may occur. Defecation and micturition are excessively painful. There may be vesical tenderness and tenesmus and even retention of urine. Persistent and perhaps painful erections may take place, nocturnal pollutions are common, and in some cases bloody and purulent ejacu-

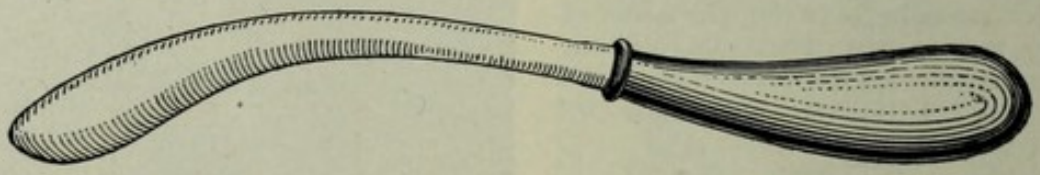


FIG. 1091.—Dufaux's prostatic masseur.

lations occur. Rectal examination detects the enlarged and tender vesicles external to the lateral lobes of the prostate and on a higher level. Massage of the vesicles causes pus or blood mixed with pus to enter the urethra, from which it can be squeezed.

Treatment.—Abandon local urethral treatment, and treat the patient as for acute prostatitis.

Chronic vesiculitis may result from the acute form or may develop insidiously in an individual with gonorrhea. It is one of the causes of a chronic urethral discharge. The patient suffers from imperative and frequent demands to micturate, and he has a gleety discharge which becomes irregularly worse and better, but does not disappear. In many cases there are symptoms of chronic cystitis. Micturition is frequent and painful, the cords and epididymes are tender and painful, urinary retention may occur, repeated attacks of epididymitis are noted in some cases, defecation causes pain, and pains are complained of in the anus, perineum, and other parts. The enlarged and tender vesicle can be felt through the rectum and massage of it causes mucopus, which may be bloody, to enter the urethra. Erections are at first frequent and painful. In most cases sexual hypochondria develops. This chronic inflammation is believed to persist because of narrowing of the duct and consequent incomplete drainage of the vesicle. In chronic seminal vesiculitis sooner or later there is sexual weakness, nocturnal emissions occur, and the semen may contain blood and pus. Calculus may develop in a vesicle. Such a calculus is composed of phosphate of lime.

Treatment.—Treat the posterior urethritis by ordinary methods. Use hot rectal enemata. Milk the ducts by Fuller's method once every seven days. During massage the patient's bladder should be full. He leans over a chair back, the knees being straight, and the body at a right angle to the thighs. The surgeon covers his finger with a rubber stall, anoints it with oil, synol soap, or catheter lubricant, introduces it into the rectum,

and makes pressure over the pubes with the fist of the other hand. The finger comes in contact with the lower half of the vesicle; it makes firm pressure for a moment and is then drawn slowly toward the duct. This stroking is repeated several times. The other vesicle is treated in the same manner. These maneuvers empty the vesicles and hasten the resolution of inflammation. In many cases the finger reaches only the very lowest part of the vesicle. In such a case practice massage by means of Dufaux's rubber masseur (Fig. 1091). After the completion of the stripping the patient should micturate, and the bladder and urethra should be irrigated.

Injection of one or both seminal vesicles by way of the vas deferens is an operation that can be done with comparative ease and may be resorted to when the other methods have failed of relief. The vas is isolated through a small cut in the posterior portion of the scrotum and fixed by a suitable pin behind it. It is further fixed by a black silk handle-suture through its outer fibrous coat and a small longitudinal slit is made into it with a tenotome. Into this slit is passed a fine filiform bougie or a strand of silkworm-gut to insure that the tube remains open to the vesicle. The bougie is withdrawn and a blunt-pointed hypodermic needle inserted and gently tied in position. Through the needle is injected a suitable antiseptic solution. The amount injected should be regulated by the patient's tolerance. Give it slowly, only a drop at a time, and when pain in the rectum supervenes, stop the injection. The needle can be left *in situ* for a few days, so that subsequent injections can be made. The operation is best done under local anesthesia. Collargol, mercurochrome, argyrol, and colloidal iodin have been used for injection. The colloids have been given, and by some are recommended. Intravenous injection of hexamethylenamin has at times done good. In chronic seminal vesiculitis associated with a gonorrheal arthritis it may become necessary to drain the vesicles (vesiculotostomy), or to remove them (vesiculolectomy).

Tuberculosis of the Seminal Vesicles.—Primary tuberculosis is very unusual. As a rule, there is evidence of antecedent tuberculosis of the testicle or prostate gland. About 50 per cent. of the cases occur in individuals under forty years of age. The diseased vesicle is at first nodular and indurated, but later undergoes caseation and softening. Finally the disease passes through the capsule and invades adjacent structures. Dreyer collected 36 cases and found that in 34 of them the lungs were involved.

Tuberculous vesiculitis may be unilateral or bilateral. In unilateral tuberculous epididymitis the vesicle of the other side is apt to become diseased. In bilateral disease of the testicles both vesicles are liable to become victims. Peritoneal tuberculosis may follow tuberculous vesiculitis. In very unusual cases spontaneous cure is obtained by fibrous tissue formation. On palpation, a tuberculous vesicle is found to contain here and there hard and but slightly tender nodules.

Treatment.—If tuberculous epididymitis is followed by tuberculous vesiculitis, it is justifiable to remove the vesicle after removing the epididymis or testicle, provided the prostate and other parts of the genito-urinary tract are free from disease and there is no distant lesion of tuberculosis. If both testicles or epididymes are removed, both vesicles can be extirpated. If a vesicle or both vesicles suffer from primary tuberculosis, operation is advised by some surgeons. Reported cases, however, do not seem to favor operation.

Kraske, Schede, and Rydygier have removed the vesicles after preliminary resection of the sacrum. Zuckerkandl, Diettl, and Schede have employed the perineal route. Villeneuve reached them by way of the inguinal region. The curved perineal incision of Zuckerkandl is the method to be preferred.

Acute Prostatitis.—Acute inflammation of the prostate gland may be caused by inflammation of adjacent structures, the use of instruments or irritant applications in the deep urethra, injury by a passing or impacted calculus, various infectious diseases, a stricture of the urethra, but particularly by gonorrhea. The gland enlarges greatly, the prostatic fluid exudes mixed with blood and pus, and the gland ducts become distended with pus. A distinct abscess may form. The orifices of the ejaculatory ducts become distended and filled with pus, and the seminal vesicles or epididymes may also suffer. An abscess is liable to form in the cellular tissue outside of the prostate.

Symptoms.—There is a feeling of weight, fulness, or soreness in the perineum; a persistent pain at the neck of the bladder; frequent micturition, pain being present and becoming most severe as the last drops are voided; perineal tenderness; painful defecation; and bulging of the anal mucous membrane. If a finger be introduced into the rectum, it causes severe pain and palpates the enlarged and tender gland, unless the outlines have been destroyed by periprostatitis, in which case there will be felt

a large, boggy, tender mass. (See Henry Morris on "Injuries and Diseases of the Genital and Urinary Organs.") These symptoms are accompanied by distinct elevation of temperature. The inflammation may abate without suppuration, but, as a rule, pus forms, the temperature becomes characteristic, the pain becomes pulsatile, micturition causes agony, the inflammatory mass felt per rectum is found to be softening, and sometimes the swollen perineum becomes dusky red. Retention of urine is almost certain to occur. The abscess may rupture into the urethra or the rectum, or may diffuse in the periprostatic cellular tissue and subsequently may open in the perineum. Spontaneous evacuation may be followed by recovery or by the development of annoying or dangerous complications.

Treatment.—Keep a hot-water bag on the perineum and three or four times a day use rectal injections of hot water. Order frequent sitz-baths. Place the patient on a milk diet. It was long the custom to leech the perineum. Give suppositories of opium and belladonna and also suppositories of ichthyol, and administer hexamethylenamin by the mouth. Retention of urine is relieved by a soft catheter. When pus forms it may be possible in some cases to rupture the abscess into the urethra by the passage of a steel sound. Most cases require to be cut externally. What is known as the *boutonnière operation* is the method of choice. The patient is placed in the extreme lithotomy position. The index-finger of the left hand is introduced into the rectum and carried to the apex of the prostate. A straight bistoury is entered to the side of the median raphé and carried into the abscess cavity, and the opening is dilated by hemostatic forceps and drained by a rubber tube. The urethra is not to be opened.

Chronic prostatitis may arise from stricture, venereal excess, chronic cystitis, or stone in the bladder, but gonorrhea is the common cause. The prostate is usually, but not always, enlarged, is somewhat softened, and the ducts contain pus and blood.

Symptoms.—There is usually a mucopurulent discharge and fluid can be obtained by massage of the prostate. There is a feeling of weight and fulness in the perineum, there is increased frequency of micturition, and the prostate is very sensitive to digital pressure. The patients are neurotic, frequently suffer from nocturnal emissions, and have but feeble power of erection. The prostatic urethra is extremely hyperesthetic. All the symptoms are aggravated by worry, sexual excitement, indulgence in alcohol, or violent exercise. An abscess may form and rupture into the urethra.

Treatment.—Tonics and nutritious food are essential. Intravesical irrigations with nitrate of silver solution (1 : 8000) do good. Massage of the prostate is useful. Some cases are benefited by touching the posterior urethra through a urethroscope tube with nitrate of silver (3 gr. to the ounce) or by injecting by means of Ultzman's syringe a few drops of silver nitrate solution (5 gr. to the ounce). Rectal suppositories of ichthyol may be ordered. Blistering the perineum at intervals may prove of service. At intervals of three or four days a full-sized cold steel sound should be gently introduced. If an abscess forms, open it through the perineum. Hot rectal injections of normal saline solution are useful. Gentle prostatic massage with the bladder filled will generally hasten cure. Always check up from time to time upon the amount of pus present in the secretion. Remember that a clear urine may be seen in association with catarrhal prostatitis.

Prostatorrhea.—Just as overaction of the glands of the urethra constitutes urethrorrhea, so overaction of the glandular apparatus of the prostate constitutes prostatorrhea. Prostatorrhea is not inflammatory, although the prostate and posterior urethra are often congested, and the latter region is usually hyperesthetic. In some cases urethrorrhea exists with prostatorrhea. Prostatorrhea is produced by sexual excess, masturbation, ungratified sexual desire, riding a bicycle with an improper seat, and sometimes by riding horseback. The condition is usually accompanied by marked neurasthenia, and may be associated with spermatorrhea and impotence. I have seen prostatorrhea in young men who have been engaged to be married for some time and who, frequently, have been conducting strenuous dalliance. At each uncompleted séance prostate fluid and mucous leaks from the penis. I term this condition of the gland "lover's prostate." The gland is usually large and boggy and the patient suffers from indigestion (hyperacidity) and phosphaturia.

The patient notices a milky or gray discharge after straining at stool (*defecation spermatorrhea*), after violent exercise, sexual excitement, or a bicycle ride. The discharge also gathers in the urethra during sleep. Examination of the discharge shows it to be prostatic fluid, although spermatozoids are sometimes found. It is not purulent and may contain Böttcher's spermatic crystals. These crystals are rhombic prisms and

terminate in fine points or rhomboid margins ("Casper's Genito-urinary Diseases" by Bonney). The composition of these crystals is uncertain, but Fürbringer proved that they are found in prostatic fluid only. The meatus is not glued up in the morning and the linen is very slightly stained. The urine is clear and contains small comma-shaped hooks. The bladder is irritable, and there is frequency of micturition and often some pain in the head of the penis at the termination of the act. Nocturnal emissions may occur.

Treatment.—The patient should correct injurious habits, even though convention expects them. If there be urethral hyperesthesia or prostatic congestion, irrigate the bladder and urethra once a day with a solution of silver nitrate (1 : 4000), and every fourth or fifth day introduce a cold sound. In some cases the occasional instillation into the prostatic urethra of a few drops of a 1 per cent. solution of nitrate of silver does good.

For the irritable bladder order hot hip-baths at night. The following prescription is of service: 15 gr. of bromid of potassium, 20 minims of tincture of hyoscyamus in ½ oz. of cinnamon-water, three times a day. Hot enemata are of service.

After the hyperesthesia of the urethra has abated and nocturnal emissions have ceased, the neurasthenia is treated by cold sponging of the body night and morning, the continued use, at intervals of several days, of a large-sized cold sound, irrigation every second or third day with silver nitrate (1 : 4000), the administration of strychnin and other tonics, and gentle outdoor exercise in the sunlight. The patient should drink milk.

Prostatic Calculi.—Corpora amylacea are often present in the prostate and should not always be considered as a diseased process. The nucleus of one of these bodies is composed of inspissated mucous and epithelial cells in a state of degeneration. About the nucleus layers of albuminoid material form which, under the microscope, resemble the cells of starch. In youth corpora amylacea are microscopic. In older persons they are visible to the unaided eye. When small they cause no trouble. When they enlarge notably, inflammation arises, and lime salts are deposited in the corpus. These true prostatic calculi are multiple, brown or black in color, and are commonly faceted. If such a calculus ulcerates into the urethra, urinary salts will be deposited; it will enlarge greatly, and an abscess will probably form.

A prostatic calculus may arise in the bladder or urethra or in a prostatic pouch. After prostatectomy the pouch may become filled with a mass of lime salts and urinary salts.

If prostatic calculi cause symptoms, the symptoms are those of chronic prostatitis or chronic posterior urethritis. Perhaps they can be felt by a finger in the rectum or by a metal sound in the urethra. Some are visible through a urethroscope. The *x*-rays show them.

Treatment.—Removal of calculi through a urethroscope or by means of a perineal incision.

Hypertrophy of the Prostate Gland.—It was pointed out by Morgagni that in old men difficulty of micturition is due to obstruction by an enlarged prostate gland. Enlargement of the prostate gland may be brought about by different forms of growth. It is, as a general thing, a senile change, occurring usually after the age of fifty, and being most likely to arise after the attainment of sixty years. It is very rare for enlargement of the prostate to cause symptoms much before the age of fifty or to begin after the age of seventy. Sir Henry Thompson maintained that 34 per cent. of men over sixty have prostatic hypertrophy, but that only half of them have troublesome symptoms. According to Freyer, 33 per cent. of all men past fifty-five years of age present some enlargement of the prostate.

There are some who oppose the view that prostatic enlargement is essentially a senile change. For instance, Dr. L. Bolton Bangs ("Jour. of Dermatol. and Gen.-urin. Dis.," March, 1901) maintains that the change is not senile; that it really begins early in life, but that its effects do not become manifest until during or after middle age. Lydston asserted that it began during the third decade of life, but the gland did not attain sufficient size to cause symptoms till beyond middle life. Socin and Buckhardt, as a result of 300 postmortem examinations, reached the following conclusions: Between the ages of thirty-six and forty the gland is hypertrophied in 13 per cent. of persons, between forty and fifty in 25 per cent., between fifty and sixty in 31 per cent., between sixty and seventy in 56 per cent., between seventy and eighty in 50 per cent., and between eighty and ninety in 54 per cent. Undoubtedly, the enlargement begins long before it occasions sufficient obstruction to induce symptoms, and the growth

progresses very slowly. Guyon and the French school in general maintain that hypertrophy of the prostate gland is always the result of arteriosclerosis, affecting not only the prostate but also the entire urinary tract. The hypertrophy that ensues affects the bladder walls notably, as well as the prostate, because of distinct growth. Caspar has apparently demonstrated that Guyon's view is not correct. He has shown that in many cases there is no sclerosis of the prostatic arteries, and that frequently there are no sclerotic changes in other portions of the urinary tract. Another important point made by Caspar is that arteriosclerosis tends to cause degeneration, and not hypertrophy.

Some think that sexual excess is a cause of prostatic enlargement; some assert that antecedent gonorrhea is the cause, but it seems very improbable that either is causal. Belfield blames altered testicular secretion; Hawley believes the cause to be altered prostatic secretion and the "chemical action of pathologic proteins resulting from irregular metabolism or derived from disintegration of the secretion, or in the usual action of tissue enzymes" ("Annals of Surgery," Nov., 1903).

In the hypertrophied prostate there is an excessive production of fibrous tissue and of ill-formed glandular tissue, the mass constituting a fibro-adenoma. Fibro-adenoma is the common cause of enlargement (W. Bruce Clarke). Typical adenoma, according to Albarran and Hallé, is found in 14 per cent. of the cases ("Annales des Maladies des Organes Génito-Urinaires," Feb. and March, 1900). Again, in not a few prostates there is no real enlargement, but there is an indurated fibrous mass producing obstruction. Albarran and Hallé (Ibid., 1898, vol. xvi) point out that in an enlargement of the prostate different elements may usually be recognized: soft hypertrophy of the gland; indurated enlargement of the glandular elements; fibrous enlargement; circumscribed tumor masses; distinct fibromata or myomata; or adenofibromyomata. The real cause of the various forms of prostatic enlargement is not known. The presence of malignant change in association with prostatic enlargement is much more common than some surgeons believe. Statistical reports are contradictory.

All the lobes may be enlarged equally; all may be enlarged unequally; the enlarged gland may surround the prostatic urethra like a horse-collar, or one lobe only may be enlarged. Symmetric enlargement of the entire gland is not so apt to produce symptoms as is non-symmetric enlargement. In some cases the chief enlargement is into the bladder; in others, into the urethra. An enlarged prostate frequently shows a circular groove about it, due to the constriction exerted by the rectovesical fascia at the vesical neck.

The bridge of prostate which joins the two lateral lobes behind the urethra is known as the *lobe of Home* or the *middle lobe*, and a comparatively trivial enlargement of the middle lobe may cause obstruction. In 1811 Sir Everard Home described the middle lobe. Prostatic hypertrophy causes narrowing and lengthening of the urethra, and gives this tube a tortuous course. The opening of the urethra into the bladder is usually pushed to a higher level, and there forms behind it a pouch in which urine collects. The urine that gathers in this pouch is known as *residual urine*. It cannot be voluntarily expelled. It may, therefore, collect in large quantity, and it is likely to decompose, producing cystitis. Residual urine strongly favors calculus formation. The mechanical resistance to the expulsion of the urine causes congestion of the neck of the bladder and of the posterior urethra and also hypertrophy of the muscles of the bladder. In consequence of the hypertrophy the bladder enlarges, thickens, and becomes fasciculated. When this takes place, micturition becomes very difficult and sometimes impossible. Enlargement of the middle lobe inevitably blocks the flow of urine and causes great distention of the bladder. In hypertrophy of the prostate gland the ureters and the renal pelves and calices may distend and surgical kidney may develop.

Symptoms.—In many cases the irritation caused by an enlarging prostate stimulates sexual feeling. This renewal of passion plus morning erections leads to unjustifiable confidence in sexual power. A morbid propensity to matrimony is a frequent early symptom. In 90 per cent. of the cases there is very trivial inconvenience, the patient merely being annoyed somewhat by episodes of nocturnal, and less urgent diurnal, frequency of micturition. During the day when the man is active the circulation of the prostate is active and so are the muscles. At night, when in bed, there is venous congestion of the prostate and base of the bladder. Hence the vesical irritability. Again, there is usually polyuria in cases of enlarged prostate, and polyuria is most marked at night. The stream of urine is slow to start and falls feebly from the end of the penis. In some cases there is interruption of the stream (*stammering of*

the bladder). The last drops fall entirely without control. If the patient becomes sexually excited, chilled, or worried, or indulges inordinately in the pleasures of the table or in wine, beer, or alcoholic liquors, nocturnal frequency of micturition becomes for a short time most harassing. Very early in a case the bladder can be completely emptied. In 10 per cent. of all cases the bladder becomes unable to empty itself completely, and residual urine collects. Frequency of micturition, at first purely nocturnal, comes on during the day as well as at night; the patient has to get up often, several or many times from his bed, the bladder never feels empty; and cystitis is apt to arise. This is known as the second stage. Guyon calls it the stage of "bladder insufficiency." The urine, at first acid and clear, becomes neutral and cloudy, and finally ammoniacal and turbid, and contains bacteria, mucopus, precipitates of phosphates, and blood. Above the pubes there is aching pain, soon spreading to the perineum, and increasing when the bladder is distended and during micturition. The rectum becomes irritable, and piles form or prolapse of the mucous membrane occurs, because of straining during micturition. The second stage may last a year, two years, or several years. The second stage passes into the third stage, in which attacks of retention of urine may occur. The bladder dilates greatly. With the retention there is usually incontinence (incontinence of retention). "With this overtaxed, overdistended bladder the sphincter relaxes every few minutes, allowing the escape of a few drops of urine, and when we question one of these old men about his urination, asking if he passes water frequently, and he says, 'Yes, every few minutes'—that always means an overdistended and dribbling bladder" (H. H. Morton, "N. Y. Med. Jour.," Sept. 9, 1916). In about one-third of all cases we can make a diagnosis by rectal palpation. In enlargement of the middle lobe alone or in pure intravesical enlargement rectal touch will fail to make the diagnosis, and the cystoscope must be relied upon. The bladder becomes thin and distended, or hypertrophied, rigid, and fasciculated. In rare cases true incontinence is caused by the median lobe growing toward the neck of the bladder and preventing closure. The health breaks down because of pain, restless nights, indigestion, and disorder of the bowels. The urine is of low specific gravity, is low in urea, and there may or may not be casts. The patient becomes somnolent and the tongue dry and parched (*urosepsis*). The kidneys may become involved (inflammation of the pelves or calices, or surgical kidney) and suppression may occur. Septic fever may arise. Calculi may form in the bladder. Death is due to exhaustion, suppression of urine, or septic cystitis. A foul catheter is the usual cause of septic cystitis, but micro-organisms sometimes enter by passing along the urethral mucous membrane.

A patient should be examined by rectal touch, by a sound, and by a cystoscope, if possible; the amount of residual urine must be determined, and the condition of the urine is to be carefully studied. The presence or absence of stone should always be determined. After an examination by instruments the patient must remain in bed for twenty-four hours. If the cystoscope cannot be passed a cystogram of the case should be made. In fact it is a good routine practice to have one made upon all prostatic cases. An encysted stone may be missed by the cystoscopist.

Treatment.—There is no known method of preventing prostatic hypertrophy. Many cases of enlargement are treated by regular catheterization, and if this is conducted with careful cleanliness, and if the patient rigidly adheres to hygienic rules, he may be kept comfortable in this way for a considerable time. When a man must depend upon a catheter to empty his bladder he is said to be in *catheter life*. We may be justified in relying upon this simple plan of treatment. Prevent cystitis by emptying the bladder each evening with a coudé catheter. If there is trouble in passing the catheter, strengthen the instrument by inserting a filiform bougie as a stilet. It is very seldom that a metal instrument is required, but if it is necessary, a catheter with a large curve is employed. If a soft or semisolid instrument can be passed, teach the patient how to clean it, how to use it, and how to keep it, but never permit the patient to use a metal instrument himself. A dirty instrument may cause fatal infection. It is true that some people use dirty instruments for long periods without trouble, but in most cases there will be trouble if it is attempted. It is absolutely necessary to use perfectly aseptic instruments only. Metal instruments are sterilized by boiling in water. Rubber catheters can be cleansed by washing with soap and running water, wrapping in gauze, and boiling. After sterilization the instruments are kept ready for use in a glass cylinder which contains calcium chlorid.[1] The cleansing of catheters is discussed on page 1309. If there are 3 oz. of residual urine, use the catheter at night

[1] R. W. Frank in "Berliner klin. Woch.," No. 44, 1895.

only. If there are 6 oz., use it night and morning. If there are more than 6 oz. of residual urine, add one more catheterization a day for every additional 2 oz. present until the catheter is used six times in the twenty-four hours. It should never be used oftener than this. Gradual dilatation with steel sounds is of benefit, but forcible dilatation is not advisable. The sound may be passed once a week. Tell the patient to avoid exercise, cold, damp, sexual excitement, and the use of alcoholic liquors; prevent constipation and indigestion, and direct him to drink milk and plenty of water. A hot hip-bath at night adds to his comfort. Hot enemata are of value. If a large quantity of residual urine exists, or if cystitis begins, wash out the bladder daily with boric acid solution, or normal salt solution, or nitrate of silver (from 1 : 10,000 to 1:4000), and give hexamethylenamin or salol and boric acid by the mouth (see Cystitis, page 1323). In some severe cases, if a large-sized rubber catheter be tied in the bladder for a few days, great relief is obtained. Retention of urine can usually be relieved by the introduction of a coudé catheter strengthened with a whalebone. In exceptional cases a silver instrument with a prostatic curve must be employed or aspiration must be practised. Unfortunately, sooner or later a man who regularly relies upon the catheter will develop cystitis. A poor man cannot give the necessary time and attention to make catheter life safe, and operation must be thought of in him sooner than in others. If the symptoms grow constantly worse, if the suffering becomes severe, if the patient cannot empty his bladder without the use of an instrument, if catheterization is painful or impossible, if the patient is too careless or ignorant to trust with a catheter, if only a catheter of very small size can be introduced, if attacks of obstinate retention occur, if there is persistent or recurring cystitis or hematuria, if there are signs of beginning infection of the kidney, or if the residual urine gradually increases in amount, operation is demanded. Do not postpone operation until the patient becomes really ill. Give palliative measures a reasonable trial, and if they fail, operate. Before determining upon any operation have an *x*-ray picture taken and make a cystoscopic examination. This is particularly valuable before a perineal operation. It shows us the condition of the bladder; the nature, size, and situation of the enlargement, the median lobe if present, and a calculus if one exists. This examination may determine the form of operation desirable. Prostatectomy is not to be regarded as a trivial affair certain to result in cure. It is a grave procedure, with a considerable mortality, which may be attended by disastrous complications and from which unfortunate consequences may arise. I agree with James E. Moore that "it is altogether too grave an operation to be resorted to as a routine treatment for every enlarged prostate, and is applicable to properly selected cases only." The operation is contraindicated if there is advanced disease of the kidneys, and if it is performed in such a case, fatal uremia is to be expected. Age is not in itself a contraindication if the kidneys and cardiovascular system are sound. An occasional sequel of prostatectomy is incontinence of urine due to injury of the neck of the bladder or to the nerves of the part. A possible sequel of operation upon sexually vigorous men is sterility, but age has rendered most of the subjects practically sterile before operation.

In the majority of cases in which palliation fails the operative indication is to remove an obstructing mass and to depress the level of the opening from the bladder into the prostatic urethra, so that the prostatic pouch is abolished and the bladder can be thoroughly drained. The surgeon chooses between prostatotomy and prostatectomy. Prostatectomy may be suprapubic or perineal, and the latter may be by enucleation without the aid of sight (as in the operations of Nicoll and Alexander) or by open dissection (as in Young's operation). No one routine plan is suitable for all cases. The patient should be studied, and the operation chosen which is safest and best for that individual case. The surgeon who uses one method only must wrong many patients, and he retains consistency at the expense of humanity. It was formerly believed that any operation of total prostatectomy must of necessity produce sterility. This it is now claimed need not be the case. It is asserted that the suprapubic operation is probably less likely to be followed by this than is the perineal, as the former is more apt to spare the ejaculatory ducts. Young claims that his perineal operation spares the ejaculatory ducts. Destruction of the ejaculatory ducts certainly produces sterility, and may, but does not of necessity, produce impotence. Willy Meyer ("Med. Record," Oct. 7, 1905) points out that impotence may be caused by damaging important nerves or blood-vessels in advancing through the perineum, and also by the operation producing relaxation of the verumontanum and prostatic urethra, parts necessary in the reflex for erection.

Perineal prostatectomy under direct vision is as safe as the suprapubic or safer, and can be rapidly performed. It is the desirable route when the gland can be palpated per rectum, and does not mount high up (when the finger can touch the upper margin of the gland) and when we are dealing with the early stages of soft hypertrophy. Prolonged drainage should be perineal. Permanent drainage should be suprapubic. According to Francis S. Watson ("Annals of Surgery," June, 1904), the mortality in 203 cases was only 2.9 per cent. In 563 cases of removal through the perineum by dissection the mortality was 5.5 per cent. Young's cases in this group number 150 and his mortality was 4.6 per cent.; the mortality of Hartman was 9 per cent.; of Albarran, 4 per cent., and of Murphy, 3.9 per cent. (Schachner in "Annals of Surgery," August, 1908). In 190 cases of blind enucleation through the perineum the mortality was 4.7 per cent. (Ibid.).

The problem of deciding the percentage of mortality in prostatectomy is a very difficult one to become definite about. He who does, must be a magician, a mathematician, and a statistician of the first order. After all it becomes the difference between Tweedledum and Tweedledee. Mortality ratio varies in accordance with the skill of the operator. This, of course, applies equally in all surgical procedures, but probably more so in prostatectomy than in most others.

After the performance of the perineal operation the drainage is at the lowest part of the bladder. In a perineal operation every effort should be made to do as little damage as possible to the urethra. If we destroy the entire prostatic urethra the operation becomes easy and rapid and Nature rapidly repairs it, but a traumatic stricture may follow and may make the patient's condition worse than at first. As Moore says, we must destroy a portion of the floor of the urethra, but we can preserve the roof and the side walls. Another point in the perineal operation is to avoid injuring the rectum. A tear may enter the rectum, or, even if the gut has not been torn, sloughing of the rectum resulting in recto-urethral fistula may occur. The rectum may be opened because the surgeon fails to stick close to the urethra in his dissection, and sloughing may be due to an injudicious use of the retractors. If the rectum is opened, it should be at once sutured with catgut. In most cases it takes about three weeks for the wound in the perineum to heal, and in some few cases a perineal urinary fistula is established. Urinary incontinence may follow this operation. By simply incising the prostate gland the floor of the urethra may be lowered to the level of the floor of the bladder. Simple incision of the prostate in this manner, or by the cautery method of Bottini, is known as *prostatotomy*. The mortality is small and the relief is often great. Prostatotomy is performed on old and exhausted patients with damaged kidneys. A large tube should be worn during the healing of the wound.

Suprapubic prostatectomy is easier than the perineal; it is said by some to be less safe; it gives excellent results if temporary drainage only be needed. According to Watson ("Annals of Surgery," June, 1904), the mortality in 69 cases was 8.6 per cent. P. J. Freyer reports 600 cases varying in age from forty-eight to eighty-nine years. There were 47 between the ages of eighty and eighty-nine, and 7 were seventy-nine; most of the cases had been entirely dependent on the catheter for periods up to twenty-four years. "Nearly all were in broken health and many apparently dying before operation. Few were free from one or more grave complications, such as cystitis, stone in the bladder, pyelitis, kidney disease, diabetes, heart disease, chronic bronchitis, paralysis, hernia; and in a few instances there was malignant disease of some other organ than the prostate" ("Archives Internationales de Chirurgie," vol. iv, Fascic. 4, 1909). In these 600 cases there were 37 deaths in periods of from six hours to thirty-seven days after operation, a mortality of 6.15 per cent. Suprapubic prostatectomy is indicated in rather young subjects in whom we greatly fear impotence; in cases in which the gland is placed high; in cases in which the gland is not palpable per rectum, but is causing serious symptoms, and in which the hypertrophy is recognized by the cystoscope (Meyer); in cases in which there is a middle lobe; in cases in which cancer exists, or in which calculus complicates the case. It is the most useful operation when the gland is very large and intravesical. It is not a suitable method if the bladder is markedly contracted or if the belly walls are very thick. If prolonged drainage (short of permanent drainage) is required, as it is sure to be in cases with advanced cystitis, the opening is better placed in the perineal operation. If when a suprapubic operation has been performed it is found that prolonged drainage is indicated, a siphon drain (Fig. 1065) or double tube drainage (Fig. 1092) may be used. If permanent drainage be required in a case, the suprapubic method is the best. After a suprapubic cystotomy has been

performed for permanent drainage, the opening may be kept patent by the retention of a tube (Hunter McGuire's operation). It is only in very advanced cases or in cancer that permanent suprapubic drainage is employed. After making a suprapubic incision the floor of the urethra cannot be brought level with the floor of the bladder by a simple incision of the prostate through this incision; it can be brought level by the performance of prostatectomy only. In the suprapubic operation the structures divided are less important, and the drainage is less conveniently placed. The bladder wall may be seriously torn, and if such a wound should be inflicted, it ought to be sutured with catgut. In this operation if the bladder be contracted, the surgeon must exercise great care to avoid injuring the peritoneum. The ureters may be damaged and subsequently become obstructed from contraction. If death occurs after prostatectomy it is due to shock, uremia, sepsis, or postoperative complications, usually pulmonary. Schachner ("Annals of Surgery," August, 1908) uses Watson's figures to present the special dangers of each operation. The figures give the percentage of the deaths due to shock, uremia, hemorrhage, and pulmonary complications. The table is as follows:

	Per cent.	
Bottini	2.7	Uremia (or renal insufficiency).
Perineal operations	35.0	
Suprapubic operations	34.0	
Bottini	52.0	Sepsis.
Perineal operations	17.8	
Suprapubic operations	8.6	
Bottini	5.0	Shock.
Perineal operations	21.4	
Suprapubic operations	30.0	
Bottini	8.0	Postoperative pulmonary complications.
Perineal operations	17.8	
Suprapubic operations	22.0	

At the International Urological Congress held in London in 1911 Young presented the records of 484 cases of perineal prostatectomy. The mortality in simple hypertrophy (450 cases) was 3.77 per cent.; 34 cases were cancerous, and of these, 2 died. Zuckerkandl's mortality from perineal operations was 9.5 per cent., from suprapubic operations, 18.7 per cent. ("Ann. des Mal. des Org. Gén.-urin.," 1911, ii). Freyer ("Amer. Jour. of Dermatology and Genito-urinary Diseases," 1912) reports 1000 cases of suprapubic prostatectomy since 1901. The average age of these cases was sixty-nine. The youngest patient was forty-nine, the oldest was ninety. There were 55 deaths (a mortality of 5.5 per cent.). Freyer's mortality in his first 100 cases was 10 per cent., in his last 100 cases it was 3 per cent. This proves the great value of experience. The less training a man has had, the higher will be his mortality. Prostatectomy is distinctly not an operation for a juvenile surgeon.

Suprapubic Total Prostatectomy.—Freyer's Method.—The bladder is washed out through a catheter with warm boric acid solution and is then filled to its previously ascertained capacity with the solution. The nozzle of a large syringe filled with fluid is inserted into the end of the catheter. This keeps the bladder fluid from running out and enables the surgeon quickly to distend the viscus more completely if the occasion arises. The bladder is exposed and opened in the midline and in an area free from veins (see Suprapubic Cystotomy, page 1328). The incision is vertical, is made toward the symphysis, and is about 1 inch in length (it can be enlarged later if necessary). If any calculi are found they are at once removed. A finger is placed in the rectum to raise up the prostate and keep it steady. The finger of the other hand is introduced into the bladder, and by means of the finger-nail the mucous membrane is scratched through over "the most prominent portion of one lateral lobe, or over the so-called middle lobe, if there be but one prominence" (Freyer in "Archiv. Internat. de Chir.," Fascic. 4, 1909). This portion of the gland is covered by mucous membrane only, and when this is scratched through the true prostatic capsule is reached. In doing Freyer's operation the author passes the finger to the extreme anterior limit of the trigone, so that the finger is really within the urethra. At this point he splits the capsule and begins the enucleation, being careful to injure the trigone as little as possible. This precaution greatly lessens the danger of incontinence. The finger is kept in close contact with the true capsule and enucleates the gland by passing first posterior, next outside, and finally in front of one lateral lobe.

"The finger is then swept in a circular fashion from without inward, in front of and to the inner side of the lobe, detaching this from the urethra, which is felt covering the catheter, and pushed forward toward the symphysis between the lateral lobes, which will, as a rule, have separated along their anterior commissure in the course of the manipulations. The other lobe is attacked and treated in the same manner. The finger is next pushed well downward behind the prostate and the inferior surface of the gland is peeled off the triangular ligament. When the prostate is felt free within its sheath and separated from the urethra, with the finger in the rectum, aided by that in the bladder, it is pushed into the bladder through the opening in the mucous membrane, which, during the manipulations, will have become considerably enlarged" (Freyer, Ibid.). The prostate is removed from the bladder by forceps. If the lobes come away separately, Freyer believes that the ejaculatory ducts are uninjured and remain attached to the urethra. There has been an active controversy as to whether Freyer's operation does or does not destroy the prostatic urethra. It seems certain that even if it is left it must slough for want of blood-supply. In my operations by this method it has come away with the prostate.

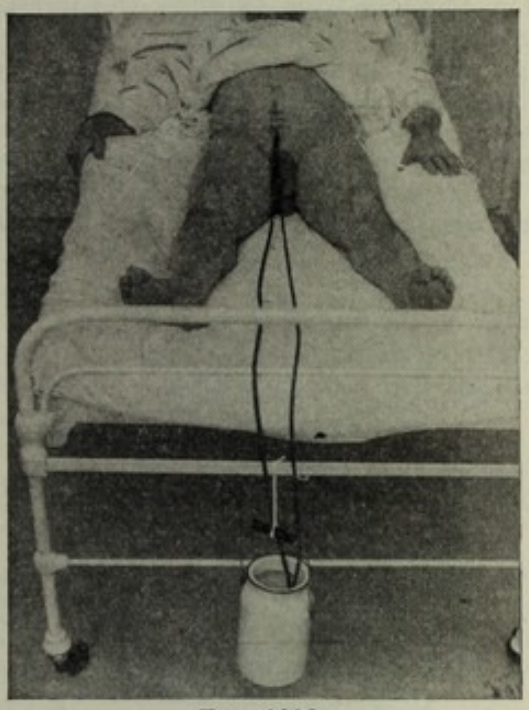


FIG. 1092.

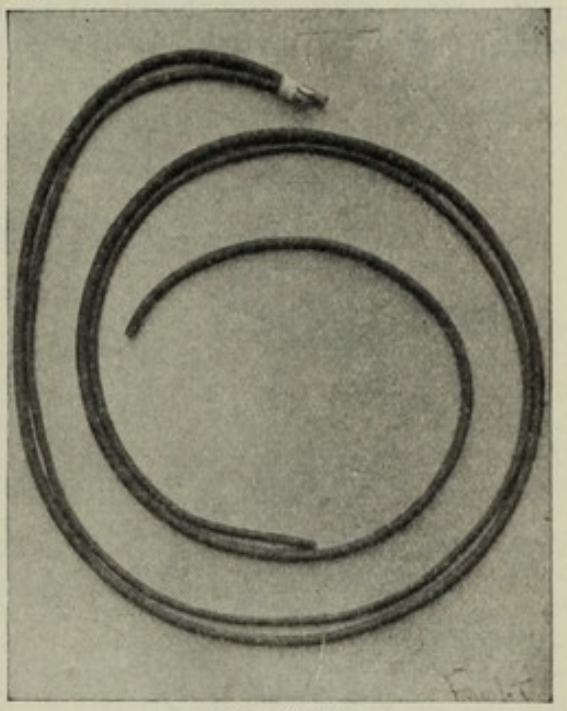


FIG. 1093.

FIGS. 1092, 1093.—Showing double-tube drainage for suprapubic operation. Figure 1092 was taken from an elevation to show the termination of the drainage-tubes. Figure 1093 shows tubes enlarged in separate view.

In Freyer's earlier operations he sought to leave the urethra and accompanying structures behind, but he is now convinced that the prostatic urethra may be torn or removed without ill results. Figure 1092 shows the drainage as I employ it after suprapubic prostatectomy. Figure 1093 shows the drain. If wide retraction is employed and an electric head-light is used enucleation may be made by scissors under direct vision.

McGill's Operation.—The bladder is opened by a suprapubic incision, the edges of the cut bladder are sutured to the abdominal wound with catgut, and the interior of the viscus is carefully explored by the finger and by sight, an electric light being used for illumination. If a sessile growth exists, the mucous membrane is incised and the growth enucleated by the finger or a curet. A pedunculated growth is cut away by sharp-edged forceps. If a mass projects into the bladder, an incision is made to divide it into two portions and each half is enucleated. Hemorrhage is arrested by irrigation with hot salt solution and by compression with gauze pads. In some cases a tampon must be inserted. The bladder is drained for several days or a number of days. As a matter of fact, a dense fibrous prostate cannot be enucleated and can be removed by scissors or cutting forceps only.

Fuller's Operation.—Open the bladder above the pubes; have an assistant push the gland up by means of a fist in the perineum. The gland can be lifted by two fingers

in the rectum. The surgeon makes a small incision through the mucous membrane over the prostate, enucleates the gland by means of the finger, and drains through an incision in the membranous urethra, as well as through the suprapubic opening.

Belfield's Operation.—Belfield performs suprapubic cystotomy, makes a perineal cut to enable the finger to approach the prostate, pushes the prostate up toward the belly, and enucleates it from within the bladder.

Perineal prostatectomy is less bloody than suprapubic prostatectomy. The sphincter of the bladder is not damaged, the entire prostate can be brought into view and removed, and perfect drainage is obtainable after operation.

Nicoll's Operation.—Perform suprapubic cystotomy. Then incise the perineum down to the prostate, split the capsule of the prostate, insert two fingers of the left hand into the bladder, and push the prostate into the perineum so as to bring it within reach. Enucleate the gland from the perineal wound without damaging the mucous membrane of the floor of the bladder.

Alexander's Operation.—Alexander makes a suprapubic incision and uses it for the same purpose as does Nicoll, but he also opens the membranous urethra on a grooved staff. After enucleating the gland he inserts a drainage-tube through the incision in the membranous urethra. In a very thin subject it may not be necessary to perform suprapubic cystotomy. Alexander has brought the gland into an accessible position in the perineal wound by suprapubic pressure, and Guitéras has done so by making an incision in the linea alba and inserting two fingers into the prevesical space. Syms advocates opening into the peritoneal cavity, inserting the hand, and pressing the prostate into the perineum without opening the bladder above the pubes.

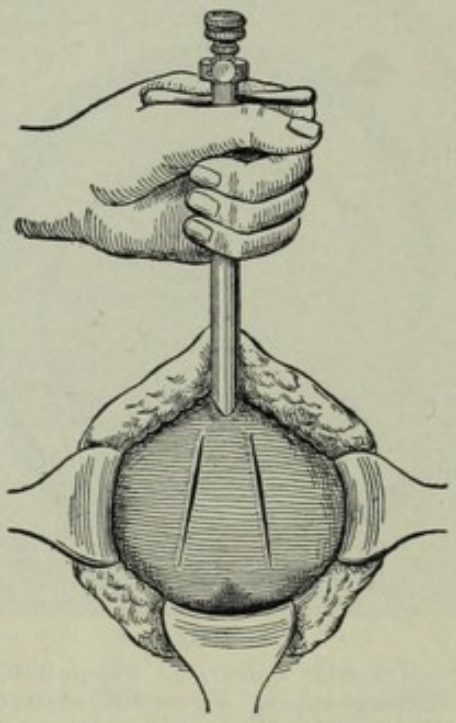


FIG. 1094.—Tractor introduced; blades separated; traction made, exposing posterior surface of prostate. Incisions in capsule on each side of ejaculatory ducts (Young).

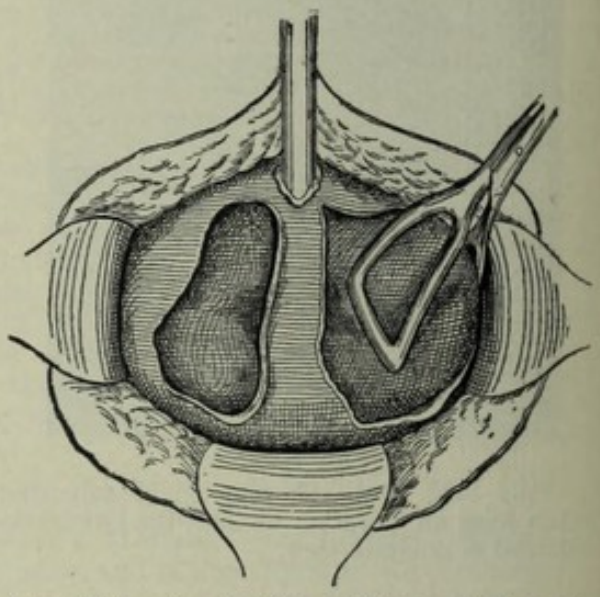


FIG. 1095.—Enucleation of lobes. Forceps in position (Young).

Bryson's Operation.—This is a satisfactory method in some cases. The bladder is irrigated and filled with warm salt solution. A grooved staff is introduced and a median perineal section is made to open the urethra just in front of the apex of the prostate gland. The knife is pushed back in the groove of the staff sufficiently far to incise the ring at the apex of the prostate; the forefinger is passed into the prostatic urethra and the staff is withdrawn. Then a short tear is made by means of a blunt instrument into the mass of the left lobe and the finger is introduced and enucleates the lobe. The same procedure is carried out on the right lobe, and, finally, if necessary, on the middle lobe. If the middle lobe requires removal, but cannot be reached, a suprapubic cut is made into the cave of Retzius, two fingers are inserted, and the lobe is pushed within reach of the finger below. A large perineal tube is introduced for drainage, a catheter is introduced and tied in place, and bleeding is arrested by packing.

Young's Operation.—This surgeon frequently operates under spinal anesthesia. He places the patient in an exaggerated lithotomy position and introduces a sound. In thin subjects the incision is in the raphé and is carried close to the anus; in short individuals the incision is an inverted V. He incises the recto-urethralis muscle transversely, exposes the membranous urethra, opens it, and inserts his tractor into the opening in the urethra (Fig. 1094). The tractor is turned 180 degrees, the blades are opened, and traction is made. The capsule is incised on each side of the ejaculatory ducts and the gland is removed by blunt dissection, the forceps grasping each lobe during enucleation (Fig. 1095). Every effort is made to save the urethra. After removing the lateral lobes the tractor is used to bring a middle lobe, if one exists, into the wound, in order that it may be also enucleated. The bladder is drained for about one week.

Young's punch operation was devised for the removal of small prostatic bars and contractures of the vesical neck involving the prostate. Young reports 200 cases, with no mortality. It can be done under local urethral anesthesia; 4 per cent. novocain is employed. The operation is performed by means of a special prostatic punch devised by Young. By means of the punch a portion of the offending bar is removed.

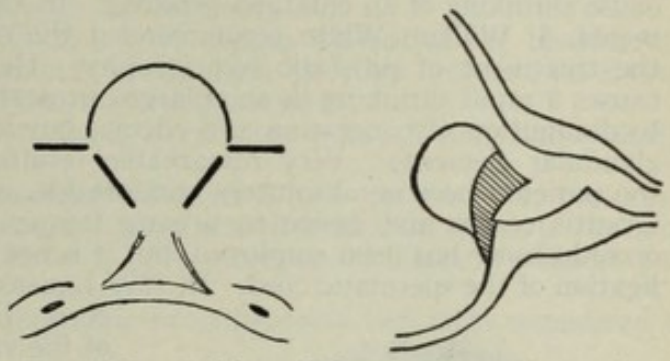


FIG. 1096.—Incisions of the middle lobe (Young).

Bottini's Galvanocaustic Prostatotomy.—Bottini, of Padula, in 1874 suggested cauterizing the prostate by means of a special instrument. He sought to burn away a portion of the gland in hope that the contraction of the scar would cause the remainder of the gland to shrink. The instrument of Bottini is shaped like a catheter, and carries a platinum blade which is heated by an electric current. Bottini's early instrument was not satisfactory and the operation never became popular until Freudenberg improved the tools in 1897.

Bottini's galvanocaustic operation is performed as follows: The bladder should be emptied, irrigated, and distended with air, and the posterior urethra must be anesthetized by instillation of cocain or eucain. The current is tried to see how many seconds it requires to heat the blade sufficiently. The current is broken, the instrument is introduced, the cooling current is set in motion, and one assistant watches this and nothing else. The current is turned on and the surgeon waits the required number of seconds for the blade to become red hot (twelve to fifteen seconds), and

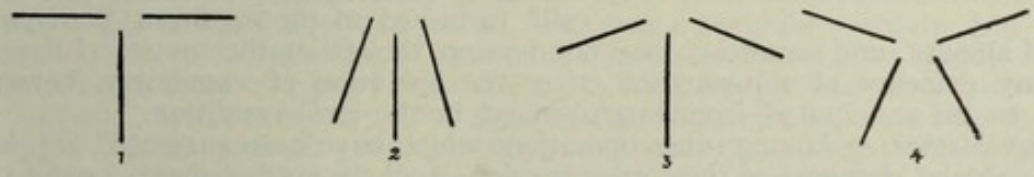


FIG. 1097.—Different incisions of prostate gland in Bottini's operation (after Young).

then turns the screw at the handle, and burns a groove in the prostate. A groove should be burned toward the rectum, one to one side, and, if it is thought desirable, one to the opposite side. No groove should be burned toward the pubes. When a groove has been burned, the blade is returned into its sheath, the current being increased while doing so in order to keep the blade from adhering to the tissue, then the current is shut off. After withdrawing the instrument it is not necessary to introduce and retain a catheter. The patient is confined to bed twenty-four hours only, there is rarely bleeding or fever, and the results are fairly good. The scars contract and the gland atrophies. During the period of healing a steel sound should be passed from time to time (Bangs). It is alleged that fibrous stricture of the neck of the bladder may follow in some cases.[1]

Bottini's operation is the procedure which may be selected for a sclerotic prostate

[1] For description of this operation see Freudenberg in "Berliner klin. Woch.," No. 46, 1897; and Willy Meyer in "Med. Record" of March 5, 1898, and May 12, 1900.

and for hypertrophy in a feeble and aged individual with damaged kidneys. The cautery operation will never replace prostatectomy. The best instrument is Young's modification of Freudenberg's instrument. Figures 1096 and 1097 show various methods of making the cuts as advised by Hugh H. Young. When there is a distinct and pedunculated median lobe the ordinary plan of burning fails entirely but, as Young shows (Figs. 1096, 1098), if an oblique cut be made on each side across the base, this lobe will drop out of the way and quickly atrophy. Bottini's operation does not gain in public confidence.

Castration and Vasectomy.—In 1886 Sanitzin demonstrated clinically the shrinking of a large prostate after double castration (Hawley in "Annals of Surgery," Nov., 1903). In 1893 Ramm, of Norway, performed double castration in order to cause shrinking of an enlarged prostate. In 1893, after a long series of careful experiments, J. William White recommended the operation of bilateral orchidectomy for the treatment of prostatic hypertrophy. He proved that removal of the testicles causes a rapid shrinking in an enlarged prostate. Much of this shrinking may be due to diminution of congestion and edema, but true atrophy undoubtedly occurs in the glandular elements. Very remarkable results have been recorded. In some cases the patients become absolutely comfortable and dispense entirely with the catheter. Cystitis ceases and desire to urinate frequently becomes less marked. Unilateral orchidectomy has been employed, but it is not satisfactory. In 1894 Mears suggested ligation of the spermatic cord. In 1895 Lauenstein suggested division of the spermatic cord. In 1896 Tilden Brown suggested ligation of the vas. Reginald Harrison in 1896 advised section of the vas. Lennander in 1897 proposed exsection of the vas deferens (*vasectomy*). It is slower in its results, but just as certain as castration. In spite of the great simplicity of orchidectomy the mortality has been considerable (from 11 to 18 per cent., according to some authors. Socin and Burckhardt say 16.2 per cent.). In several instances mental disturbance has followed the operation. Castration is now very seldom performed, as vasectomy is just as useful and is safer. Vasectomy is valueless in cases of fibroid prostate, does some good in adenoma, but is most valuable when the prostate is generally hypertrophied and prone to great congestion, causing violent symptoms. The testicle does not atrophy after vasectomy, mental disturbance does not occur because the internal secretion of the testicle is still furnished to the organism, perhaps in increased amount, and impotence may not develop, though sterility must. I have never seen any evidence of rejuvenation after the operation of vasectomy, beyond the extent to be anticipated from improvement in the local condition.

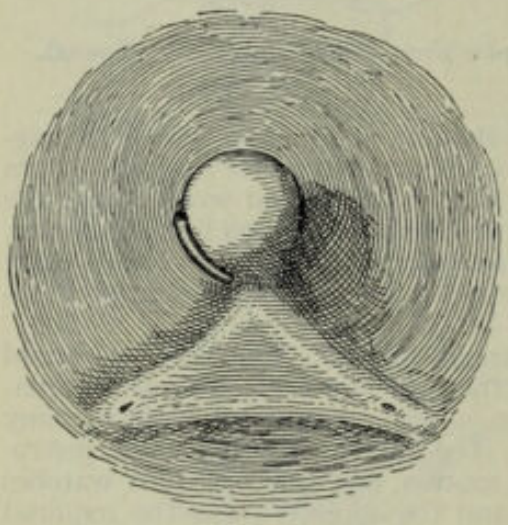


FIG. 1098.—Incising the middle lobe (Young).

Other Methods.—Among other operations which have been suggested are: ligation of the vascular elements of the cord; resection of all the cord elements except the vas and its artery and vein (*angioneurectomy*, proposed by Albarran in 1897); parenchymatous injections of cocain into the testicles; and ligation of both internal iliac arteries. Angioneurectomy has a mortality of 5.5 per cent. (Socin and Burckhardt).

Selection of Operation and Results.—The relative merits of these various operations alluded to above are in dispute. It is certain that many cases of prostatic hypertrophy can be kept comfortable by aseptic catheterism. If this procedure fails, or for other reasons must be abandoned, or if the surgeon decides not to employ it, a careful study of the case should be made before selecting a special operation. The Bottini operation for a time had somewhat extensive use. Some applied it to almost any sort of case, claiming that the operation was practically free from danger. Meyer used it for any case of uncomplicated hypertrophy, but if the prostate was very large, ligated the vasa deferentia some weeks before cauterizing the prostate in order to lessen the danger of thromboses.

A more conservative view is that of Eugène Fuller, who, doubting the permanence of the results of the Bottini operation and fearing that stenosis of the vesical neck may follow, would restrict the operation to uncomplicated cases not of a grave char-

acter, and in which the bladder has not been seriously damaged. It is the operation of choice if the prostate be fibrous. It may be the preferable operation if the patient be old, debilitated, or the victim of kidney disease. Some residual urine usually remains after a Bottini operation. In over 10 per cent. of cases no benefit follows. Vasectomy is used for an engorged and generally enlarged prostate. It may do great good or may fail completely. If the urine be extremely foul, some operation permitting drainage is advisable. In an adenomatous prostate in which enucleation is easy many prefer the perineal method. In other cases in which it is probable enucleation will be difficult; in cases of uncertain diagnosis; in cases in which a calculus may exist; and in cases in which the middle lobe is at fault, do a suprapubic operation, although in some few cases a perineal incision may be made, and a cut be made in the prostate to bring the floor of the urethra level with the trigone.

In old men with great obstruction and with serious disease of the bladder and involvement of the kidneys, and in individuals with prostatic cancer, permanent suprapubic drainage is sometimes the most useful procedure.

The mortality from Bottini's operation is over 5 per cent. Young had 3 deaths in 41 operations.

Vasectomy done early gives a mortality of from 3 to 5 per cent. If performed later, the mortality is 10 to 15 per cent. Socin and Burckhardt estimate the mortality of bilateral vasectomy as 8.3 per cent. The mortality of bilateral orchidectomy is over 11 per cent.

The mortality of perineal and suprapubic prostatectomy has been considered on page 1369.

Prostatic Fibrosis.—This condition was described by G. J. Guthrie in 1830. He called it a bar at the neck of the bladder. Enlargement of the middle lobe is not the bar, that is due to hypertrophy. Young calls prostatic fibrosis a median bar formation, Fuller speaks of it as contraction of the vesical neck, Barth designates it atrophy of the prostate, and Guyon names it *vesical prostatisme* (see the elaborate study by Alexander Randall in the "N. Y. Med. Jour.," Dec. 4, and 11, 1915).

The entire prostate is in a state of fibrosis and the bar forms in the muscular tissue. It impairs the elasticity of the vesical neck which becomes unable to dilate and leads to the gathering of residual urine and the symptoms of prostatic enlargement. The lobes may be enlarged. It can occur in persons still in the forties.

Treatment.—Some practise prostatectomy, but the patient is still in the age of virility and the operation is difficult and dangerous. Some treat it by fulguration, some by applying the cautery through a perineal incision, some follow Young, and remove the bar by means of a punch (see page 1373).

Malignant Disease of the Prostate Gland.—Primary malignant growths of the prostate are not infrequently encountered, but secondary growths are much more rare than primary growths. When malignant disease does occur it is usually cancerous. Secondary cancer of the prostate finds its most usual antecedent in cancer of the rectum. Epithelioma does not occur. Scirrhus occasionally occurs; but the most frequent form is encephaloid. Carcinoma occurs during or after middle age. The symptoms are those of urinary obstruction. A hard, nodular mass is palpated through the rectum. Sarcoma is very rare, although probably not quite so rare as has been thought. Some cases of prostatic tumor obviously inoperable when first seen by the surgeon are probably sarcomatous. Round-cell, spindle-cell, or mixed-cell sarcoma may develop. Powers says there have been but 31 authenticated cases of primary sarcoma reported ("Annals of Surgery," Jan., 1908). According to Gibson ("Jour. Amer. Med. Assoc.," April 23, 1910) there are on record 36 absolutely authenticated cases of sarcoma of the prostate. In 1912 Marcel Descums was able to collect 41 positive cases and Parmenter later reported a case. Sarcoma is most frequent in childhood, but may occur at any age. It grows rapidly, is usually soft, and causes difficulty of urination and defecation and pain in the rectum and perineum or pubic region, but early in the case, at least, there is seldom residual urine (Powers, loc. cit.). In some cases the chief symptoms are rectal (alternations of diarrhea and constipation and abdominal pains), in some vesical (frequency of micturition, slowness in inaugurating the act, loss of projectile power, and dribbling). A mass is detected by rectal palpation and is seen through a cystoscope. The mass may be soft, suggesting abscess, or densely hard. No real cure of carcinoma or sarcoma has yet been reported.

Carcinoma of the prostate may occur at an earlier age than ordinary hypertrophy of the prostate. The latter does not become evident until after the age of fifty; but

carcinoma of the prostate may begin at any time after the age of forty, and sarcoma of the prostate may commence in early youth.

At first the carcinomatous growth enlarges slowly; but it soon begins to grow with rapidity. It breaks through the capsule and fungates into the bladder or into the urethra. The pelvic, the inguinal, and the femoral glands become involved early in the course of the disease. It is unusual to find great obstruction to urination or to the passage of a catheter at an early period, but later both these conditions are noted. Early in the case there is pain only when obstruction to urination occurs; later, the pain in the neck of the bladder may be severe, and there may also be pain in the loin and in the sciatic nerves. Hemorrhage usually occurs. In the beginning the hemorrhage is trivial and intermittent, but when fungation exists, large hemorrhages generally take place. The blood is usually mixed with urine, but there is sometimes a large hemorrhage unassociated with micturition. The urine is not likely to contain pus or any large quantity of mucus unless the bladder is involved in the growth.

When the prostate gland is felt by means of a finger in the patient's rectum, it is found to be nodular, of stony hardness, and to be firmly anchored in place. Reginald Harrison points out that an ordinary hypertrophied gland is not so firmly anchored as a carcinomatous gland; that the bowel moves over it with freedom; and that, although it is firm to the touch, it is not of stony hardness. The patient with carcinoma of the prostate loses flesh rapidly and develops distinct cachexia, and metastatic deposits are likely to form in the vertebral column, in the kidneys, and in other organs and structures.

In making a diagnosis Harrison insists upon the value of the cystoscope. He says that in cancer one does not find much intravesical projection, and that what projection there is is uneven and irregular. In an ordinary adenomatous prostate, on the contrary, the surface is smooth and rounded and projects into the bladder.

Treatment.—Radical operation by the knife is out of the question in these cases. Permanent suprapubic drainage is made in most instances, and usually gives the patient great relief. (See "Remarks on Cancer of the Prostate," by Reginald Harrison in "Brit. Med. Jour.," July 4, 1903.) Radium may be tried, perhaps radium needles may be used.

Tuberculosis of the prostate gland is rarely primary. It is usually secondary to tuberculosis of the kidney. It may follow tuberculosis of the epididymis. In the majority of cases of tuberculosis of the prostate the lungs are involved in a tuberculous process when the patient is first seen by the surgeon. The disease appears particularly between the ages of twenty and thirty years, but it may attack elderly men and even the aged. It begins by the formation of a number of tuberculous nodules in the immediate neighborhood of the prostatic tubules. These nodules caseate and run together, forming cavities and, eventually, tuberculous abscesses, which are prone to rupture into the urethra. In very rare instances a large tuberculous abscess ruptures through the perineum, into the rectum or into the peritoneum.

The disease occasionally undergoes spontaneous cure through fibrous tissue formation or calcification. The tuberculous process is liable to spread to the seminal vesicles, the bladder, the ureters, and possibly to the peritoneum; and in some cases it inaugurates thrombophlebitis and pyemia.

Symptoms.—The patient suffers from pain during micturition; there is frequent micturition, and from time to time the urine contains blood. Attacks of cystitis take place, and weakness and loss of flesh are greater than is commensurate with any ordinary inflammation. Tuberculosis of the prostate alone is said not to cause marked hectic fever, but when adjacent structures become involved the temperature is definitely elevated and becomes characteristic. When the disease has advanced there is not unusually urinary incontinence on account of the involvement of the circular muscular fibers about the neck of the bladder. Commonly, there is a mucopurulent discharge, or mucopurulent matter may be obtained by massaging the prostate. This matter may contain tubercle bacilli, and in some cases the urine also contains bacilli. Early in the course of the case rectal examination detects some enlargement of the gland, many nodules, and tenderness; later in the disease it finds marked enlargement and areas of softening.

Treatment.—Early in the case Senn recommends parenchymatous injections of iodoform emulsion, the punctures being made through the perineum. If these fail, operation must be considered. When one takes into account how rare primary tuberculosis of the prostate is, one is impressed with the infrequency with which a radical operation should be attempted. If there is absolutely no evidence that any adjacent

organ is involved or that any distant focus of disease exists, it is justifiable to perform perineal prostatectomy. As a rule, however, the only surgical operation performed consists in making, in front of the rectum, a curvilinear incision which exposes the prostate, and permits the surgeon to open and curet caseous foci. If an abscess forms, it should be evacuated by means of a perineal incision and cavities should be curetted and packed with iodoform gauze.

When a patient is convalescent after an operation or if it is determined that no operation is advisable, full antituberculous treatment is employed (see page 162). One should look to the patient's general health, administer hexamethylenamin, and avoid using urethral instruments as much as possible; because, as Sir Henry Thompson has shown, instrumentation irritates the prostate, causes a great deal of pain, and makes the disease worse in every case.

Retained and Malplaced Testicle.—The cause of non-descent is unknown. Certain it is that the vaginal process is not a factor in descent. Some think the condition is a reversion to type. Buedinger thinks the gland is restrained by adhesions the result of fetal peritonitis. It has been asserted that a short mesorchium is responsible. Eisendrath ("Annals of Surgery," 1916, lxiv) thinks that the contributing factors are deficiency in the arching fibers of the internal oblique and a weakness of the conjoined tendon which allow of retraction by the cremaster. The normally descended testicle is entirely within the scrotum. In 1 person of 100 there is either undescended or ectopic testis. In 80 per cent. of individuals the testicles have descended at birth; most often it is the right testicle which fails to descend. Sometimes a testicle descends after being retained for months or even years. In Keyes's case it descended in the thirtieth year. Late descent usually causes hernia, and in over 90 per cent. of all cases hernia exists. In not a few cases of non-descent there is hypopituitarism. The testicle may be arrested in its passage to the scrotum (*cryptorchism*, single or double); it may remain in the lumbar region; it may reach the internal abdominal ring; it may lodge in the inguinal canal; it may emerge from the external ring, but fail to enter the scrotum; or it may pass into an unnatural position, as into the perineum or the crural canal (*ectopia of the testis*). The failure of descent may be unilateral or bilateral, but when bilateral the degree of descent is seldom the same on the two sides. The gland may be, but seldom is, functionally active. When retained in the abdomen it never has the power of spermatogenesis. Before puberty the testicle (if not abdominal) may be normal, but after puberty there is practically always more or less atrophy. In about 1 case out of 5 there is spermatogenesis for a time. A retained testicle is liable to attacks of orchitis and may become tuberculous, carcinomatous, endotheliomatous, or sarcomatous. Coley ("Annals of Surgery," 1915, lxii) reports that among 59,235 cases of inguinal hernia admitted to the N. Y. Hospital for Ruptured and Crippled there were found 737 cases of sarcoma of undescended testicle. In some cases mixed tumors form (sarcocarcinomata). See case of Butt and Arkin ("Jour. Alumni Assoc. Coll. Phys. and Surgeons," 1915, xvii). If both testicles are retained, one or both may become the seat of neoplastic formation. In some cases of retention torsion of the cord occurs. In most cases there is neither pain nor tenderness, and the patient presents himself for treatment because a lump has appeared in the groin. In some cases there are sudden attacks of violent pain, accompanied by nausea (Rawling on "Incompletely Descended Testicle" in "Practitioner," August, 1908). A testicle in the inguinal or crural canal or in the perineum is far more apt to become sarcomatous than one retained within the abdomen. Over 10 per cent. of cases of sarcoma of the testicle are in undescended glands. Russell Howard ("Practitioner," Dec., 1907), out of 57 cases of undescended testicle, found 15.7 per cent. with malignant disease. In double cryptorchism, in which the testicular function has been abolished, there may be delayed union of the bony epiphyses and epiphyseal fractures are common, and there may be excessive growth of long bones. The same liability is noted in those subjected to castration in infancy. When such a subject reaches manhood he may develop some disease of the skeleton which is usually seen in children only (Gross and Sencert, "Rev. de Chir.," No. 11, 1905). In operating on these cases we usually find a well-developed gubernaculum and a vaginal tunic extending below the testicle.

Treatment.—If one testicle is undescended at or after the eighth year of life and before puberty, if it lies in the canal, and if the other testicle is sound, the former should be removed if it is found impossible to draw the gland into the scrotum. Both testicles should not be removed from a child: one should be placed within the abdomen if neither can be put in the scrotum. I would save one testicle in order to have

the child certainly enter and remain in the masculine groove. Removal of both testicles is permissible in an adult, because he has definitely become and will remain masculine, and undescended or ectopic testicles in an adult are or will surely become functionally useless and menaces. If a testicle is retained in the abdomen it should not be operated upon unless it causes trouble. Always try to get an inguinal gland into the scrotum before the age of puberty. If it is retained after puberty, it will be almost certain to remain so and to become functionally useless. An ectopic testicle should be put in the scrotum if possible; if not, it should be removed. Even when operation is performed to replace the testicle, success is seldom enduring. Of Rawling's 29 cases, only 4 were permanently successful. Other operators, however, claim better results. For instance, Broca reports 79 cases traced from one to six years, and in 31 of them the result was perfect and permanent. The method I employ is that advocated by Coley, viz., Bassini's incision through the aponeurosis, separation of the cord from the peritoneum (it is usually in the posterior sac wall); removal of the vaginal process, the cremaster and fibrous adhesions around the cord; the making of a scrotal pouch by the fingers, closure of the canal as in hernia; suturing of the cord to the pillars of the external ring, as advocated by Dowd. This is practically Broca's method. Bevan operates for a testicle within the canal by separating and dividing the vaginal process, removing all the coverings of the cord, and leaving the testicle suspended by the vas and spermatic vessels only. This proceeding gives the testicle a very wide range of mobility. A pocket is made in the scrotum by means of the finger, the testicle is placed in the pocket, and remains there without suturing. The canal is now sutured as in a Bassini operation without cord transplantation. There is a certain though small risk of gangrene of the testicle after Bevan's operation. I believe Bevan's method should be employed in the more severe cases. If there is no hernia, operation should not be performed until between the eighth and twelfth years of life.

If an atrophied testicle can be moved into the scrotum it might be proper to take a text from a remarkable case reported by Robert T. Morris ("Jour. Amer. Med. Assoc.," Sept. 2, 1916). A boy of 13 lost both testicles as a result of mumps. The scrotum seemed empty. A wedge-shaped graft was secured from the testicle of a hernia patient who was free from syphilis and tuberculosis. One piece of the graft was inserted under the sheath of the right, another under the sheath of the left rectus muscle of the abdomen. The remainder of the graft was placed in the scrotum. As the graft placed in the right scrotum began to disappear the vestige of testicle began to enlarge. About a year later another graft was inserted into the right scrotum. It was then seen that the testicle appeared normal and was about one-third natural size. Evidently the graft stimulated the vestige to development. Lespinasse reports the case of a man who lost both testicles and the power of erection. A graft from the testicle of a live man restored the power of erection ("Jour. Med. Assoc.," 1913, lxi). This is a new principle which might be utilized when a functionless undescended testicle is drawn into the scrotum.

Orchitis is inflammation of the testicle. *Acute orchitis* may follow cold, wet, traumatism or epididymitis, and may follow or develop during gout, mumps, rheumatism, or a specific fever. Mumps seldom attacks the testicle before puberty. Orchitis before puberty may be due to tuberculosis or to cord torsion. The testicle is round, swollen, tender, and very painful, the scrotum is red and swollen, the tunica vaginalis is filled with fluid, and there is fever. *Chronic orchitis* results from the acute form or from a chronic urethral inflammation, and is almost always combined with epididymitis. *Gonorrheal orchitis* is rare and almost certainly results in sloughing of the testicle.

The **treatment** of the *acute* form consists in rest in bed and applications as for epididymitis (see page 1382). The *chronic* form requires the removal of the causative lesion, if possible, the wearing of a suspensory bandage, applications of ichthyol or mercurial ointment, and the administration of iodid of potassium by the mouth. Strapping with zinc oxid adhesive plaster may do good. Castration may be required.

Tuberculosis of the testicle may perhaps be primary, but in the vast majority of cases is secondary to tuberculosis of the kidney, prostate, bladder, or seminal vesicles. As Keyes ("Annals of Surgery," June, 1907) says, careful examination will show one of three conditions—tubercle bacilli in urine, indurations in the prostate, and vesicles or "a distinct haze in the urine due to prostatic catarrh." Tuberculosis of the prostate or vesicles exists in probably one-half the cases (Barney in "Boston Med. and Surg. Jour.," March 14, 1912). In about one-third of the cases there is evidence of tuberculosis distant from the genito-urinary organs (especially in the lungs or bones).

Patients with tuberculosis of both testicles are nearly always sterile. The disease may be preceded by pulmonary tuberculosis, lymphatic tuberculosis, peritoneal tuberculosis, anal fistula, renal tuberculosis, or tuberculous disease of bones or joints; and primary tuberculosis of the testicle may be followed by near or distant tuberculous lesions. In some cases involvement of the prostate exists, but cannot be detected (*latent tuberculosis of the prostate*); in other cases the prostate is in a state of subacute inflammation. The epididymis is usually involved before the testicle and early chronic lesions are localized there for some time. In most cases the bacilli reach the prostate and vesicles by way of the blood, and reach the epididymis by way of the vas deferens, the lesions of the prostate and vesicles developing first or remaining latent. In some cases tuberculosis of the kidney or bladder is followed by tuberculosis of the testicle. The spread from the prostate, vas, or bladder is by epithelial infection. There is no evidence confirmatory of the idea of ascending infection from the urethra. In a child with an open vaginal process, tuberculous peritonitis may directly cause tuberculous epididymitis. The disease begins in one testicle, but in the vast majority of cases the other testicle becomes involved after a few weeks or months. If the other testicle remains free for three years its chance of remaining free is good. If but one epididymis

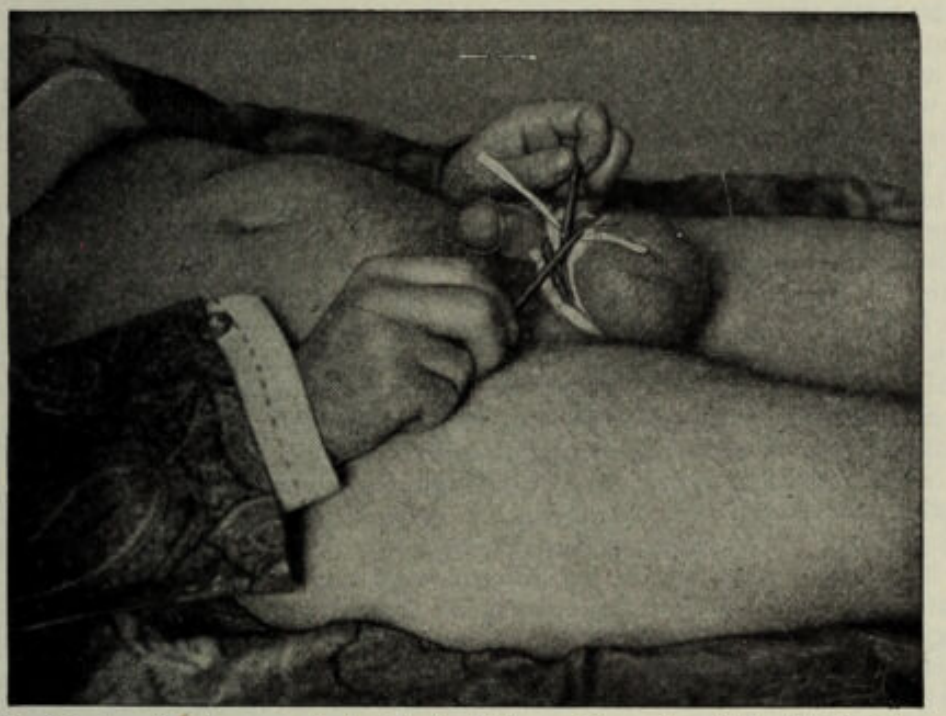


FIG. 1099.—Obstructive hyperemia for the testicles. The ends of the elastic tube are held by the patient, crossed. A piece of tape is placed beneath to be tied by an attendant (Meyer and Schmieden).

is involved the testicle proper may not be affected for weeks or months. Von Bruns says that in 18 per cent. of such cases the testicle is not involved for six months; in 40 per cent. for over two months ("Archiv. f. klin. Chir.," Bd. 63, H. 4). It usually comes on gradually, but it may begin acutely, as I have seen in two instances during the progress of tuberculous peritonitis. An acute onset or an acute exacerbation of a chronic case usually means mixed infection. The disease may follow a slight injury or inflammation, and is most common in young men, but may arise at any age. The causal influence of antecedent or existing gonorrhea is doubtful. Some maintain that sexual excess predisposes. There is often a family history of tuberculosis. A chronic case begins by swelling of the epididymis. Palpation detects one or two or several rounded nodules, or a diffuse hardening. In the latter case the epididymis is much enlarged, and there is usually a slight hydrocele. Rectal examination commonly detects nodules in the prostate and vesicles. In a few cases there are frequency of micturition, tenesmus, hematuria, and seropurulent fluid can be massaged from the vesicles and prostate and milked from the urethra. In some cases bacilli are found in the urine. In others the urine is hazy. In about 80 per cent. of cases the guinea-pig test will prove the presence of bacilli. In some cases the urine is normal. Sooner or later nodules appear in the testicle. The vas is always swollen and may or may not be palpable. In

an acute case one testicle is involved. The testicle is very painful and the epididymis is greatly swollen and smooth. The testicle quickly swells, there is always a hydrocele, and the scrotal skin becomes reddened. In a few days the acuteness of the symptoms subsides, and suppuration may occur. In any case of tuberculosis of the testicle nodules tend to soften and run together. After a time the skin may become red and adherent, give way, and expose a caseous, breaking-down epididymis or testicle. Caseation can occur without mixed infection, but in many cases in which softening and sinus formation occur there is mixed infection. The duration of the disease is uncertain; 10 per cent. of the 100 cases carefully studied by Keyes were known to be alive ten years after the beginning of the trouble, and 4 (and not one of them had been operated upon) seemed free from tuberculous lesions anywhere. One-third of the cases that suppurated were apparently well after three years ("Annals of Surgery," June, 1907). Except in the acute cases the testicle is only slightly, if at all, painful, and tenderness is trivial. In one-sixth of the cases a small hydrocele forms. If a hydrocele exists the fluid should be withdrawn by tapping in order that cultures may be made from it.

Treatment.—Before attempting any operation try Bier's method. The patient is placed recumbent, the diseased testicle is lifted upward, cotton batting is placed around the neck of the scrotum, and a rubber drainage-tube of a caliber of 25 of the French scale is wound twice around and fastened with a string or clamp. If both testicles are diseased, both are held up and the neck of the scrotum is embraced by the tube with the required firmness (see Fig. 1099). The treatment is applied for two or three hours a day or longer. The patient had best be recumbent during the application. In the intervals he wears a suspensory and gets about. During the use of Bier's method full antituberculous treatment is required (see page 162). If a cold abscess forms, open it and dress the part antiseptically. Durante injects iodin into the body of the epididymis once a month. If Bier's treatment fails, consider the advisability of operation. An acute case requires unilateral castration. If in a chronic case the disease is limited to the epididymis or to the epididymis and vas, resect the epididymis (*epididymectomy*) and the vas deferens. If the testicle is diseased, *orchidectomy* is performed. It was long believed that orchidectomy was useless if the vesicles and prostate were involved, but Koenig and others maintain that vesicular and prostatic tuberculosis improves after removing the diseased testicle or epididymis. If the epididymis of each testicle is involved, bilateral epididymectomy should be performed. When both testicles are diseased and other organs and structures are not extensively involved, bilateral orchidectomy is performed or, better, the testicle which is most diseased is removed and the *diseased portion* of the other is extirpated. Cumston points out that when the testicle is diseased the disease may not be detectable even on operative exposure. Hence in doing epididymectomy he splits open the testicle to see if it be diseased. If it be not diseased he sutures it with catgut and removes the epididymis. If it be diseased he considers the advisability of unilateral orchidectomy (Charles Greene Cumston in "Annals of Surgery," June, 1909).

In many cases after epididymectomy sinuses form. They may remain open for months. In association with and after operation employ antituberculous remedies, order a nourishing diet, send the patient to a good climate, and insist on an open-air life. Tuberculin may prove useful. A considerable percentage of unilateral cases are cured by operation (over 40 per cent.). Some few bilateral cases are cured.

Cysts and Tumors of the Testicle.—Innocent growths are so rare that their existence has been disputed, but certain teratomata are innocent. A large majority of growths is beyond question malignant. Some are entirely malignant, some show a mingling of benign and malignant elements. Even a growth, innocent in the beginning, has a most powerful tendency to become malignant. It is estimated that 15 per cent. of testicle tumors follow traumatism. Ewing believes that practically all of these tumors are of teratomatous origin. We used to regard a malignant growth as sarcoma, but Tanner ("Surg., Gynec., and Obstet.," Nov., 1922) points out that the malignancy is usually cancer, though sarcoma can occur.

Teratoma is in the beginning innocent. It springs from the three embryonal layers and may contain muscle fiber, hair, teeth, and cartilage. Cysts are apt to form, which cysts are lined, some by squamous and some by columnar epithelium. H. Morriston Davies ("Lancet," Feb. 17, 1912) considers embryomata to be "composite tumors containing elements derived from epiblast, mesoblast, and hypoblast." They arise in the body of the testicle and not in the epididymis, although the epididymis may eventually become involved.

Southham and Linell ("British Journal of Surgery," October, 1923) point out that any or all of the elements of these so-called fibrocystic tumors may become malignant, resulting in squamous cell carcinoma, columnar cell carcinoma, sarcoma or carcinoma with sarcoma, a mixed condition of malignancy known as carcinosarcoma, and further, that the innocent tumor may undergo metaplasia and that a malignant tumor is certain to do so. Mixed tumors, which are identical with mixed tumors of the salivary glands, are rather uncommon. The mixed tumor is regarded by Southham and Linell (Ibid.) as a myxo-chondro-endothelioma. It has a capsule and does not form metastasis, although, as in the parotid gland, nodules are apt to break through the capsule, hence thorough removal requires removal of the capsule and the use of radium in the wound after the operation to destroy small areas which may have escaped excision. Tanner (Ibid.) says that 35 per cent. of all testicular tumors are cancerous and that sarcoma is rare. As previously stated, cancer may arise from the epithelial elements of a teratoma. What is known as the spermatocytoma which arises from the germinal epithelium of the seminiferous tubes is the most common of all testicular tumors. (Sixty-two per cent. of Tanner's 101 cases.)

These soft growths enlarge with great rapidity and are usually designated as sarcoma. When the epiblast alone becomes malignant it gives origin to a superficial form of growth known as the chorion-epithelioma which resembles a hydatid mole. (See Nicholson, "Guy's Hospital Reports," 1907.)

Sarcoma is so rare that its existence has been denied and it is usually confused clinically with spermatocytoma. It arises from the mesoblast alone.

All tumors of the testicle should be regarded as possessing the potentiality of malignancy and even the so-called innocent growth may undergo metastasis.

Malignant disease may arise from a teratoma or may be malignant from the start. If a tumor which has long existed, perhaps years, begins to grow rapidly, we may assume that there is malignant change in an embryoma. It is seldom possible to diagnosticate the form of a malignant tumor, although it is nearly always cancer. Sarcoma may occur at any age, but the period of greatest liability is from twenty to forty. Sarcoma is usually of the small round-celled variety (the type known as lymphosarcoma), but the spindle-celled growth is sometimes seen. It begins in the mediastinum of the gland. The other testicle soon becomes involved in malignancy. The growths disseminate rapidly. In 10 per cent. of cases the testicle is undescended. Any sarcoma is liable to sudden increase in size because of hemorrhage.

Nicholson ("Guy's Hospital Reports," vol. lxi, 1907) divides carcinomata into encephaloid (which is commonest) and scirrhus (which is rare), and regards so-called columnar carcinomata as teratomata. Carcinoma is rare before the age of forty. Davies ("Lancet," Feb. 17, 1912) admirably sums up the clinical picture of malignant disease of the testicle. I have utilized his article extensively below. The tumor may attain a great size (that of a cocoanut). It is usually oval, but may exhibit a few rounded projections "due to the presence of degeneration in the tumor or of fluid in the tunica vaginalis." Early in the development the growth is smooth (except for the projections mentioned); later it breaks through the tunica albuginea and so later has an irregular surface. The epididymis is at first free, but sooner or later becomes part of the tumor. The consistence of malignant tumors is very variable (may be hard, elastic, soft, or fluctuating), and the consistence of a tumor may vary in different parts. In most cases there is an associated hydrocele in which the fluid may be limited or may be distributed throughout the entire sac. The hydrocele may be translucent, the tumor never is. Pain is seldom severe and tenderness seldom acute in the testicle. I have seen terrible agony when the lumbar glands were involved. The tumor when raised on the hand feels very heavy. The cord becomes enlarged because of involvement.

The growth finally adheres to the scrotum, the skin reddens and gives way and fungation occurs. When this happens there is severe pain. Sarcoma of the testicle, unlike sarcoma in most other regions, causes early glandular involvement. The glands along the renal veins are especially liable to invasion. Carcinoma, of course, involves glands. The inguinal glands are not involved unless the scrotum be attacked. The lumbar glands receive the testicular lymphatics. Secondary growths are early and wide-spread and are common in the skin.

Malignant growth of an undescended testicle causes acute pain in the iliac fossa and later a mass can be felt. Such symptoms, in one whose testicle of that side is not in the scrotum, at once suggest the cause.

H. M. Davies emphasizes the great fatality of malignant disease of the testicle;

quotes Chevassu's collection of 100 cases treated by castration, of which 81 died of malignant disease and only 19 were cured, and insists that "early diagnosis and the removal of the testicle and surrounding fascia and the glands in the lumbar region offer the only hope of decreasing so appalling a mortality" ("Lancet," Feb. 17, 1912).

Orchidectomy, or Castration (*Excision of a Testicle*).—Bilateral castration should never be performed without deliberate consideration. It often produces grave mental disorder. This is in part the result of the mental depression attendant on knowing that the highly prized glands are gone for ever, and in part the loss to the organism of the internal secretion of the testicles. A boy castrated before puberty never becomes potent and assumes feminine attributes of mind and body. Castration after puberty does not lead to effemination. A man, of course, becomes sterile, but may retain potency for a considerable time after castration. I removed a tuberculous kidney from a man who had been castrated by my colleague, Dr. Horwitz, two years before, and that he was still able to have intercourse was testified by him and by his wife. Unilateral orchidectomy does not make a man either sterile or impotent and does not produce mental disturbance. In orchidectomy for benign disease an incision is made over the cord, commencing just outside the external ring and running down over the base of the tumor. Clamp the cord and divide it near the ring, remove the testicle, ligate the spermatic artery alone, and then ligate the entire thickness of the cord. The cord is ligated with chromic gut. The skin is sutured with silkworm-gut. Drainage is not required. It is often advisable to remove a considerable amount of scrotal skin. Orchidectomy for malignant disease must be a much more radical procedure. After the cord has been divided and the testicle removed, as in the ordinary operation, the incision is prolonged along and through the roof of the inguinal canal, and is continued in the same direction to a point a little above the anterior superior spine of the ilium. The incision is then curved and carried up to "the costal margin at the level of the tenth rib" (Davies in "Lancet," Feb. 17, 1912). The peritoneum is exposed. The cord is traced well into the true pelvis, is tied, and divided. The fascia over the iliacus and psoas muscles is dissected, "together with the contained spermatic vessels and lymphatics," and the glands upon "the inferior vena cava and aorta" are removed (Davies, Ibid.). This operation was first performed by Grégoire in 1905. Davies did the thirteenth operation on record (Ibid.).

Epididymitis, or *inflammation of the epididymis*, is usually due to inflammation of the urethra. It is apt to occur in the stage of decline of a gonorrhea, and in such a case is announced by a notable diminution or a complete cessation of discharge. It may result from the passage of a urethral instrument, the voiding of urine which contains fragments of calculi, or as a complication of prostatic hypertrophy. *Acute epididymitis* is characterized by swelling of the epididymis, severe pain in the groin, and tenderness over the posterior part of the testicle. The pain becomes acute, swelling rapidly increases, and the constitution sympathizes. The swelling is due partly to engorgement of the epididymis and partly to fluid in the tunica vaginalis (*acute hydrocele*). *Chronic epididymitis* is usually linked with orchitis, and it follows an acute exacerbation of a chronic urethral inflammation.

Treatment by aseptic puncture with a tenotome, if fluctuation be marked, will relieve tension and pain. Hagner makes multiple punctures in the epididymis. Leeching over the external abdominal ring, the use of an ice-bag early in the case, elevation of the testicles upon a bunch of towel, applications of guaiacol, and the administration of laxatives and opium constitute the usual treatment in the acute stage. Applications of guaiacol over the cord, epididymis, and testicle seem to relieve pain and distinctly lessen swelling. Two applications a day should be made for one week. At each application paint the scrotum and the skin over the external ring with 15 drops of guaiacol in 1 dram of glycerin or olive oil. Strapping is employed as the inflammation subsides. The treatment of the chronic form is the same as that for chronic orchitis.

Strangulation of the Cord by Axial Rotation.—In nearly one-half of the cases the testicle is undescended or only partly descended. In every case there is a long mesorchium, and if a normal testicle be normally placed torsion of the cord will hardly occur (Chas. L. Scudder, "Annals of Surgery," Aug., 1901). The twisting may be toward the right or toward the left. The symptoms arise suddenly, and usually during exertion. In some cases a hernia also exists. When the rotation occurs, the testicle swells, hemorrhages take place into it, and gangrene may develop. If the cord of an undescended or partially descended testicle twists, swelling and tenderness are noted in the abdomen or groin. If the swollen testicle is in the scrotum, the gland

feels nodular and the epididymis is found to be anterior instead of posterior, as it is in a normally placed gland. The symptoms are sudden pain, vomiting, moderate shock and a swelling in the groin or a swollen testicle in the scrotum. The swelling



FIG. 1100.—Hydrocele.

receives no impulse on coughing. The symptoms resemble those of strangulated hernia, but are less violent, and the bowels, though often much constipated, are not obstructed.

Treatment.—An incision should be made, and if the twisting has been recent and the testicle is not gangrenous, the cord may be untwisted and the testicle fastened to the scrotum by a catgut stitch. If the testicle is gangrenous it should, of course, be removed. Scudder tells us that in 88 per cent. of cases the testicle is found to be gangrenous. Scudder found 32 recorded cases: 31 were operated upon and 1 was not, but all recovered; in 3 the testicle sloughed and in 2 it atrophied ("Annals of Surgery," Aug., 1901).



FIG. 1101.—Hydrocele "en bissac." This hydrocele extends up the cord into the inguinal canal and to the internal abdominal ring (Horwitz).

Vaginal hydrocele (*chronic hydrocele*) (Figs. 1100 and 1102, *e*) is a collection of fluid in the tunica vaginalis testis. An enlargement of the testis may cause it (*secondary hydrocele*), but in most instances the cause is unknown and no signs of inflammation exist (*primary hydrocele*). The fluid is albuminous, but it does not coagulate spontaneously; it is thin, straw colored, and may contain crystals of cholesterin. The testicle is at the lower and back part of the sac. The pyriform mass fluctuates, is translucent, grows from below upward, and the introduction of an exploring needle permits yellow fluid to flow out. Sometimes a hydrocele has an hour-glass shape. This is the *hydrocele "en bissac"* of the French. In this condition (Fig. 1101) two cavities exist, usually but not invariably communicating. The constriction between the cavities is due to inflammatory thickening.

Treatment.—In secondary hydrocele the treatment of the diseased testicle is the essential plan. We discuss here the treatment of primary hydrocele. Simply tapping the sac with a trocar is only palliative; air must run in as fluid runs out, and suppuration may occur, which will be dangerous without drainage. Never tap a rigid sac. The injection of irritants should be abandoned, as it exposes the patient to serious danger because of inflammation occurring without provision for drainage. A successful plan is to incise the sac, dry its interior by bits of gauze, swab it out with pure carbolic acid, pack it with iodoform gauze, and dress it antiseptically. The packing is removed in twenty-four hours and the wound is allowed to close. I have used this method frequently. If the sac is rigid and will not collapse, either stitch it to the skin and pack it or excise a large portion of its parietal layer and insert a drainage-tube (*Volkmann's operation*). Another plan is to tap the sac with a trocar and cannula, leaving the cannula in place as a drain for some days, and dressing antiseptically.

Longuet's operation is easy and is advocated by many surgeons. It is called *extraserous transposition of the testicle*. It was introduced by Longuet in 1898 ("Progrès Méd.," Sept. 21, 1901). Doyen and Winklemann do a similar operation. Jaboulay, too, advocates splitting the sac and turning it inside out. He folds it around both the testicle and cord and stitches it so that the smooth endothelial surface of the tunic will be in contact with the raw scrotal tissue. It will adhere to the scrotal tissue ("Keen's Surgery," vol. iv). A local anesthetic is injected and an incision 2 inches in length is made. The testicle is lifted from the scrotum. The serous and all the other coats except the skin fall together behind and make a sheath for the cord. One catgut suture will hold them behind the cord. A bed is made for the testicle beneath the

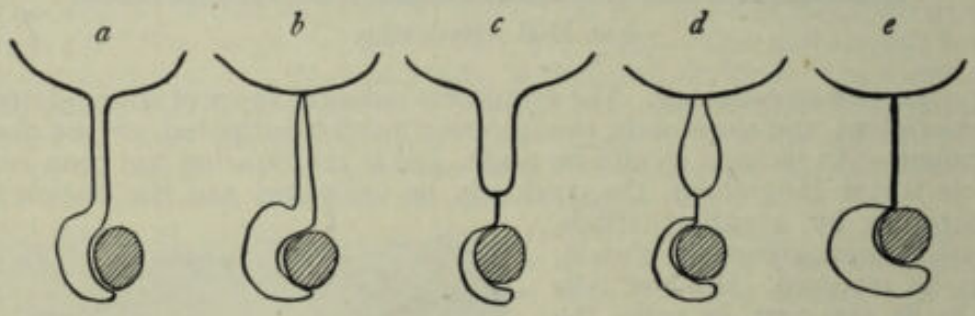


FIG. 1102.—Varieties of hydrocele: *a*, Congenital; *b*, infantile; *c*, funicular; *d*, encysted; *e*, vaginal.

inner edge of the skin wound by tearing with the fingers. The testicle is rotated on its long axis and inserted into this cavity. The testicle rests against the scrotal septum, and in front of the gland is the cord covered by the tunic. The skin is sutured and the wound is dressed. E. Wyllys Andrews devised *the bottle operation* ("Keen's Surgery," vol. iv). The unopened tunic (with the testicle) is separated from the scrotum and dislocated through the scrotal wound. A small incision is made near the summit of the funnel-like prolongation of the sac upon the cord. The sac empties and then resembles a bottle or bag with a small opening at the top. The testicle is squeezed through the opening. When this is done the sac is inside out and the edges of the small opening lie closely about the cord. The skin is closed without drainage. In some cases after doing any one of the operations which turn the sac inside out a large tender mass forms, composed of swollen testicle and thickened sac. I have had this experience several times. In such a case it is necessary to excise the thickened sac.

Congenital hydrocele (Fig. 1102, *a*) is hydrocele through an unclosed funicular process into the tunica vaginalis. If the pelvis be raised the fluid runs back into the peritoneal cavity, from which it originally came.

The **treatment** is the application of a truss to obliterate the funicular process, and when that occurs, if the counterpart of an infantile hydrocele persists, puncture and scarification of the walls of the sac.

Infantile hydrocele (Fig. 1102, *b*) is a collection of fluid in a funicular process of the tunica vaginalis, the funicular process being closed above, but not below.

The **treatment** is to puncture the sac and to scarify the sac wall with a needle.

Funicular Hydrocele (Fig. 1102, *c*).—The funicular process is closed below, but is open above. Raising the pelvis causes the fluid to trickle back into the peritoneal cavity.

The **treatment** is the application of a truss.

Encysted Hydrocele of the Cord (Fig. 1102, *d*).—In this variety the funicular process is obliterated above and below, but it is patent between these two points and fluid collects.

The **treatment** is the same as that for infantile hydrocele. If this fails, incise and pack.

Encysted hydrocele of the testicle and of the epididymis may occur. *Diffused hydrocele* of the cord is simply edema of the cord. *Hydrocele of a hernia* is the distention of a hernial sac by peritoneal fluid.

Hematocele (Fig. 1103).—*Vaginal hematocele* is blood in the tunica vaginalis, the result of traumatism, a tumor, or the tapping of a hydrocele. There is a pyriform swelling which fluctuates, but which gradually becomes firmer; the scrotum is livid and the testicle is below and posterior to the tumor. The mass cannot be transilluminated. The *encysted* form of *hematocele of the cord* is a hydrocele of the cord into which bleeding has occurred. The *diffused* form is due to extravasation of blood into the cellular substance of the cord. *Encysted hematocele of the testicle* is due to effusion of blood into an encysted hydrocele of the testicle. *Parenchymatous hematocele* is extravasation of blood into the substance of the testicle.

The **treatment** of a recent case of vaginal hematocele is to put the patient to bed, support the scrotum, and apply an ice-bag over the testicle. If the swelling does not soon abate, incise, irrigate, and pack.

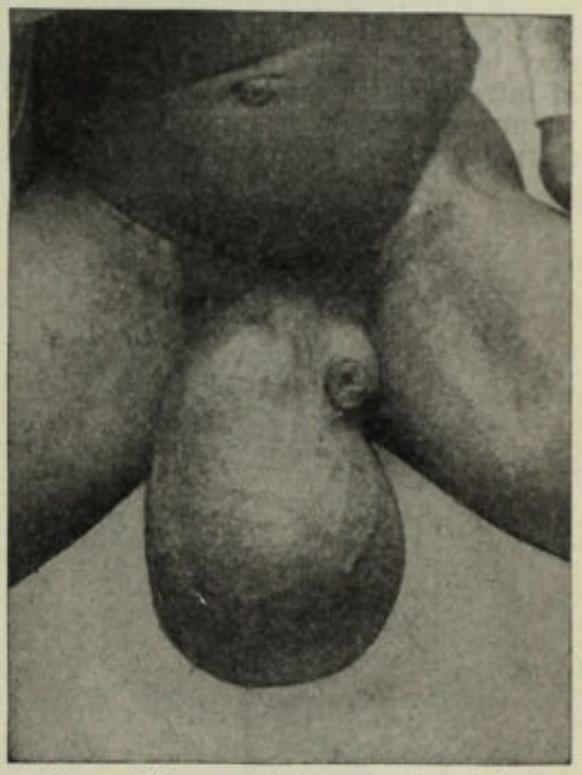


FIG. 1103.—Acute hematocele of tunica vaginalis the result of traumatism (Horwitz).

Varicocele is varicose enlargement of the veins of the venous plexus of the spermatic cord. It may be unilateral or bilateral. The veins are thickened, lengthened, dilated, and convoluted. The assigned causes are straining, coughing, constipation, and an occupation requiring prolonged standing. Some believe ungratified sexual desire is a cause. Hereditary predisposition is probable. There are more left-sided than right-sided varicoceles, because the right spermatic vein has valves and empties into the vena cava at an acute angle, but the left spermatic vein has no valves and empties into the left renal vein at a right angle. Varicocele is a very common condition. The elder Senn found it in 21 per cent. of 10,000 recruits. An irregular swelling exists within the scrotum and extends up the cord. This swelling feels like "a bag of earth-worms"; it exhibits a slight impulse on coughing; the scrotal skin and cremaster muscle are attenuated; the testicle lies at the bottom of the swelling and is softer and smaller than normal; the swelling diminishes on lying down and increases on standing or on making pressure over the external ring. The scrotum is pendulous and the scrotal skin frequently contains varicose veins. The testicle may be soft and shrunken. There is usually some discomfort, aching, or dragging in the testicle and the groin, and often neuralgic pain in the cord. There may be no discomfort of any sort. A large varicocele may be free from discomfort and a small varicocele may produce much annoyance, or vice versa. There are sometimes mental depression and hypochondriasis. As a man reaches middle age a varicocele usually ceases to give trouble.

Treatment.—In treating varicocele, reassure the patient: tell him there is no real danger of impotence; order cold shower-baths, correct constipation and indigestion, give occasional tonics, and order the patient to wear a suspensory bandage. If the testicle is undergoing atrophy, if the pain and the dragging are annoying, or if the mind is much depressed, operate.

Operation for Varicocele.—Subcutaneous ligation is no longer practised. The open operation is universally employed.

The patient is placed in a recumbent position. Local anesthesia is very satis-

factory. A fold of skin is pinched up over the external ring, and the surgeon transfixes it in the line of the cord, so that he will have an incision about 1½ inches long. The skin and fascia are cut by a scalpel, the veins are well exposed, and the cord is located and held aside. A double ligature of strong catgut or chromicized gut is passed under the veins by an aneurysm needle. The threads are separated 1 inch, tied tightly, and the ends are left long. The veins between the ligatures are excised. The two gut ligatures are tied together and cut. This shortens the cord. The wound is sewed up with silkworm-gut.

Bloodgood points out that it is well to avoid dividing the genital branch of the genitocrural nerve which supplies the cremaster muscle. If this nerve should be divided, the cremaster will become lax and return of the varicocele will be favored. Bloodgood makes the incision over the external ring, draws the veins up, and resects them. A wound so placed heals more certainly and promptly than does a wound of the scrotum. Of late years I have always followed this plan.

XXXV. AMPUTATIONS

An amputation is the cutting off of a limb or a portion of a limb. Removal of a limb or a portion of a limb at a joint is known as "disarticulation." Amputation may be necessary because of the existence of severe injury, of gangrene, of tumor, of intractable disease of bone or joint, of ulcer which will not heal, of traumatic aneurysm, etc. A reamputation may be required because of the existence of a defective stump or disease in the stump.



FIG. 1104.—Esmarch's elastic bandage.



FIG. 1105.—Application of tourniquet.

Classification.—Amputations are classified as follows: (1) As to time of operation after the injury: a *primary* amputation is performed soon after the occurrence of the accident—as soon as the sufferer reacts from shock, and before he develops fever; a *secondary* amputation is performed some time after the accident, suppuration having supervened; and an *intermediate* amputation is performed during the existence of fever, but before the development of suppuration. (2) As to the situation, where the bone is divided or according to which joint is cut through. (3) As to the form and situation of the flap.

In performing an amputation maintain rigid asepsis; completely remove the hopelessly damaged portion; sacrifice as little of the sound tissue as possible; prevent hemorrhage during the amputation, and carefully arrest it after the operation; if flaps be used, have enough sound tissue in the flap to *cover* the bone, and enough skin to *cover* the muscles; and secure drainage at a dependent point. In military surgery where gas gangrene is to be expected (shrapnel, condition of soil, etc.) the guillotine, "chop" or other flapless amputation may be used; in civil surgery, however, where gas gangrene is the very great exception rather than the rule, flaps should always be employed.

Hemorrhage may be prevented by the elastic bandage of Esmarch. We used to apply this bandage from the periphery to well above the line of prospective incision (Fig. 1104), encircle the limb with an elastic band (not the thin tube shown in the cut), and remove the bandage. The bandage and band, asepticized before using, are applied to the limb, which has been carefully sterilized. After the band has been applied the limb should not be freely or forcibly moved, because of the danger of tearing muscles which are firmly fixed by the compressing band. When elastic compression has been used in an operation the surgeon, after removal of the band, should be very careful to tie *every visible vessel*. The paralysis of the small vessels induced by pressure often prevents bleeding, and unless their mouths be found and the vessels be tied reactionary hemorrhage will occur. Reactionary hemorrhage is the great danger after the use of the Esmarch bandage, and paralysis or sloughing may also follow its employment. If there be an area of suppuration or of gangrene or an extra-osseous malignant growth, do not apply the bandage as directed above. One bandage can be applied from the periphery to near the lower border of the area of growth or infection, and another, from near the upper border of this area, up the limb. If the bandages are applied in this manner the contents of the diseased area (tumor cells and fluid or septic products) are not squeezed into the circulation. In most cases and especially in cases like the above we do not use the broad bandage at all, but drain the limb of blood by holding the extremity in a vertical position for three minutes, lightly stroking it toward the body with the hand, and then apply the constricting

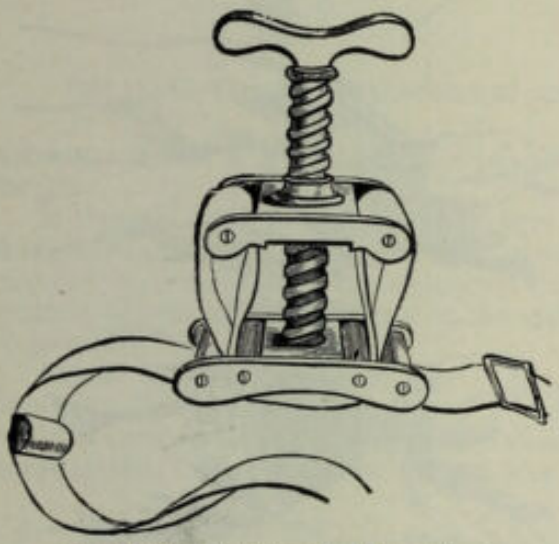


FIG. 1106.—Petit's spiral tourniquet.

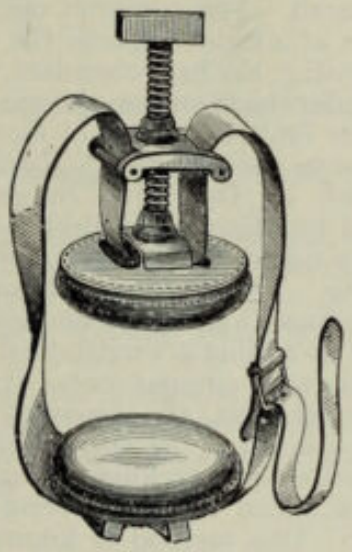


FIG. 1107.—Charrière's tourniquet.

band. As a matter of fact, this plan satisfactorily empties the limb of blood, and it is not necessary in any case to force the blood out by elastic compression. The vertical position not only brings gravity to our aid, but by causing arterial spasm hinders the entry of blood into the limb. Some surgeons prefer the tourniquet (Fig. 1105). The simple or field tourniquet was devised by Morell, of France, in 1674. The perfect instrument was the device of Petit. Figures 1106 and 1107 show two forms of tourniquet. To apply Petit's tourniquet, place the plates in contact, apply a small, firm compress over the artery and a broad thick compress over the outer surface of the limb, buckle the tapes around the limb so that the plate is over the broad pad, and tighten the tourniquet by separating the plates by the screw (Fig. 1105). When a tourniquet is applied to arrest bleeding during transportation, bandage the limb, sew the compress pad to a bandage, and place the plates of the instrument over the pad. Monprofit's all-metal tourniquet may also be used. Signorini's horseshoe tourniquet may be used upon the brachial artery. The extended use (several hours, during transportation, etc.) of the elastic band or of the tourniquet is to be deprecated. Frightful gangrene often followed its prolonged application in the World War. As before stated (see Shock) the use of the band retards the onset of shock. In hip-joint and shoulder-joint disarticulations Wyeth's pins may be passed, and after the limb is emptied of blood the band can be fastened above them. These pins prevent the band from slipping.

The instruments and appliances required for amputation are Esmarch's apparatus

or tourniquet, amputating knives (Fig. 1108), a bone-knife, scalpels, saws (Fig. 1108), a lion-jaw forceps, bone-cutting forceps, a periosteum elevator, retractors of cloth or of metal (Monprofit's), dissecting, hemostatic, and toothed forceps, a tenaculum, an aneurysm-needle, a probe, scissors, needles, ligatures, sutures of silkworm-gut, dressings, bandages, and solutions. A cloth retractor has two tails for the thigh and arm

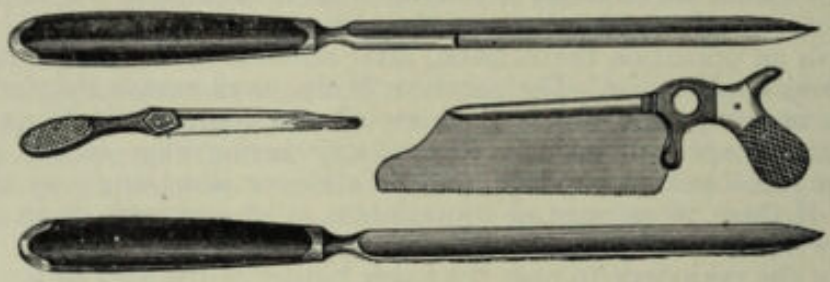


FIG. 1108.—Catlin, long knife, and saws for amputation.

and three tails for the leg and forearm: it is made by taking a piece of muslin or of linen 8 inches wide and 12 inches long and cutting tails on one side 8 inches in length.

Methods of Amputating.—The *transverse circular* is the oldest method of amputating. Petit and Cheselden, about the same time, suggested the basis of the operation. The modern circular is due to Hey, of Leeds, Alanson, of Liverpool, and Benjamin Bell, of Edinburgh. The common circular incision is at a right angle to the axis of the limb. Kocher considers also as a circular incision an oblique cut around the limb if the line of incision "continues in one direction" (Kocher's "Text-book of Operative Surgery," translated by Harold J. Stiles). This method is called the *oblique circular amputation*. The *flush circular method* makes no flaps at all. A *racket incision* is formed by adding a longitudinal cut to a transverse circular cut. If the edges are rounded, the *lanceolate incision* is formed. *Rectangular* flaps are formed when two longitudinal incisions are added to a transverse circular cut. This method is known as Teale's amputation and was introduced by Teale, of Leeds, in 1855 (Fig. 1118*a*). If the corners of rectangular skin-flaps are trimmed, *rounded flaps*

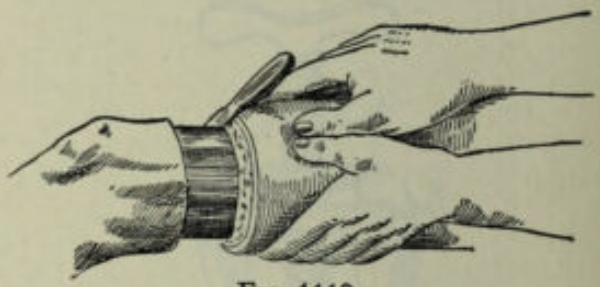


FIG. 1110.

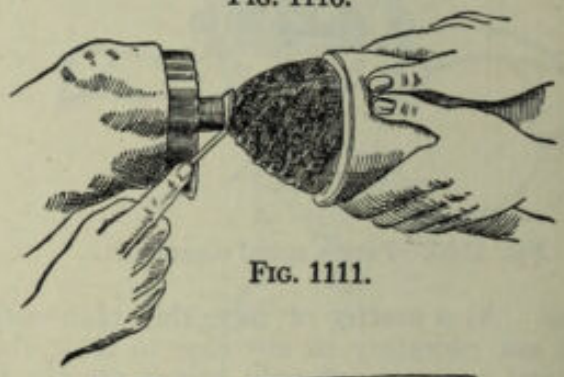


FIG. 1111.

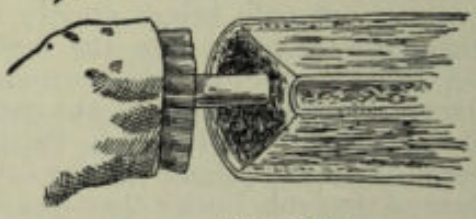


FIG. 1112.

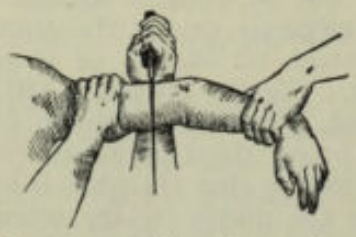


FIG. 1109.—Amputation of arm by the circular method (Druitt).

FIGS. 1110–1112.—The steps of a transverse circular amputation (Kocher).

are formed. The last-mentioned plan is considered under the head of the Modified Circular Amputation (see page 1390).

Transverse Circular Method (Figs. 1109–1112).—The surgeon should stand to the right of the limb and use a long amputating knife which cuts from heel to point (Fig. 1108). After an assistant has retracted the skin the operator divides the soft parts by a series of circular cuts. He does not cut at once to the bone, but divides the skin and subcutaneous tissues, while an assistant is drawing them toward the body. At the retracted edge of the first cut the superficial muscles are divided, and after these

muscles retract the deep muscles are divided. The periosteum is incised by a bone-knife and pushed up by an elevator, and after the application of the retractors the bone is then sawed, the saw starting from heel to point. A periosteal flap can be made to cover the end of the bone, but it is not wise to do so. It is better to cut away the periosteum from a narrow area over the end of the bone. In this amputation is formed a cone whose apex is the bone and whose base is the skin edge. Figures 1110–1112, from Kocher, show the steps of the operation and the shape of the resulting stump. In one form of circular amputation (*amputation a la manchette*) the retracted skin is cut by a circular sweep of the knife, a cuff of skin and subcutaneous tissue is freed and turned up, and the muscles are cut circularly at the edge of the turned-up cuff (Fig. 1113). The pure circular amputation is performed on the arm and the thigh;

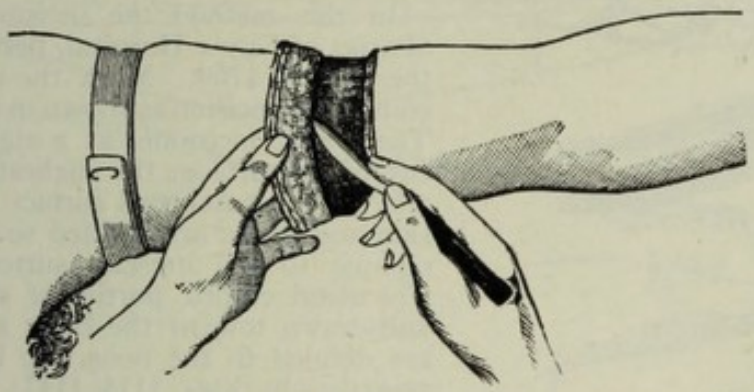


FIG. 1113.—Circular amputation *a la manchette*: Dissecting up the skin-flap (Esmarch).

the amputation *a la manchette* is performed chiefly through the wrist and the lower forearm.

If there is more sound skin upon one side of the extremity than upon the other, the transverse circular incision sacrifices more of the limb than is necessary and the oblique circular is preferable. An objection to the transverse circular incision is that the cicatrix lies directly at the end of the stump and is liable to cause pain when subjected to pressure.

Flush Circular Method (the *Chop Amputation*, the *Guillotine Amputation*).—Scultetus (1662) shows division of a limb by shears and by chisel and mallet. In the modern method the skin and superficial fascia are divided as in an ordinary circular amputation. The muscles are divided transversely at the level of the retracted

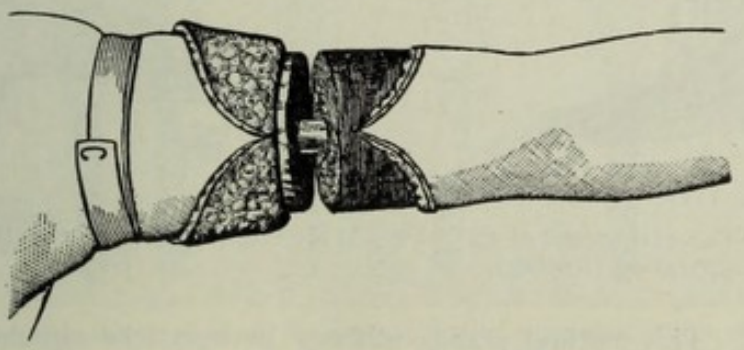


FIG. 1114.—Modified circular amputation: Skin-flaps and circular cut through muscles (Esmarch).

skin. The bone is sawed through at the level of the retracted muscles. The nerves are drawn down and divided and the vessels are ligated. The wound remains open. dressings are applied, and traction on the skin is made by an apparatus like that of Gurdon Buck for making extension in hip-joint fracture (Figs. 1119–1121). The soft parts are thus drawn gradually over the bone. This operation was practised extensively during the World War. It preserves length of limb, diminishes the danger of secondary hemorrhage, and because of the clean transverse incision, free drainage, open wound, and accessibility to disinfection, lessens the danger of gas gangrene, tetanus, and sepsis. Kelly ("Brit. Jour. Surgery," 1916, iii) calls it the "flapless amputation," and Watson ("Brit. Med. Jour.," 1916, i), the "flush circular method."

Modified Circular Method (Figs. 1114–1128).—This operation was suggested by Liston, of London, in 1840. In this operation the circular skin cut may be modified by making a vertical incision to join the first wound, the muscles being cut by a circular sweep (racket incision), or by making two vertical skin incisions (rectangular flaps). The lanceolate incision is made by rounding the edges of the flaps which result from a racket incision. Liston's modification consists in dissecting up two short semilunar integumentary flaps and in dividing the muscles circularly (Fig. 1114). This is known as the "mixed method." Another plan is to make one flap, preferably the anterior, longer than the other. The modified circular method can be used upon the thigh, the leg, the arm, and the forearm.

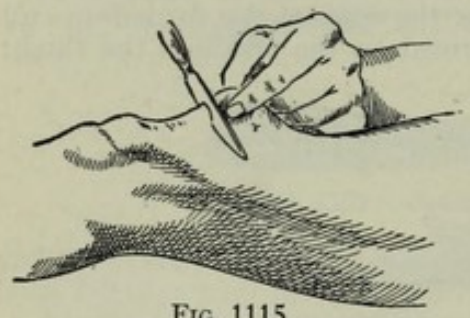


FIG. 1115.

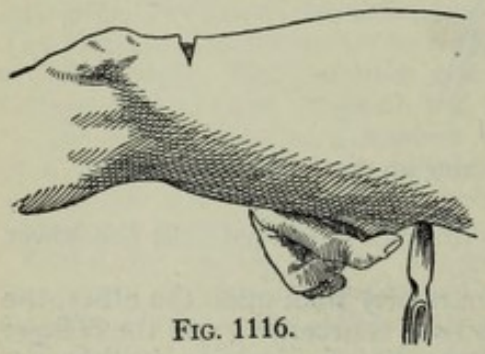


FIG. 1116.

Oblique Circular Method (Elliptic Method).—In this method the incision is an ellipse. Sharpe, of Guy's Hospital, performed it below the knee in 1769. Mark the upper and lower ends of the incision as shown in Figs. 1115–1117. The lowest incisionis at a right angle to the cutaneous surface; the highest incision is parallel to the cutaneous surface (Kocher). The skin and fascia are divided so that an incision oblique to the muscles surrounds the limb. The distal elliptic portion of skin is picked up and drawn toward the body and the muscles are divided to the bone, the knife being held transversely (Figs. 1115–1117). Kocher points out that this flap increases in thickness toward the bone. The rest of the muscles are divided on a level with and in the direction of the skin edge. The periosteum is cut transversely and is treated as in the transverse circular operation. The flap of muscle and integument is brought

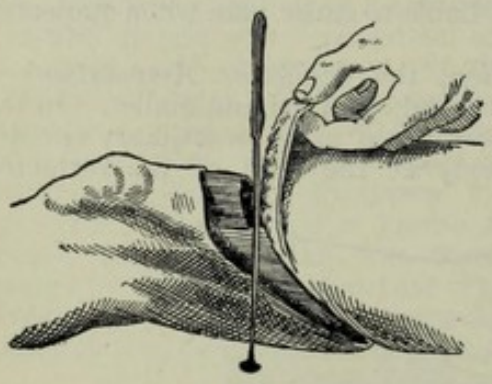


FIG. 1117.

FIGS. 1115–1117.—The early steps of an oblique circular amputation (Kocher).

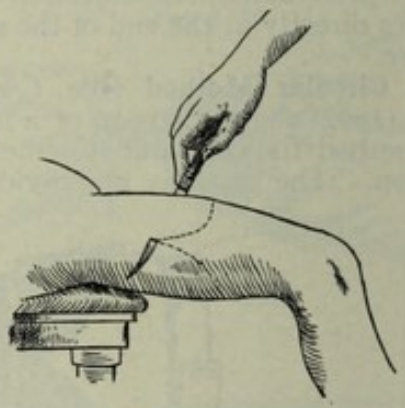


FIG. 1118.—Amputation of the thigh by transfixion (Gross).

over the wound. This method stands midway between the circular operation and the operation by a single flap, and is employed particularly in certain disarticulations.

Flap Method.—The single flap method was introduced by Lowdham, of Exeter, in 1679. We owe the double flap method to Vermale. A flap may be composed of *skin* only or of both *skin* and *muscle* (Fig. 1148), but the skin-flap must always be longer than the muscle-flap, so that the latter will be covered by it. A flap containing much muscle heals badly, but the ideal flap has a moderate amount of muscle (enough skin to cover the muscle and enough muscle to cover the bone). Flaps may be *single* or *double*. Double flaps may be *lateral* or *anteroposterior*, *square* or U-*shaped*, *equal* or *unequal*, and they may be cut by *transfixion* (Fig. 1118), by cutting from without inward, by dissection, or by cutting the skin from without inward and the muscles by transfixion.

Oval or Racket Method (if flaps are rounded, is known as the "oval" or "lanceolate" incision).—This method, though not devised by, was certainly popularized by Malgaigne,

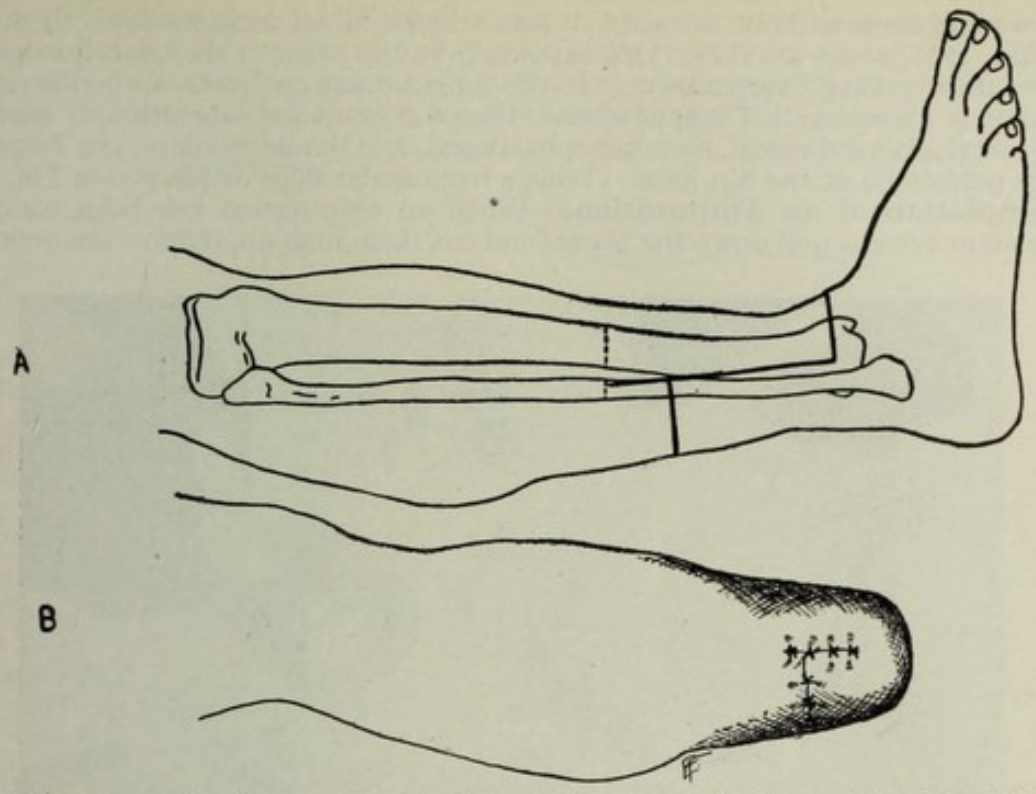


FIG. 1118*a*.—Amputation by unequal mixed rectangular flaps: A, Form and position of incisions and line of bone section; B, resulting suture line (Bickham).

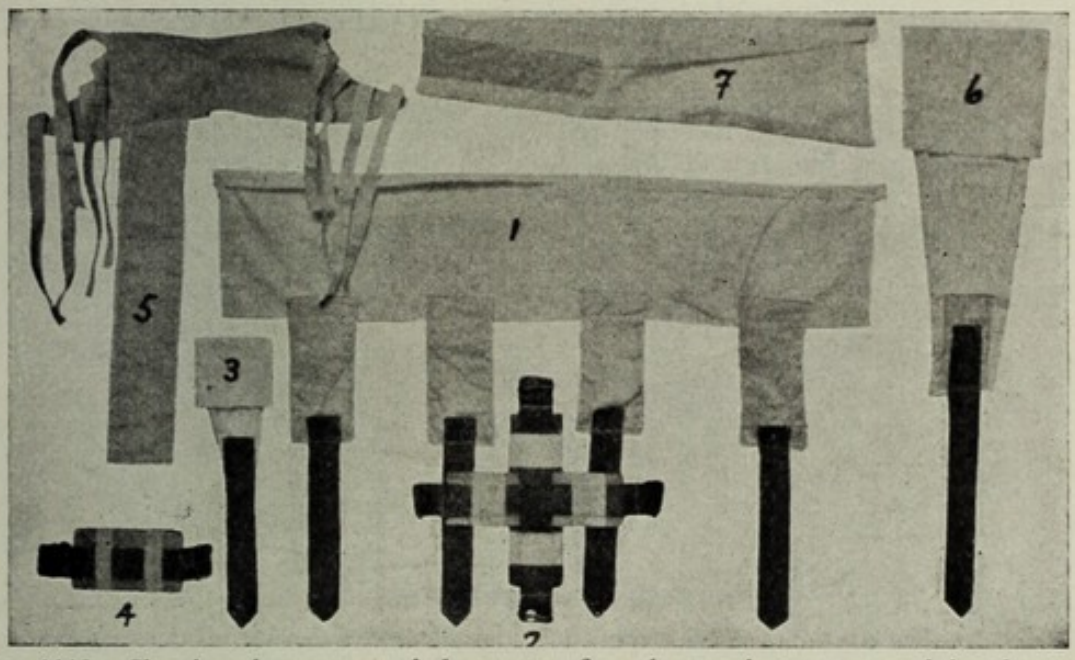


FIG. 1119.—Showing the pattern of the canton flannel extension straps used for the purpose already mentioned. The material used was a medium weight canton flannel. (1) The broad piece, with extension straps, used for the skin traction apparatus. (2) The wooden cross-piece to which the above extension straps are buckled. (3) Cloth, with webbing extension, which is glued to the forearm in the overhead extension treatment of compound fractures of the humerus. (4) Wooden traction piece to which the foregoing webbing is buckled. (5) Cloth anklet used to obtain extension on the foot in cases where the wound in the leg was low down or involved the ankle-joint. The horizontal piece is secured over the dressing around the ankle, while the vertical piece turns under the plantar surface and is afterward pinned to the horizontal piece. (6) Cloth extension strap, with attached webbing, to be glued to the leg in the application of the Blake splint. (7) A double extension cloth, the ends of which are glued to the leg, used as a substitute for adhesive plaster in the application of Buck's extension (Fauntleroy).

of Paris (1834). In an *oval* amputation the incision through the skin and subcutaneous tissue is an oval with a pointed end or a triangle; and the other parts down to the

bone are cut from without inward. When a longitudinal incision down to the bone (see Figs. 1131, *ac–cd–ce*, 1125, 1126) extends from the point of the oval, the operation is called the "racket" amputation. If the longitudinal cut joins a circular cut, the operation is known as a T-amputation. The oval or racket operation is performed at the metacarpophalangeal, metatarsophalangeal, and shoulder-joints; the T-operation may be performed at the hip-joint. Teale's rectangular flaps are shown in Fig. 1118*a*.

Completion of an Amputation.—When an amputation has been completed, tie the main vessels, pull down the nerves and cut them high up, remove the periosteum

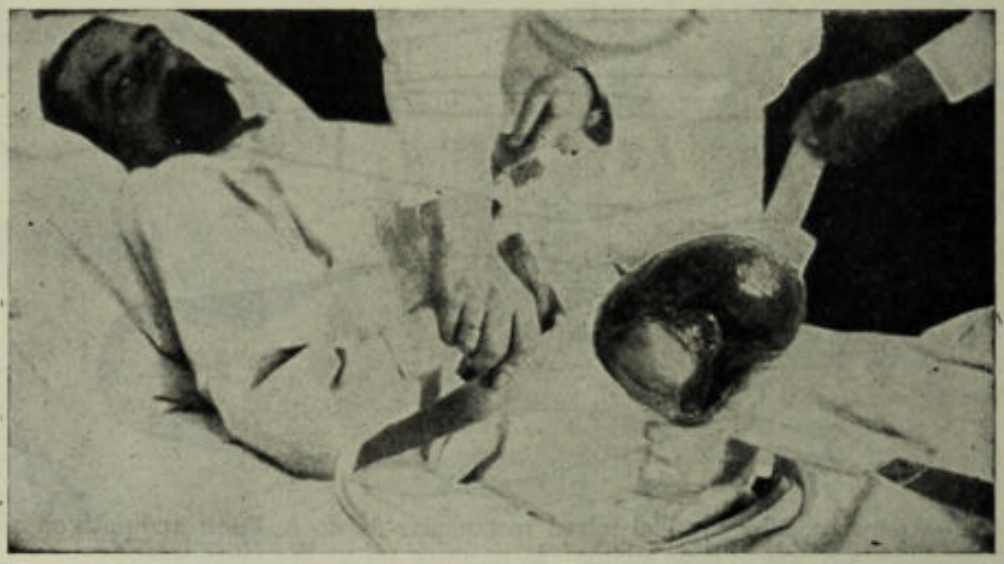


FIG. 1120.—Showing an old amputation case under treatment with skin traction apparatus. This case improved steadily, and after one month a minor plastic operation completed the cure (Fauntleroy).

and bone-marrow for a distance of 2 cm. This may save the patient from a painful stump. It is bad practice to cover the end of the bone with periosteum. Smooth the flaps, gradually loosen and finally take off the constricting band, and ligate all bleeding points. Apply to the raw surfaces pads wet with water at 120° F., and make compression for several minutes. The hot water arrests capillary bleeding. It also restores tone to some vessels of larger size which, palsied by the action of the constriction, have been open, but are emitting no blood. Tone being restored, such vessels

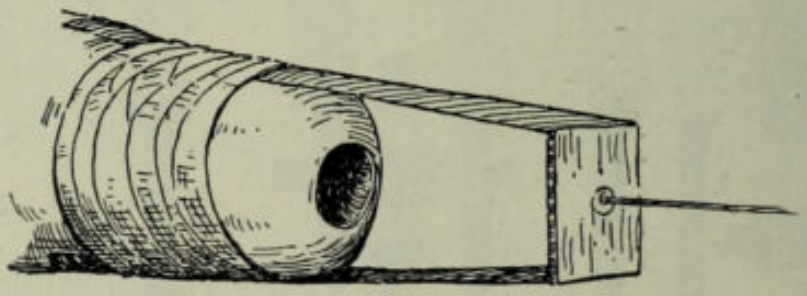


FIG. 1121.—The treatment of an amputation stump by extension. This drawing was sketched from a case of direct circular amputation through the thigh. The soft tissues and bone were cut in one section at the same level. In order to bring the soft parts over the end of the bone longitudinal strips of strapping were placed on the skin and supported by a bandage. The cord passed over a pulley and was attached to a light weight. The effect of the extension was such that the tissues were drawn well over the end of the bone and a good stump resulted. The wound contracted until a comparatively small scar remained, which was drawn well to the back of the limb (Hull).

bleed, and can be seen, picked up, and tied. Hemorrhage from the medullary canal is to be arrested by antiseptic wax. Except in amputation of the fingers and toes, drainage-tubes are necessary. Take two tubes and fasten an end of one to an end of the other with a catgut stitch and attach the point of junction to the depths of the wound by a suture of catgut. When the time comes to remove the tubes, one is drawn out from one side of the flap, the other from the other side. Were one tube used removal would necessitate dragging one free end first within and then all the way across

the wound. Sutures are now to be inserted. In some cases the deep parts are stitched with a continuous catgut suture and the superficial parts are closed with silkworm-gut; in other cases the deep parts are not stitched at all, the skin alone being sutured with silkworm-gut. Suture of opposing tendon groups prevents atrophy of the stump.

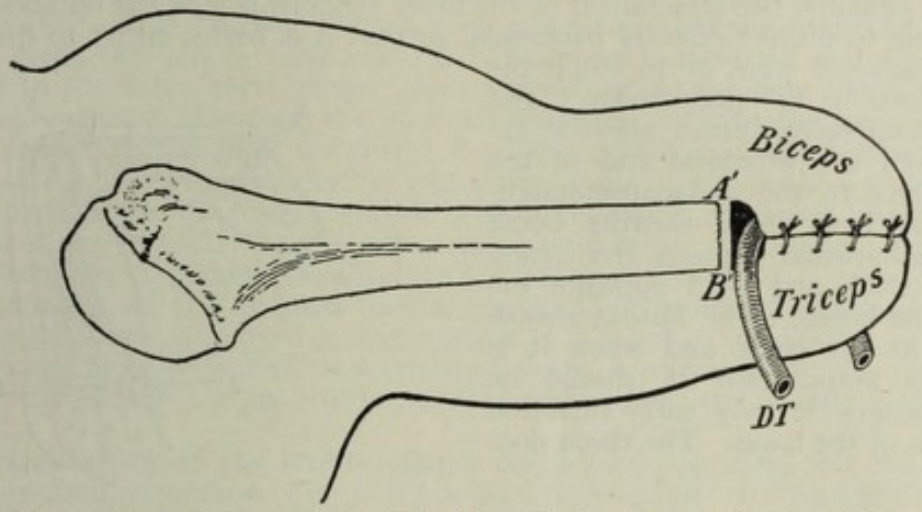


FIG. 1122.—Cinematoplastic amputation. The biceps has been sutured to the triceps and a rubber tube is passed through the loop before dressing the stump (Ashhurst).

Painful Stumps.—A painful stump may be due to neuromata. Retrenchment of the nerves lessens the danger of neuromata. If neuromata form, excision is necessary. A weight-bearing scar, if painful, may necessitate re-amputation. Periosteal irritation leads to bone formation and causes pain. This is prevented by removing the periosteum and medulla for a distance of 2 cm. If irritation exists, a like operation should cure it.

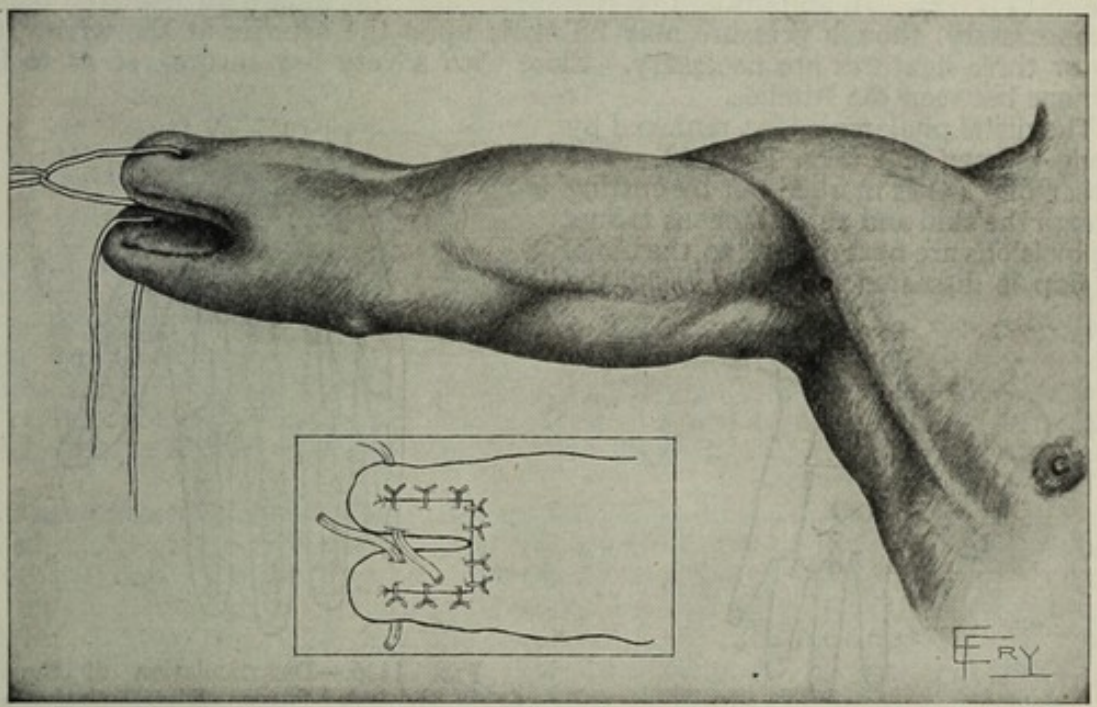


FIG. 1122*a*.—Vanghetti's cineplastic amputation through the forearm, providing double plastic loop motors. The line-drawing shows the manner of suturing and the rubber tubes temporarily distending the "buttonholes." (From Bickham's article, "Keen's Surgery").

Cinematoplastic Amputations.—Vanghetti devised the method in 1898. The plan is to make a muscular or tendinous loop or muscular or tendinous loops at the end of a stump, so that the movements of the loops can be applied to move an artificial hand. It is seldom performed as a primary amputation. The stump is allowed to heal. (See Figs. 1122, 1122*a*.)

Special Amputations

Fingers and Hand.—A finger amputation should be done by a palmar flap operation. In amputating the thumb and index-finger save every possible scrap of tissue. If it is necessary to amputate one of the other fingers above the middle of the middle phalanx, the attachment of the flexor tendons will be cut off and the finger will be liable to project directly backward, so that it is better either to disarticulate at the metacarpal joint or to stitch the flexor tendons to the periosteum. The flexor tendons have fibrous sheaths extending from the proximal end of the distal phalanx to the metacarpophalangeal articulations, these sheaths being thin and collapsible opposite the joints, but being thick and rigid opposite the shafts of the bones. The fibrous sheath is known as the *theca*, and when it is cut in an amputation it should be closed, otherwise it may carry infection to the palm of the hand. The theca does not exist over the distal phalanx, and it is not distinctly visible over the joint between the distal and middle phalanges. To effect closure over the shaft of a bone, strip up the periosteum and pass catgut sutures vertically through the theca and the periosteum (Treves). In amputation of the fingers and the thumb an Esmarch bandage is unnecessary, though pressure may be made upon the arteries at the wrist. Only two or three ligatures are necessary. Close with a very few sutures, so as to favor drainage between the stitches.

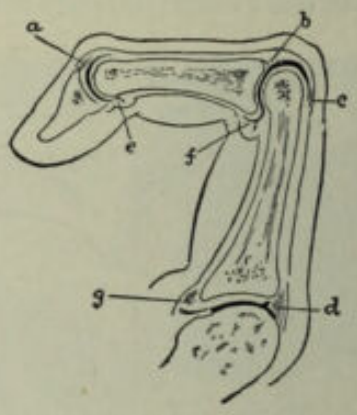


Fig. 1124.—The line of the joints in the flexed position of the finger: *a*, Extensor longus digitorum; *b*, interossei and lumbricals; *c*, extensor longus digitorum and interossei; *g*, interossei and lumbricals; *f*, flexor sublimis; *e*, flexor profundus (Kocher).

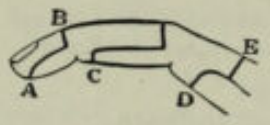


Fig. 1123.—Amputation of the finger.

The distal phalanx is best removed by a long palmar flap (Fig. 1123, A). The palmar flap (A) is marked out by cutting through the skin and subcutaneous tissue. The incisions are next carried to the bone, the flap is dissected from the bone, the finger is strongly flexed, a transverse incision (B) is carried across the dorsum on a level with the base of the third phalanx, the soft parts are pushed back, the joint is opened, the lateral ligaments are cut from within outward, the third phalanx is forcibly extended, and the remaining structures are cut from below upward. Figure 1124 shows the lines of the joints when the finger is flexed. The middle phalanx can be

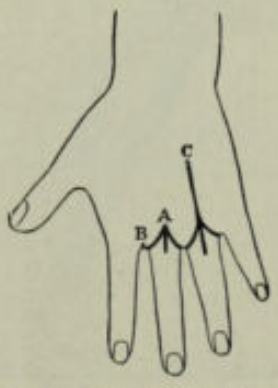


Fig. 1125.—A, Disarticulation of a metacarpophalangeal joint; C, amputation of a finger with the metacarpal bone.

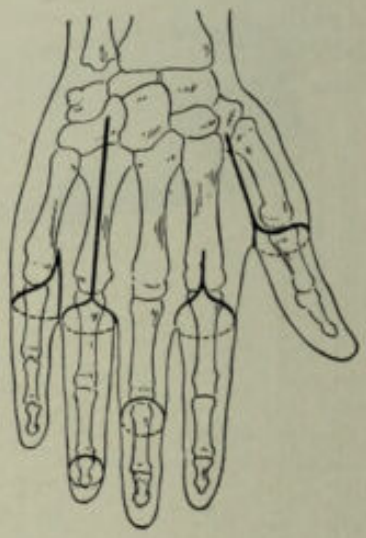


Fig. 1126.—Disarticulation of the little finger and index-finger. Disarticulation of the ring finger with its metacarpal bone. Disarticulation of the thumb with its metacarpal bone (Kocher).

removed by the same method (Fig. 1123, c). The proximal phalanx can be removed by a long palmar flap or by a long palmar and a short dorsal flap (Fig. 1123, D, E).

Disarticulation at a metacarpophalangeal joint is best performed by the oval method. The incision upon the dorsum (A) is begun just above the head of the metacarpal bone, is carried down to beyond the base of the phalanx, and involves the skin only (Figs. 1125, 1126). One incision sweeps around the finger at the level of the web, going through the skin only (B); the finger is extended and the palmar cut is carried to the bone; each lateral incision is carried to the bone while the finger is bent in the opposite direction, the flaps are dissected back to the joint, the finger is strongly extended, the joint is opened from the palmar side, and disarticulation is effected. Cutting off the head of the metacarpal bone improves the appearance of the stump, but weakens the hand, hence in a workingman it must not be done unnecessarily. If it be necessary to remove a metacarpal bone, the incision (c) (Fig. 1125) is made from the carpometacarpal joint (Fig. 1126)

Amputation of the thumb through its distal or proximal phalanx is performed in the identical way employed in amputation of a finger. Amputation of the thumb, with a portion or the whole of its metacarpal bone, is performed by the oval or racket incision (Fig. 1126). *Carpal* and *metacarpal amputations* are usually piece-meal procedures.

Disarticulation at the wrist-joint is not a good operation. It can be done by the oblique circular method (Fig. 1127) or by a double flap. In the double-flap amputation a dorsal flap is made by carrying a semilunar skin incision between the styloid processes; the skin is lifted, the wrist is forcibly flexed, the joint is opened by a trans-

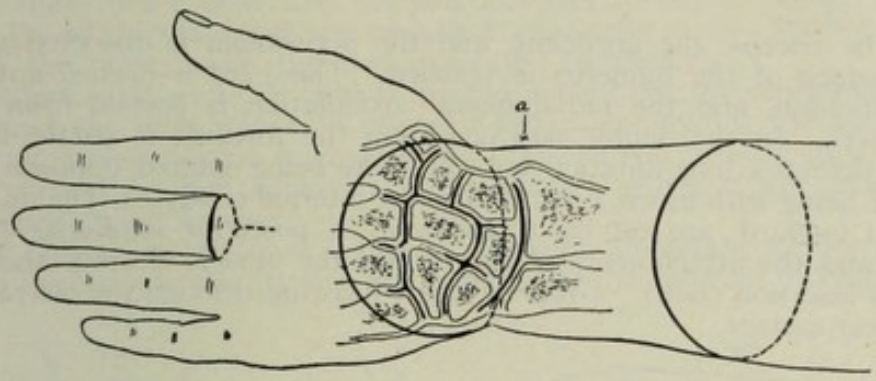


FIG. 1127.—Disarticulation of the middle finger. Disarticulation at the wrist-joint. Amputation through the forearm by the oblique circular method (Kocher).

verse cut, and a long semilunar palmar flap which includes the skin and fascia only is made by dissection. Kocher prefers to amputate by an oblique incision. The lower end of this incision is about the middle of the palm and the upper end is on the dorsum in the line of the wrist-joint (Fig. 1127). The hand is strongly flexed, the extensor tendons are divided, the posterior ligament of the joint is incised, and incisions below the styloid processes divide the lateral ligaments and certain tendons. The flexor tendons are separated from the bone and are divided so as to remain in the palmar flap.

Amputation through the forearm should be done if possible below the insertion of the pronator radii teres muscle. It should never be done within 3 inches of the elbow-joint. We can't adjust an artificial limb to too short a stump. Amputation may be effected by the oblique circular method (Fig. 1127), the circular, the modified circular (Fig. 1128), or the flap operation. The modified circular, making equal anterior and posterior skin-flaps, is an excellent plan. A semilunar skin-flap on the extensor surface and a semilunar skin-flap on the flexor surface are made. The flaps are raised, the muscles are cut circularly (Fig. 1128), the interosseous space is cleared by the knife, a three-tailed retractor is applied, the periosteum is pushed up, and the bones are sawn ½ inch above the flap. In sawing the bones start the saw upon the radius, draw it from heel to point, make a furrow on the radius and ulna, and saw both bones at the same time. After sawing, cut away any irregular edge with bone-pliers. Periosteum is retrenched. In the lower third Teale's amputation may be done, the dorsal flap being the long one (Fig. 118*a*). In Teale's amputation rectangular flaps are made. The long flap is equal in width and length to one-half the circumference of the limb at the point where it is to be sawn. The short flap is equal in width to the long

flap, but is only one-fourth its length. The two longitudinal cuts are at first taken only through the skin, but the two transverse cuts go at once to the bone. The flaps are dissected up from the interosseous membrane and the bone. The operation was devised by the first T. Pridgin Teale, of Leeds. It does not give a satisfactory stump for an artificial limb. In the middle or the upper third of a fleshy forearm two semilunar skin-flaps can be cut from without inward, and the muscles can be cut by transfixion.

Disarticulation at the elbow-joint gives a poor stump for an artificial limb. It is better to amputate 3 inches below the joint or 1 inch above the condyles. It can be done by a long anterior and short posterior flap. In Kocher's oblique operation the incision begins anteriorly over the joint line and ends posteriorly a handbreadth below the summit of the olecranon (Fig. 1129). A posterior flap which contains the integument, the insertion of the triceps, the anconeus, and the periosteum is dissected up until the posterior surface of the humerus is reached. The joint is opened anteriorly by a transverse incision, and the radiohumeral articulation is opened from without inward (Kocher). In the double flap operation the forearm is partly flexed and a skin-cut marks out a long anterior flap, the knife being entered opposite the external condyle and being withdrawn 1 inch below the internal condyle. The muscles, which are bunched forward, are cut by transfixion. A posterior semilunar flap is made, which separates the attachments of the radius, the ulna is cleared, and the triceps is cut at its insertion (Bell). Gross advocated sawing through the olecranon and the inner trochlear surface.



FIG. 1128.—Modified circular amputation of the forearm (Bryant).

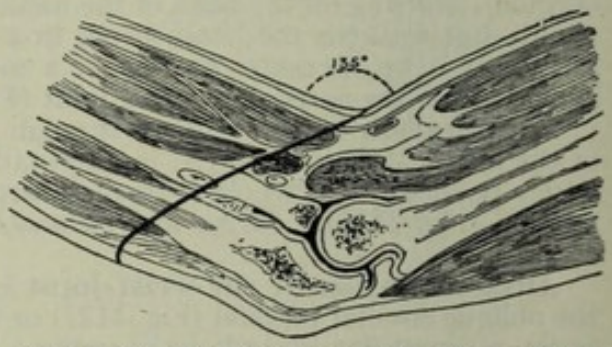


FIG. 1129.—Disarticulation of the elbow-joint by the oblique circular method (Kocher).

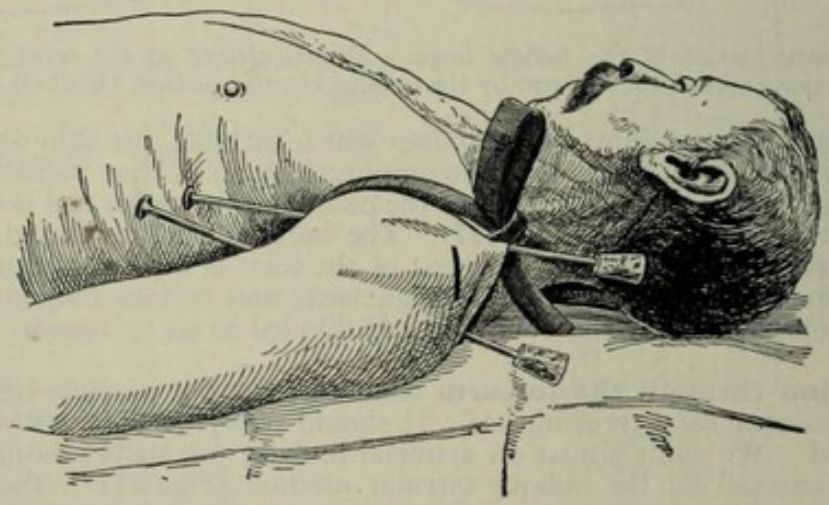


FIG. 1130.—Use of Wyeth's pins in amputation at the shoulder-joint. The acromion is marked by a black line (Keen).

Amputation of the arm is best performed by marking out with a knife two equal semilunar anteroposterior flaps, the first cut being carried through the skin alone, the muscles being then transfixed with a long knife. Teale's method is not recommended. The circular amputation is satisfactory. If it is not possible to save 3 inches of the humerus, amputate through the shoulder-joint. A shorter stump does not permit of the adjustment of an artificial limb (Lockwood, Ibid.). During healing of an amputation of the arm combat adductor contraction (Lockwood, Ibid.).

Disarticulation at the Shoulder-joint.—It is said that Le Dran did this operation in 1715. Larrey certainly did it during the Napoleonic Wars. Dupuytren

made the procedure notable in 1812. In this operation many surgeons use Wyeth's pins to hold the Esmarch band in place. The anterior pin is entered at the middle of the lower margin of the anterior axillary fold, and emerges 1 inch to the inside of the tip of the acromion. The posterior pin is entered at a corresponding point on the posterior axillary fold, and emerges more posteriorly than the first pin and an inch to the inside of the tip of the acromion. After the extremity has been drained of blood by the Esmarch bandage or by stroking and a vertical position, the Esmarch band is applied above the pins (Fig. 1130). With a competent assistant, however, the pins are not necessary, the surgeon dividing his main vessels as the last step of the operation, and the assistant controlling them, before they are cut and until they are tied, with digital compression; or, the main vessels may be ligated as a preliminary step.

Larrey's Operation.—This is the operation of choice. It was devised by the great surgeon of the armies of Napoleon. In this method of shoulder-joint disarticulation the limb is held away from the side and an incision is made down to the bone, the incision beginning just below and in front of the acromion and running vertically for 4 inches down the outer surface of the arm (Fig. 1131, *a–b*). From the center of this incision an oval incision (*c–d*, *c–e*) is carried around the arm, the inner aspect of the oval reaching as low as the lower end of the vertical cut. The oval incision at first involves only the skin and subcutaneous tissues. The anterior structures are divided close to the bone, and the posterior structures are next cut. To disarticulate, cut the capsule transversely upon the head of the bone; while the arm is rotated outward cut the subscapularis, and while the arm is rotated inward cut the supraspinatus and infraspinatus and the teres minor. Cut away any tissue holding the humerus to the body, hanging nerves, capsule fragments and tissue shreds, insert a tube, and sew up the wound vertically. Bell advised an oval incision with a racket handle. Spence used an anterior racket incision.

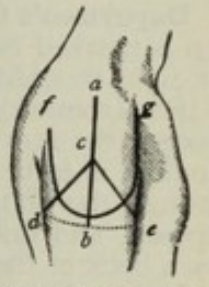


FIG. 1131.—Amputation at the shoulder-joint: *a–b*, *c–d*, *c–e*, Larrey's operation; *f–g*, Dupuytren's operation.

Kocher's Operation.—Kocher makes an anterior lanceolate incision (Fig. 1132). The incision begins over the clavicle just external to the coracoid process of the scapula, and is carried downward, dividing, as it advances, the anterior fibers of the deltoid muscle. "Bleeding vessels and the cephalic vein are ligatured. In the upper part of the wound the acromial branches of the acromiothoracic artery are also ligatured. The knife is carried down to the bone at the edge of the deltoid (only the upper fibers of which have been divided). The capsule is divided over the lesser tuberosity and the bicipital groove. The periosteum, the insertions of the subscapularis, pectoralis major, latissimus dorsi, and teres major are detached along with the cap-

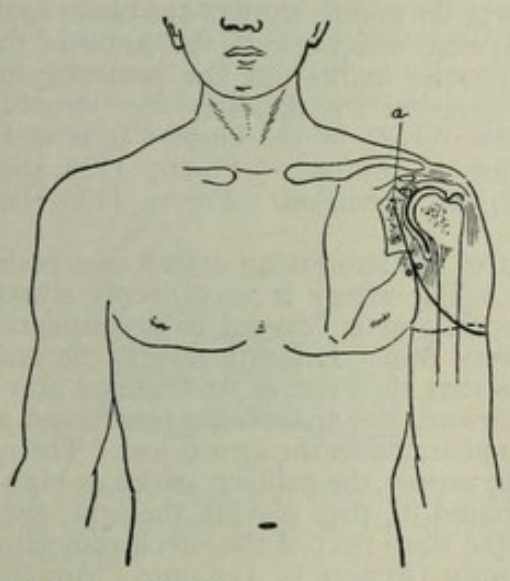


FIG. 1132.—Disarticulation at the shoulder-joint by Kocher's method (Kocher).

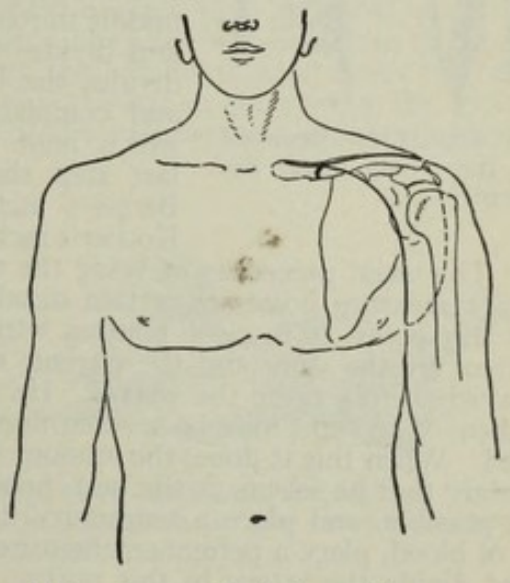


FIG. 1133.—Removal of the entire upper extremity (Kocher).

sule. The capsule, along with the insertions of the supraspinatus, infraspinatus, and teres minor muscles, is also detached from the upper part of the head and from the great tuberosity. The head of the humerus can now be protruded from the wound. In cutting down over the surgical neck it may be necessary to ligature the circumflex arteries; in any case the anterior vessel must be tied. The racket incision is now completed by dividing the skin circularly at the level of the axillary folds. The vessels and nerves are then easily isolated, the former being ligatured and the latter divided" (Kocher's "Text-book of Operative Surgery," translated by Harold J. Stiles). Kocher cautions us to avoid the circumflex nerve which supplies the deltoid, as the deltoid is the muscle of the stump.

Dupuytren's Operation.—In Dupuytren's shoulder-joint disarticulation a U-shaped flap is marked out by a skin incision (Fig. 1131, *f–g*). If the amputation is to be at the right shoulder, the arm is carried across the chest; the knife is entered at the root of the acromion, follows the margin of the deltoid, and is withdrawn at the coracoid process, the arm being gradually abducted and pulled off from the chest. If the left shoulder is to be amputated the procedure is reversed (Treves). The knife next cuts through the deltoid and raises a flap composed of this muscle, the shoulder-joint is exposed, and disarticulation is effected as in Larrey's method. The knife is passed down back of the bone and a short internal flap is cut.

Lisfranc's amputation is by transfixion with the formation of an anterior and a posterior flap, and can be performed very rapidly by a skilful surgeon.

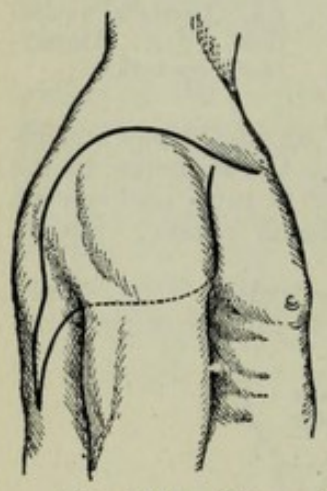


FIG. 1134.—Removal of the whole upper extremity.

Amputation of the Entire Upper Extremity.—Berger's Operation—amputation above the shoulder-joint (removal with the limb of a portion of the scapula and of the clavicle) was first done by Cuming in 1808.—*The Interscapulothoracic Amputation.*—This operation, which is an amputation above the shoulder-joint, was described by Berger in 1887. By it are removed the arm, the scapula, and a portion of or the entire clavicle. It is occasionally employed in cases of malignant disease and of severe injury. The operation is attended with profuse hemorrhage, and as a preliminary the subclavian vessels should be ligated. The incisions must be varied according to the necessities of the case. In this operation Berger divides the clavicle at the junction of its outer and middle thirds, and resects the middle third of the bone; ligates and divides the subclavian vessels; cuts the anterior flap; divides the brachial plexus; marks out the posterior flap; and completes the operation by dividing the structures which hold the shoulder-blade to the chest. It is in this last step that bleeding is profuse. Figure 1134 shows Berger's incisions for the operation. Figure 1133 shows Kocher's incisions.

The usual procedure of tying the third part of the subclavian artery as a preliminary measure possesses certain disadvantages. The artery is very deeply situated at this point, is in close relation with the pleura, and is covered to a considerable extent by the vein, and the phrenic nerve is very near. LeConte resects the entire clavicle before tying the vessels. He maintains that then one of two courses may be taken: The veins may be severed first, and afterward the artery may be exposed and tied. When this is done, the amount of blood remaining in the arm is lost. The procedure that he selects as the best, however, is to expose the axillary artery as high up as possible, and place a temporary ligature around it; then elevate the arm, empty it of blood, place a permanent ligature around the third part of the subclavian artery, and divide the artery in this portion of its course (Robert G. LeConte, "Annals of Surgery," Oct., 1902). If the scapula be involved in the tumor, the mortality is something over 23 per cent. (Berger, "Revue de Chir.," Aug., 1905). I have twice performed the operation successfully and in each case followed LeConte's plan.

Amputation of the Toes and the Foot.—It is not nearly so important to save toes as fingers. Never save the great toe alone. It will prove without value, and will be in the way. Only through the great toe is *partial* amputation performed, and it is effected by the formation of a long plantar flap, just as a long palmar flap is formed from a finger. Amputation at a metatarsophalangeal joint is performed by an oval or racket incision (Fig. 1135, *c*, *c*). Amputation of a toe with removal of its metatarsal bone is shown in Fig. 1135, *a–b* and *d–e*.

Disarticulation at the Tarsometatarsal Articulation.—Lisfranc's Operation, first performed by Lisfranc, of Paris, in 1815 (*after Treves*).—In order to amputate the right foot by this method begin an incision on the outer border of the foot, behind the tubercle of the fifth metatarsal bone; carry the incision forward 1 inch and sweep it across the foot ½ inch below the tarsometatarsal articulations; bring the incision to the inner edge of the foot, ½ inch in front of the articulation of the tarsus with the first metatarsal bone, and carry the cut straight back along the inner margin of the foot until it reaches a point ¾ inch above the articulation of the metatarsal bone of the great toe. A very short semilunar dorsal skin-flap is thus formed. Figure 1141 shows the flaps as cut by Kocher. After the skin-flap has been dissected back for ¼ inch

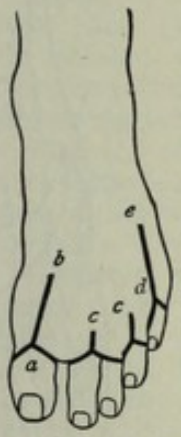


FIG. 1135.—Amputation of the toes with and without the metatarsal bones.

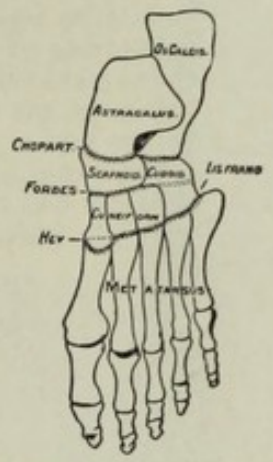


FIG. 1136.—Lines in amputations of the foot (Gross).

the tendons are divided, and the flap, which now contains all the soft parts, is dissected back to *above* the joint. A long plantar flap is cut, reaching from the origin of the first flap to the necks of the metatarsal bones. The skin-flap is dissected up until the hollow behind the heads of the metatarsal bones is reached, when, with the toes in extension, the tendons are cut across and a flap composed of all the soft parts is dissected up to above the tarsometatarsal joint. Figures 1136 and 1141 show the line of Lisfranc at the tarsometatarsal articulation. The joint is opened from the outer side according to the following rule: in separating the fifth metatarsal direct the edge of the knife toward the distal end of the first metatarsal; in separating the fourth metatarsal direct the knife toward the middle of the first metatarsal; in separating

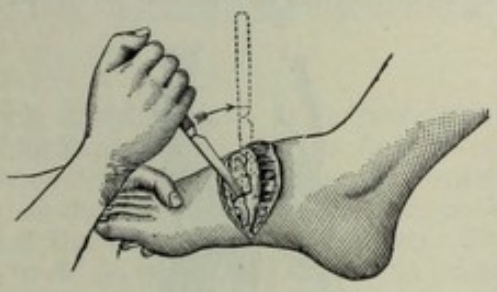


FIG. 1137.—Lisfranc's amputation: First step in disarticulating the second metatarsal bone (Guérin).



FIG. 1138.—Lisfranc's amputation: Second step in disarticulating the second metatarsal bone (Guérin).

the third metatarsal carry the knife almost directly across. The separation is facilitated by bending down the toes and the foot, and at the same time the tendons of the peroneus brevis and tertius are divided. Open the joint between the first metatarsal and the inner cuneiform bone, turning the knife toward the middle of the shaft of the fifth metatarsal, and at the same time divide the tibialis anticus muscle. Treves says that in disarticulation of the second metatarsal the knife is to be held as a trocar, it is to be thrust between the base of the first and second metatarsal bone until the is point strikes bone (Fig. 1137), and is then to be raised to a perpendicular and the cut to be made toward the external malleolus to sever the ligament of Lisfranc (Fig. 1138). Divide any remaining ligaments, and also the tendon of the peroneus longus muscle.

The skin incisions in the *left* foot are begun on the inner side, and, in disarticulating, the tarsal joint of the great toe is first opened. Figure 1142 shows the parts after disarticulation in the line of Lisfranc. After Lisfranc's amputation a patient can walk with very little limp, but usually, after a time, the heel draws up and he walks on a tender scar.

Hey's Operation.—First performed by Hey, of Leeds, in 1797. In Hey's method the incision is practically the same as that for Lisfranc's amputation. The four ex-



FIG. 1139.—Anterior intertarsal disarticulation (Kocher).

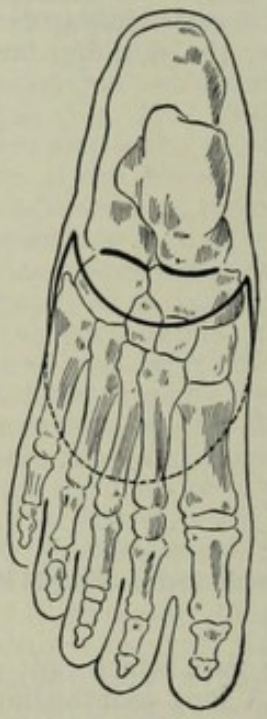


FIG. 1140.—Chopart's amputation (Kocher).

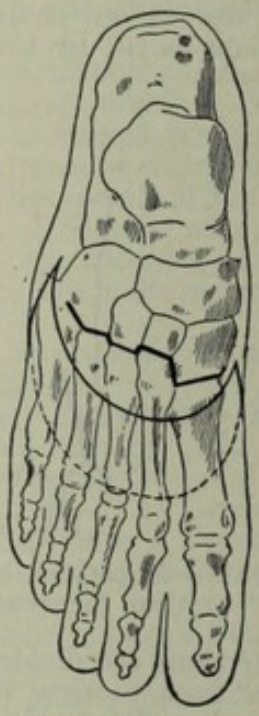


FIG. 1141.—Lisfranc's amputation (Kocher).

ternal metatarsal bones are disarticulated, but the first metatarsal is removed by sawing a portion of the internal cuneiform bone. Guérin advised sawing all the bones across. Skey advised the division of the head of the second metatarsal. Figure 1136 shows the line of Hey. This operation results as does Lisfranc's.

Anterior Intertarsal Disarticulation (Amputation Devised by Forbes).—First described by Forbes, of Toledo, in 1874. The disarticulation is effected between the

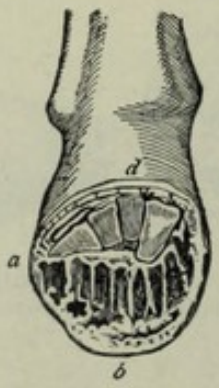


FIG. 1142.—The parts after Lisfranc's amputation (Bernard and Huette).

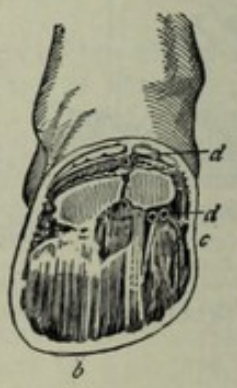


FIG. 1143.—The parts after amputation by Chopart's method (Bernard and Huette).

three cuneiform bones in front and the scaphoid behind, and the cuboid is sawn across. Figures 1136 and 1139 show the line of Forbes. The incision of the soft parts is as for Lisfranc's amputation (Fig. 1141). This operation results as does Lisfranc's.

Disarticulation Through the Middle Tarsal Joint.—Chopart's Operation, first described by Chopart, of Paris, in 1792. (*Posterior Intertarsal Disarticulation*).—Make a transverse incision through the skin of the instep, 2 inches below the ankle-

joint, cut the tendons and muscles, expose the tarsus, and make on each side a small longitudinal incision reaching to below and in front of the corresponding malleolus. The flap thus formed is retracted. The plantar flap is made as in Lisfranc's amputation. The flaps as made by Kocher are shown in Fig. 1140. Open the astragaloscaphoid joint, then the calcaneocuboid joint, and disarticulate. Figures 1136 and 1140 show the line of Chopart. Figure 1143 shows the parts after Chopart's disarticulation. Chopart's amputation seldom gives good results. The heel usually draws up and the patient walks on a tender scar. A secondary operation is usually necessary.

Subastragaloid Disarticulation (was first performed by Textor in 1841).—A circular incision is carried around the foot at the level of the middle tarsal joint and a racket incision is added to it running below and posterior to the tip of the external malleolus (Fig. 1144). "The joint between the astragalus and scaphoid is opened upon the dorsum, without opening the calcaneocuboid joint. A narrow knife is then passed backward and slightly upward beneath the head of the astragalus so as to divide the strong interosseous ligament between it and the os calcis. The soft parts are then dissected off the os calcis, first from its upper surface, then from its outer and under surfaces, and lastly from its inner and posterior surfaces. The greatest difficulty is met with at the inner side in clearing the projecting sustentaculum tali" (Kocher's "Text-book of Operative Surgery," translated by Harold J. Stiles).

Disarticulation at the Ankle-joint. —Syme's Method (Fig. 1144*a*).—The operation was devised in 1842 by Syme, of Edinburgh. Syme's amputation came into renewed confidence during the World War, in which it was found that a high Syme gave much satisfaction. It is preferred to a Lisfranc, a Forbes, a Hey, or a Chopart amputation. The foot is held at a right angle to the leg, and a skin incision is carried from just below the external malleolus straight across or a little backward across the sole to a corresponding point on the opposite side. If the incision is run forward the skin edge may slough. Do not take this incision near the inner malleolus, as to do so would endanger the posterior tibial artery. The incision is carried to the bone, the flap being pushed back and separated from the bone by means of a strong knife and the thumb-nail until the tuberosity of the os calcis has been reached. The foot is now extended and a transverse cut is made across the dorsum, joining the two ends of the first incision; the ankle-joint is opened, the lateral ligaments are cut, disarticulation is effected, and the foot is finally completely removed by severing the tendo achillis. A thin piece of bone including both malleoli is sawn from the tibia and fibula. The flap is perforated posteriorly to secure drainage. The patient will be able to walk with very little limp.

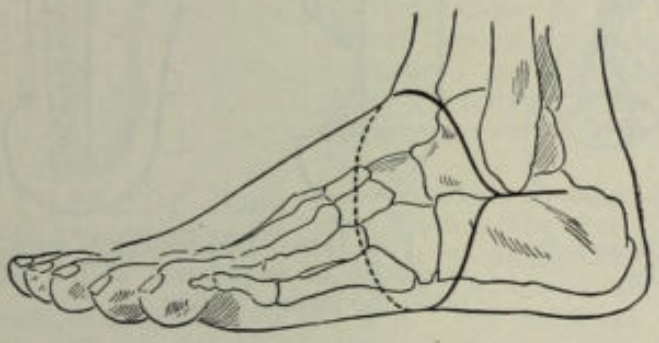


FIG. 1144.—Subastragaloid disarticulation (Kocher).

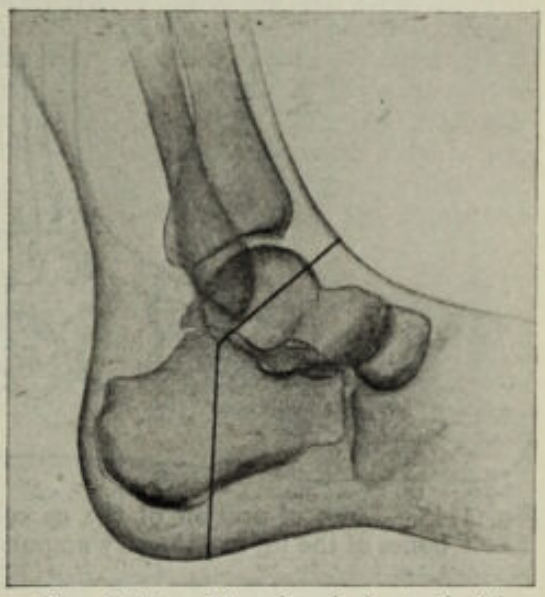


FIG. 1144*a*.—Dorsal and plantar incisions in Syme's amputation of the foot at the ankle-joint (Bickham).

Pirogoff's Method.—The operation was devised by Pirogoff, of St. Petersburgh, in 1852. Flex the foot to a right angle with the leg. "Make an incision from the tip of the internal malleolus across the sole, a little in front of the long axis of the tibia, to a point in front of the apex of the external malleolus down upon the bone."[1] Dissect the flap backward from the calcaneum for ¼ inch, but do not dissect the flap from

[1] "Operative Surgery," by Joseph D. Bryant.

the posterior portion of the os calcis. Join the extremities of the first incision by another cut which reaches to the bone, and which is "½ inch in front of the lower extremity of the tibia" (Bryant); but saw off this bony projection obliquely and leave it adherent to the tissues. The saw is used after disarticulation of the ankle-joint; it is passed behind the astragalus, cutting downward and forward, sawing the os calcis obliquely, and leaving a considerable portion in place in the flap. The lower ends of the tibia and fibula are well exposed by raising the anterior flap slightly; the sawing is begun anteriorly just above the articular surface, and is completed ½ inch above the articular surface posteriorly. The lines *a* and *b* (Fig. 1145) show the sections made by the saw. The sawn surface of the os calcis is brought into contact with the sawn surfaces of the tibia and fibula, and the flaps are sutured.

Amputations of the Leg.—The so-called "point of election" is at the upper part of the middle third of the leg. Eighty years ago Liston advised surgeons not to amputate in the lower third of the leg because of the scantiness of the soft parts, because the stump is apt to ulcerate, and because it is uncomfortable in an artificial leg. These views have been much modified. The amputation near the ankle is safer than the amputation near the knee, and artificial legs are now made which may be worn with comfort. As a matter of fact, flaps cut in the lower third of the leg are prone to heal slowly and are rather apt to ulcerate. Binnie ("Annals of Surgery," 1914, lx) maintains that in order to get a proper stump for a good artificial leg the lowest point considered for amputation should be 8 inches from the ground and the highest point

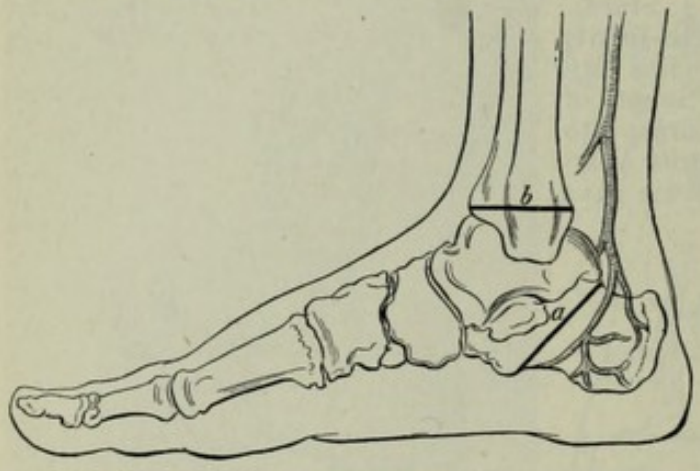


FIG. 1145.—Lines of section of the os calcis and the bones of the leg in Pirogoff's amputation.

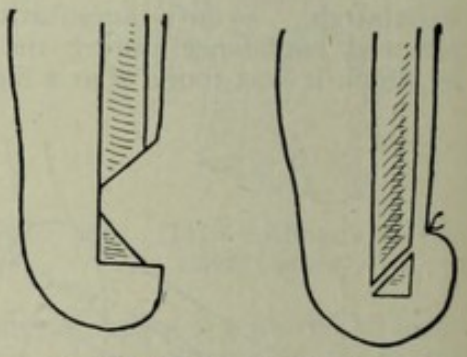


FIG. 1146.—Diagrammatic representation of amputation of the leg after the method of Bier.

4 inches below the lower margin of the patella. The so-called **point of election** is 4 inches below the level of the knee-joint. If a higher amputation is required, go above the joint rather than through it. After a high leg amputation we no longer strive to maintain a movable knee-joint. We allow the joint to stiffen in extension. The circular incision seldom gives a good weight-bearing stump because the scar is over the end of the bone. The flap method should be used if possible. The removal of the periosteum and bone-marrow for a distance of 2 cm. tends to prevent a painful stump. In amputations of the leg by the *long anterior flap*, cut through the skin, dissect up the anterior muscles with the flap, and cut all the posterior tissues with a single transverse sweep. This is a very satisfactory method. Amputation by the *rectangular flap*, Teale's method, is used by some. The long flap is anterior, and is in length and breadth equal to one-half the circumference of the limb. The short flap is one-fourth the length of the long flap. The flaps are dissected up, the bones are sawn, the long flap is turned upon itself, and its edges are sutured to the edges of the short flap. The flap of Teale's amputation is too redundant and an artificial limb cannot be adjusted satisfactorily (Fig. 1118*a*).

Bier suggests a plan (Fig. 1146) to increase the supporting power of the stump after a leg amputation. After the wound has healed a wedge-shaped piece of bone is removed above the level of the stump. The lower extremity is turned forward and upward through an arc of 90 degrees, and unites in this position (Zuckerkandl's "Operative Surgery"). Thus the medullary cavity is closed and the skin which must bear pressure is healthy and free from cicatrices; and as the muscles are still attached to the bone, they do not undergo atrophy.

Sedillot's leg amputation (Fig. 1147) is by a long external flap. A longitudinal incision is made along the inner edge of the tibia, the tissues are drawn toward the fibula, a knife is introduced and passed to the outer edge of the tibia, just touching the fibula, and is brought out posteriorly, thus transfixing the calf muscles and cutting an external flap. A convex incision is made on the inner side, the bones are cleared and are sawn 1 inch above the flaps, ½ inch more being taken from the fibula than from the tibia, and the tibia being beveled anteriorly.

Modified Circular Amputation of the Leg.—Cut semilunar skin-flaps, lay them back, and cut circularly to the bone at the edge of the turned-up flap. Another method of modified circular amputation is by adding to the circular cut a vertical incision down the front of the leg. In sawing the bones of the leg the surgeon, who stands to the outer side of the right leg and to the inner side of the left leg, divides the fibula first, and at a higher level than the tibia, and bevels the anterior surface of the tibia. In sawing the left fibula the saw points to the floor; in sawing the right fibula it points to the ceiling.

Amputation of the Leg by a Long Posterior and a Short Anterior Flap.—In this operation a posterior U-shaped flap is made equal in length and breadth to the diameter of the limb. The skin incision is begun 1 inch below the point where the bone is to be sawn, and behind the inner edge of the tibia, and is carried to a point posterior to the peronei muscles. The gastrocnemius muscle is divided transversely at the level of the flap, the soft parts on either side in the line of the flap being cut to the bone. Through these vertical cuts the muscles are lifted from the bones and are divided through their lower part by cutting from within outward. The anterior flap is formed by making a semilunar skin-flap and by cutting the muscles across at its retracted edge (Fig. 1148).



FIG. 1147.—Sédillot's amputation of the leg (Wyeth).

Amputation of the leg by lateral flaps is not a popular operation, as it offers too much encouragement to subsequent protrusion of the bone.

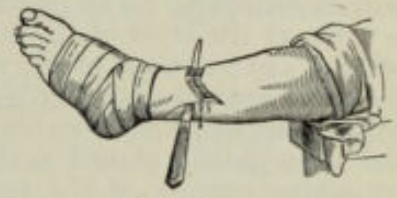


FIG. 1148.—Amputation of the leg by a short anterior and a long posteror flap (Gross).

Amputation Just Below the Knee.—The seat of election is 4 inches below the level of the knee-joint. No muscle is needed in the flap. The modified circular method is chosen. Cut two flaps of skin, equal in size and of semilunar shape, these flaps beginning anteriorly 2 inches below the tuberosity of the tibia. One flap is antero-external and the other is postero-internal. The flaps are pulled up, the anterior muscles are cut as high up as possible, and the posterior muscles are cut through the middle of the portion exposed (Bell). The bone is sawn 1 inch below the tuberosity. Shall we remove the remainder of the fibula? To do so adds to the amount of available skin (Muirhead's book on "Amputations and Stumps"). It prevents the disposition of the fibula to tilt from the tibia ("Orthopædic Surgery of Injuries," edited by Sir Robert Jones). If retained, it may be responsible for pain on pressure and may interfere with fitting and wearing of an artificial leg (Charles Noon in "Brit. Med. Jour.," March 3, 1923).

Disarticulation at the Knee.—The stump after disarticulation is difficult to fit with an artificial limb and the operation is seldom performed. In disarticulation by the long anterior flap make a long anterior skin-flap, incise the ligament of the patella, turn up a flap containing the patella, open the joint, and complete the disarticulation by cutting from within outward and downward. The knee may be disarticulated by means of a long anterior and a short posterior flap. Kocher prefers the oblique incision (Fig. 1149). This secures an anterior flap. The leg is so held that it makes an angle with the thigh of 135 degrees and "the incision falls in the continuation of the long axis of the thigh" (Kocher's "Text-book of Operative Surgery," translated by Harold J. Stiles). The posterior part of the incision is opposite the line of the joint and the anterior part of the incision ends four fingerbreadths below the tibial tubercle.

Amputation Through the Femoral Condyles.—*Syme's Method by a Long Posterior Flap.*—Carry a skin incision, with a very slight downward curve from one condyle to

the other, across the middle of the patella. Cut down to the bone, retract the flap, and cut the quadriceps above the patella. Insert a long knife at one angle of the wound, pass it back of the femur, and make it emerge at the opposite angle, and cut a posterior flap 8 inches long. Retract the posterior flap, clear for sawing, and section the condyles horizontally. In *Carden's method* a long anterior flap of skin and fat is cut, all other soft parts are divided transversely, and the bone is sectioned through the base of the condyles. The patella is, of course, removed. In children Buchanan showed that we can easily separate the lower femoral epiphysis. In *Gritti's amputation* an oblique incision is made. The upper end of the incision is posterior to and just above the condyles. Its lower end is anterior and two fingerbreadths below the

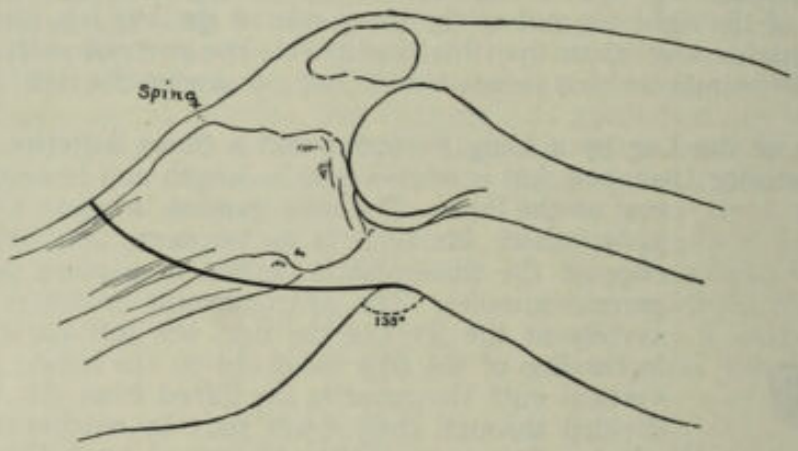


FIG. 1149.—Kocher's oblique incision for disarticulation at the knee-joint (Kocher).

patella (Kocher). The ligament of the patella is cut, the flap is turned up, the femur is sawn at the level of the adductor tubercle, the articular face of the patella is sawn off, the sawn surface of the patella is placed upon the sawn surface of the femur, and the flaps are sutured (Fig. 1150). In *Stokes's amputation* (which is really a supracondyloid amputation) the femur is divided about ¾ inch above the condyles and the sawn patella placed against the surface so formed. In Gritti's amputation the remaining portion of the patella is apt to be pulled forward and to tilt. Stokes's operation corrects this tendency and the two bone surfaces are nearly equal in size. Sabanejeff makes an anterior flap, opens the knee-joint from behind, saws the condyles at their broadest part, takes a bone-flap from the anterior portion of the tibia, and fastens it to the femur (Fig. 1151).

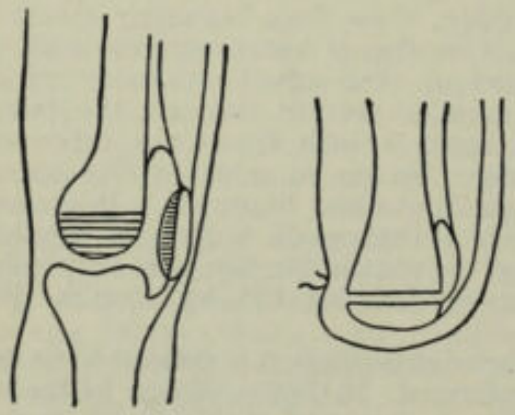


FIG. 1150.—Diagrammatic representation of Gritti's operation.

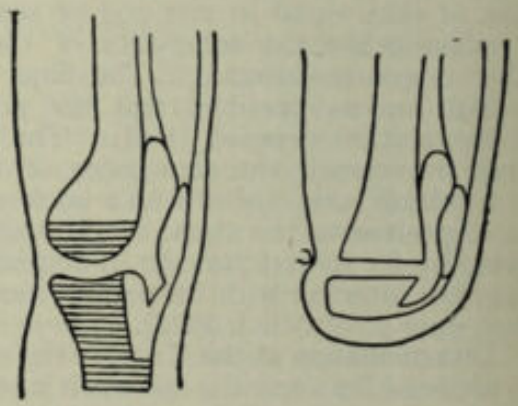


FIG. 1151.—Diagrammatic representation of Sabanejeff's operation.

Amputation of the Thigh.—We want as long a stump as possible. The greater the length, the greater the leverage. Equal flaps are not to be made. The best operation for the lower third and the middle third is a long anterior and a short posterior flap. It is much better than a circular. In a double-flap operation a semilunar skin incision should be made from without inward, and the muscles should be cut by transfixion (Fig. 1152). The length of the anterior flap is somewhat more than two-thirds of the diameter of the limb at the point of bone section. The length of the posterior flap is somewhat more than one-third the diameter. The scar will be posterior and

above the end of the bone. In amputations in the lower part of the *upper two-thirds* of the thigh the best plan is to mark out the anterior and posterior semilunar skin-flaps, divide the skin with a scalpel, enter the long knife at one angle of the anterior flap, bring it out at the other angle, and cut the muscles by transfixion. Cut the posterior flap in the same manner. Some surgeons prefer a long anterior semilunar flap and a short posterior semilunar flap. In an amputation high up use a racket incision, making a long postero-external and a long antero-internal flap (Lockwood, Ibid.). If it is not possible to retain at least 3 inches of femur below the lesser trochanter, saw the neck of the femur (Lockwood, Ibid.).

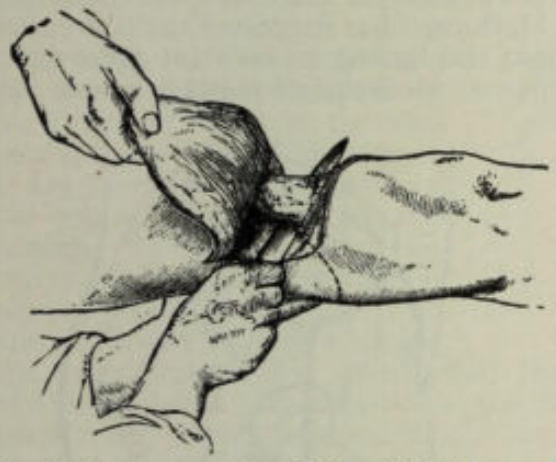


FIG. 1152.—Amputation of the thigh (Bryant). (The posterior flap should be shorter.)

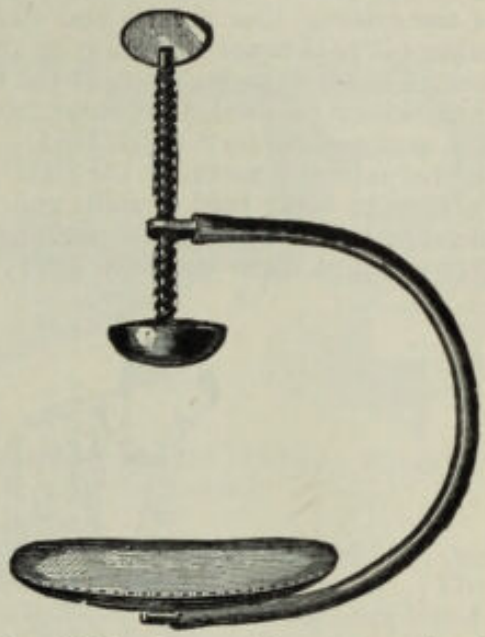


FIG. 1153.—Pancoast's aorta tourniquet.

Disarticulation at the Hip-joint.—The first hip-joint amputation through living parts was performed by Mr. Henry Thompson, of the London Hospital, in 1743. Kerr, of Northampton, operated in 1778, and Larrey, in 1793. All these cases died. It is claimed that the elder Blandin, Larrey's assistant, operated three times in 1794, and that 2 of the patients recovered. In 1806 Walter Brashear, of Kentucky, operated successfully; so did Brownrigg, of the British Army, in 1812; so did Valentine Mott in 1824. Farabeuf speaks of forty-five methods of operation. Various methods have been employed to prevent or limit hemorrhage during this formidable operation. Abernethy used digital compression of the external iliac artery or of the femoral artery.

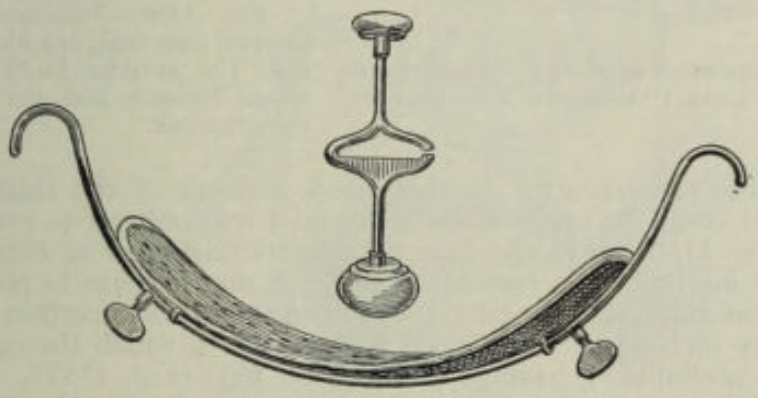


FIG. 1154.—Von Esmarch's aorta tourniquet.

This is an extremely tiresome procedure; the finger is liable to slip; and, in any case, compression so situated fails to intercept the blood-current in a number of large vessels.

Various other methods have been employed. It was formerly the custom to compress the aorta by means of an abdominal compressor (Figs. 1153, 1154). A tourniquet is very likely to be displaced during the operation. The intention is to compress the artery against the spine, but in effecting this the circulation in a portion of the intestine may be impaired. In any case, as Senn says, the circulation is cut off from half the body, and the patient is exposed to grave danger from "sudden vascular engorge-

ment of important internal organs" (Senn). Again, an abdominal compressor of this sort does not arrest venous bleeding. A number of years ago Davy suggested that a suitable cylindric piece of wood, about 25 inches long, and shaped like a cone at the end, might be introduced into the rectum and used to compress the common iliac artery upon the pelvic brim. This appliance is known as *Davy's lever*. It is apt to slip, and may do serious damage to the rectum.

Some surgeons have practised preliminary ligation of the common femoral artery or of the external iliac artery, and others have tied the vessels while making the flaps. I employed preliminary ligation of the common femoral with perfect satisfaction in 2 of my 4 cases of amputation at the hip-joint for sarcoma of the femur. If any form of compression be used, that recommended by Macewen, of Glasgow, is the most successful and satisfactory (Fig. 1155). The weight of the assistant's body is thrown upon the patient's aorta by the right fist, placed slightly to the left of the umbilicus, the extremity being held straight and rigid. McBurney has suggested the prevention of bleeding by making a small abdominal incision and having an assistant make direct digital pressure upon the iliac artery. I employed McBurney's method in one case



FIG. 1155.—Macewen's method for compression of the abdominal aorta ("American Text-book of Surgery").

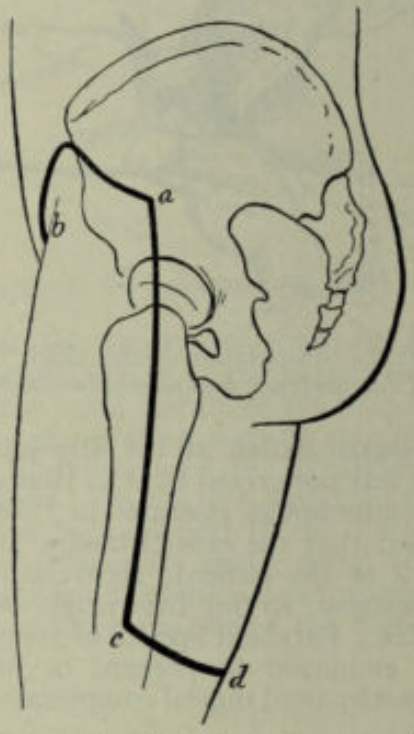


FIG. 1156.—Posterior flap in author's unusual case requiring hip-joint amputation: *a–b*, The anterior incision; *a–c–d*, the external incision and the beginning of the posterior cut.

and found it most satisfactory. In this case a sarcoma of the thigh reached up so far that no band could be applied above it, and I was obliged to make the posterior flap shown in Fig. 1156. If in any case the constricting band of Esmarch be applied by the ordinary method, it is certain to slip. It may remain in place if applied as a figure-of-8 of the thigh and the pelvis, but even then it is uncertain.

A satisfactory method in many cases is Wyeth's, in which the constrictor is held in place by the preliminary passage of two steel pins (Fig. 1157). Trendelenburg's method consisted in passing one pin and winding an elastic tube about it. Wyeth applied the principle and greatly improved the method. The outer pin is inserted $1\frac{1}{2}$ inches below and a little internal to the anterior superior spine of the ilium, and is brought out just back of the great trochanter. The inner pin is entered 1 inch below the level of the crotch and internal to the saphenous opening, and it emerges $1\frac{1}{2}$ inches in front of the tuberosity of the ischium. A sterile cork may be pushed on the end of each pin, to save the surgeon from wounding himself upon the sharp points. A cork is apt to come off during the course of the operation. Because of the insecurity of the cork I have devised pins with removable points. After a pin has been passed, the point is unscrewed and a knob is screwed on in its place. After the limb has been

emptied of blood by holding it in a vertical position for five minutes and stroking it from the periphery toward the body, the constricting band is fastened about the limb above the pins.

In the *bloodless method of Wyeth* (Figs. 1157, 1158), after passing the pins, draining the limb of blood, and applying the band of the Esmarch apparatus, the amputation is proceeded with. The hip is brought well over the edge of the table, a circular incision is made down to the deep fascia, 6 inches below the constricting band, and is joined by a longitudinal skin-cut reaching from the band to the level of the circular incision, and the cuff is reflected to the level of the lesser trochanter. The muscles are cut by a circular sweep at the level of the retracted cuff, the capsule of the hip-joint is opened freely, the cotyloid ligament is cut posteriorly, the thigh is bent upward, forward, and inward to dislocate the head of the bone, and, using the thigh as a handle, the round ligament is incised and the limb removed. After ligating the vessels and introducing drainage-tubes the flaps are sewn together vertically. The old transfixion operation is practically extinct. A T-*amputation* may be employed. It consists of an external straight incision down to the bone, starting over the great

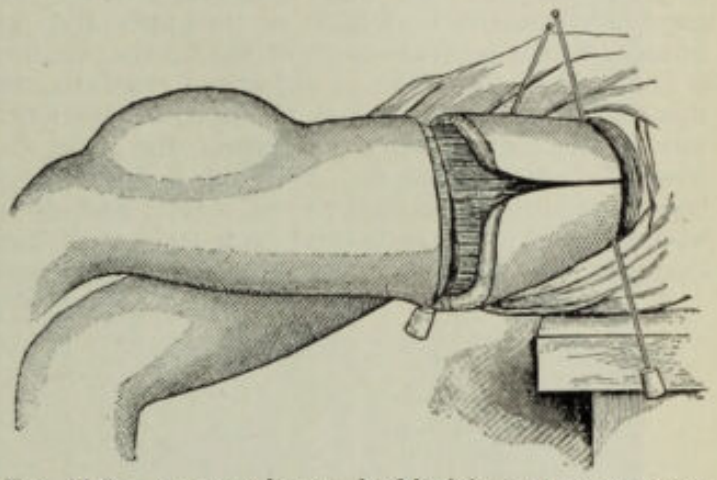


FIG. 1157.—Amputation at the hip-joint: Wyeth's bloodless method.

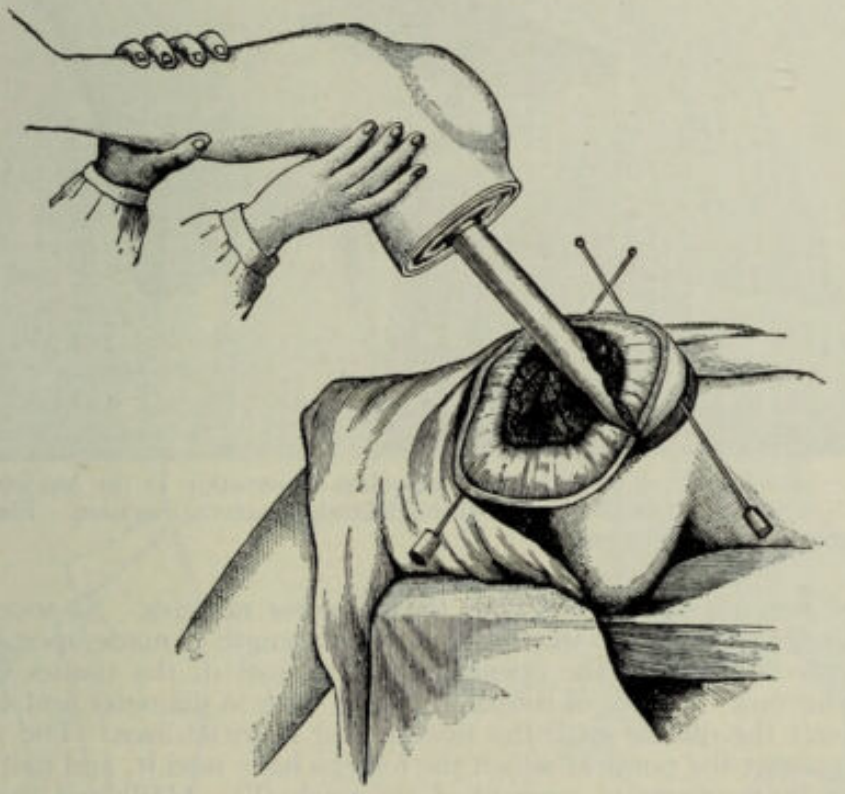


FIG. 1158.—Wyeth's bloodless amputation at the hip-joint: Cuff of skin and subcutaneous fat turned back, muscles divided at level of small trochanter, bone partly stripped, and large vessels exposed for ligation.

trochanter, down the outer side of the limb, and a circular incision through the skin 5 inches below the constricting band, the muscles being cut by a circular sweep at the level of the retracted skin. This method affords easy access to the joint. The bloodless method of Wyeth, as applied to the hip-joint and shoulder-joint, is a notable advance in the art of surgery.

Senn's Bloodless Method.—The elder Senn has devised a method of preventing hemorrhage during amputations through the hip-joint. He makes a straight incision, about 8 inches in length, in the direction of the long axis of the femur and directly over the center of the great trochanter. This incision reaches about 3 inches above the upper margin of the great trochanter. The muscular insertions are divided close to the bone, and the thigh is flexed, strongly adducted, and rotated inward. The capsular ligament is divided at its upper and posterior aspect. While the thigh is brought into a position of slight flexion the remaining portion of the capsular ligament is cut. Then the thigh is dislocated outward, and the ligamentum teres is cut. If this cannot be accomplished, the head of the bone is forcibly dislocated upon the dorsum of the ilium. After dislocating, the lesser trochanter and the upper part of the femoral shaft are cleared. The limb is now brought down in a straight line with the body, the thigh is slightly flexed, a long and stout pair of forceps is inserted into the wound behind the femur and on a level with the normal situation of the lesser trochanter, and the instrument is pushed downward and inward, 2 inches below the

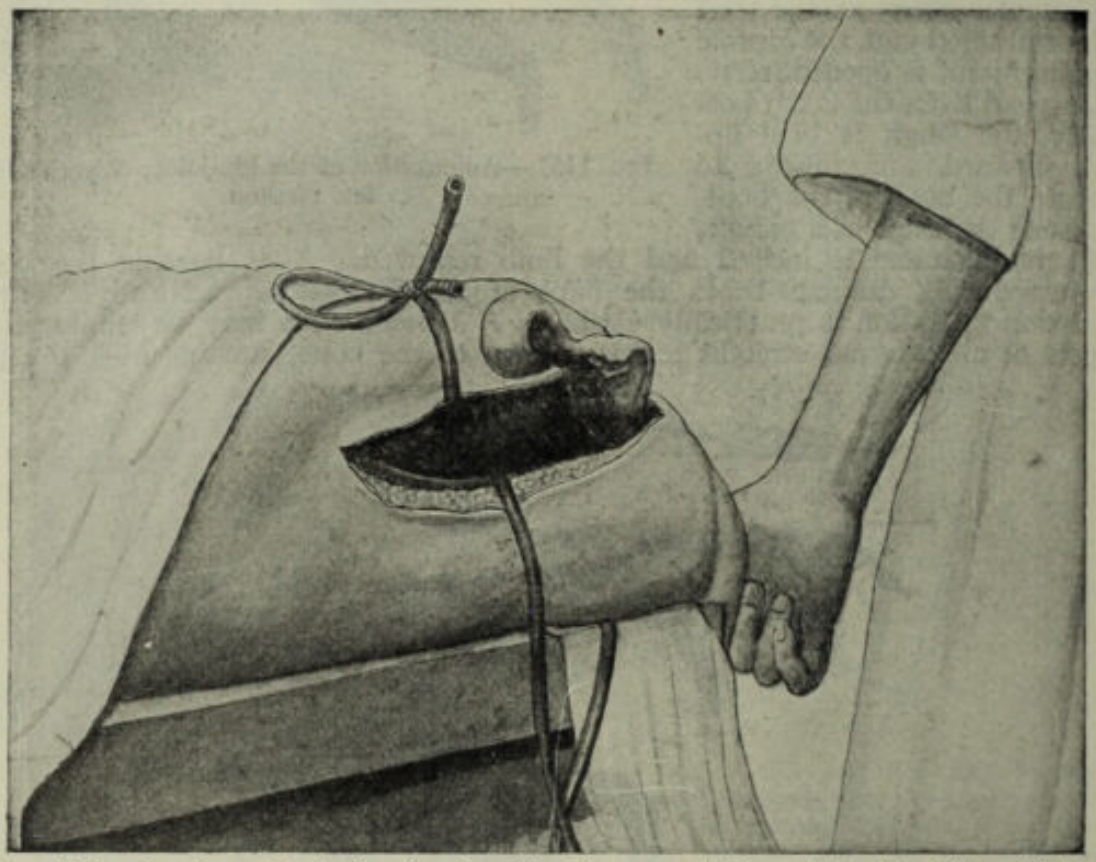


FIG. 1159.—Senn's method of performing bloodless amputation at the hip-joint. Dislocation of head of femur and upper portion of shaft through straight external incision. Elastic constrictors in place, the anterior one tied (Senn).

ramus of the ischium and just behind the adductor muscles. As soon as the point can be felt under the skin, an incision 2 inches in length is made upon it, and the instrument is forced through the opening. The tunnel in the tissues is enlarged by opening the forceps. A piece of rubber tubing $\frac{3}{4}$ inch in diameter and 4 feet in length is caught about the middle with the forceps and is withdrawn. The rubber tube is cut in two at about the point at which the forceps have held it, and half of the tube is used to constrict the anterior segment of the thigh (Fig. 1159) and the other half to constrict the remaining portion of the thigh (Fig. 1160). Before the constricting bands are tied the limb is held vertically for a sufficient length of time to make it practically bloodless; the amputation is then completed (Senn's "Practical Surgery").

Other Methods.—John G. Sheldon ("Amer. Med.," April 19, 1902) has modified Senn's method as follows: He disarticulates the head of the femur and frees the upper part of the femur from its attachments. He then introduces a pair of long, stout artery forceps behind the femur and clamps the femoral vessels. He forms the flap, removes the limb, and ligates the vessels. In this operation the surgeon can work

rapidly and can make a flap of any size or shape, and is not hindered by a constriction apparatus; but this method does not cut off the bleeding from the obturator and the sciatic arteries.

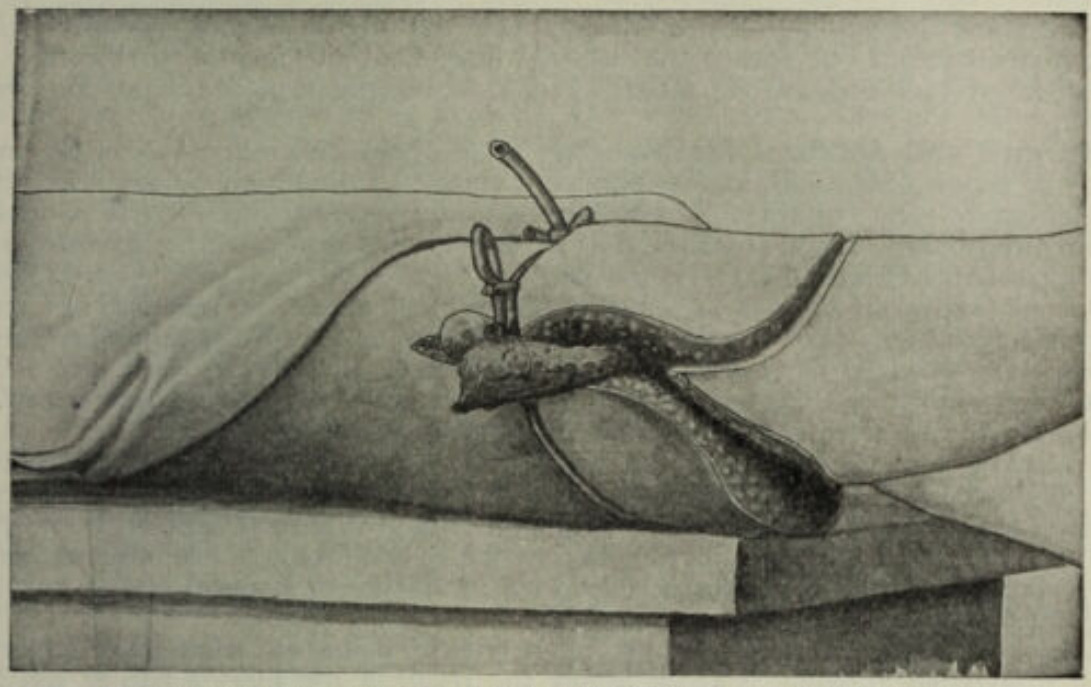


FIG. 1160.—Elastic constriction completed by constricting the posterior segment of the thigh. Flaps formed, including all the tissues down to the muscles (Senn).

Larrey amputated by lateral flaps, and Liston by anteroposterior flaps. Forneaux Jordan's method consists in dividing the soft parts low down, tying the blood-vessels on the face of the stump, shelling out the femur from the soft parts, and disarticulating. It leaves clumsy and redundant flaps.

Interilio-abdominal Amputation.—This very formidable operation is occasionally performed for sarcoma of the ilium. The operation was first performed by Billroth in 1891, and the patient died. Prof. Keen and I collected 19 cases, including 1 of our own. Five of these cases recovered (W. W. Keen and J. Chalmers DaCosta, in "International Clinics," vol. iv, 13th series). Our patient perished in thirty-three hours from suppression of urine and with gangrene of the parts supplied by the internal iliac



FIG. 1161.—Keen and DaCosta's method of interilio-abdominal amputation ("International Clinics," vol. iv, 13th series).

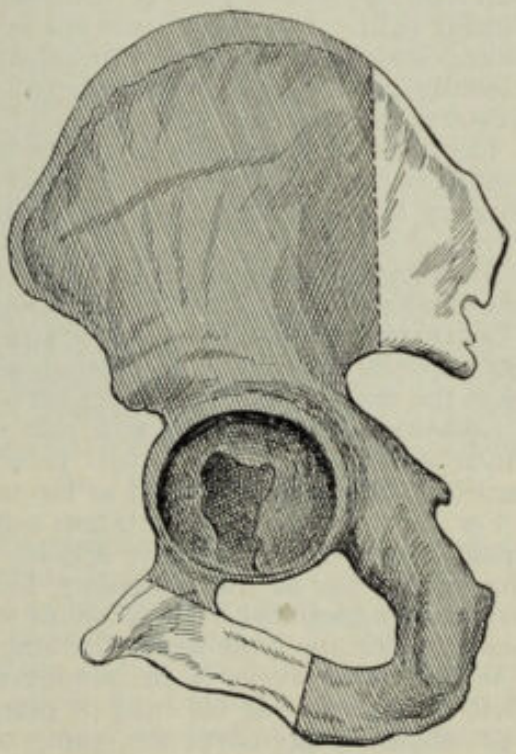


FIG. 1162.—Keen and DaCosta's case of interilio-abdominal amputation. The shaded portion of the bone was removed ("International Clinics," vol. iv, 13th series).

artery. J. H. Pringle has collected 43 cases and has performed the operation five times personally. The mortality in the series was 58.1 per cent. Pringle had 3 recoveries out of 5 cases ("Brit. Jour. Surgery," 1916, iv). In some cases the entire innominate bone has been removed; in others, portions of it have been left. In our case we made the flap shown in Fig. 1161, tied the internal iliac artery after rolling up the peritoneum, but spared the external iliac, kept the femoral in the flap, and sawed through the bones as indicated in Fig. 1162, leaving in place the portions shown in white.

Stumps and Artificial Limbs.—One must always bear in mind in an amputation to do an operation and to pursue a course of treatment which will permit the patient to wear comfortably and early a useful artificial limb. It is possible to obtain a thoroughly sound stump so that we may early adjust a temporary bucket and later a permanent limb. (A. C. Lockwood, "Jour. Amer. Med. Assoc.," Oct. 28, 1922.) Lockwood points out some of the causes of ill results, namely, (1) selection of a wrong site for amputation; (2) failure to cut the flaps so as to avoid disastrous pressure on the scar; (3) too short flaps which will cause tension or too long flaps which result in a redundant stump; (4) improper dealing with the nerves; (5) carelessness in dividing the bone; (6) failure in asepsis, and (7) insufficient postoperative care.

In 500 patients with stump trouble he found the following conditions: (1) adherent scar; (2) ulceration; (3) turning in of the skin with excoriation or eczema; (4) tender cicatrix; (5) sinuses; (6) eczema; (7) redundant flaps; (8) sequestrum; (9) bony spines and spicules; (10) osteomyelitis and periostitis; (11) fibroma; (12) bulbous nerves; (13) small aneurysm; (14) contractures with limitation or fixation of movement in the joint above.

Lockwood (Ibid.), in this very instructive article, points out some most important things: That an adherent scar is usually the result of too short a flap or too little material in the flap; it may be due to a low-grade infection. That an ulcer may be due to tension of the flap, or to pressure upon a bony edge or spur. In such a case the treatment is excision of a portion of the bone.

If the above condition is not found as a cause, it is probable that the flap is congested from too much use and too early use, and from a dependent position. The treatment for this is rest in bed, elevation and extension, and direct sunlight or artificial light. If these means fail and the ulcer is indurated, it must be excised. Folding inward of the skin is found in redundant flaps and in flabby limbs, but occasionally occurs as a result of puckering after circular amputation. It is often necessary to excise the scar.

The cause of a tender scar may be lack of sufficient covering of the bone by muscle or fat, a nerve in the scar, a sharp piece of bone, or a retained ligature. Usually it is necessary to excise such a scar. If curetment fails to cure a sinus, excision is necessary.

A redundant stump is a bad affair. We cannot fit it properly with an artificial limb. In such a case let the limb shrink as much as it will and then reoperate.

Sequestra, osteomyelitis, bony spurs, and fibromata require operation. A nerve bulb requires excision, and at that operation alcohol injections are made near the end of the nerve.

Lockwood lays it down as a rule that stumps should be end bearing except for counterpressure upon the ischial tuberosities in high thigh amputations. Muscular insertions should be preserved as far as possible in the operation.

For the method of amputation advisable in each case the reader is advised to consult Lockwood's impressive article. There is no doubt whatever of the very great value of the use of the temporary limb (pylon) after amputation. In many cases traction by a modified Thomas splint will be found to aid in securing a good stump in cases in which the bone seems too long.

Within three weeks of the amputation we should be able to put on a temporary pylon. This is a peg leg held in place by plaster of Paris. It enables the patient to get about, to accustom the stump to motion and pressure, and to fit the parts for the early adjustment of a permanent leg. (See Carl Bearse in "Surg., Gynec., and Obstet.," April, 1922, and H. Winnetore, "Surg., Gynec., and Obstet.," Oct., 1922.)

XXXVI. DISEASES OF THE MAMMARY GLAND

Hypertrophy of the Breast (Fig. 1163).—This is a rare condition. It may affect one breast or both. It is most apt to appear at the age of puberty, but it may appear in childhood, adult life, or old age. "Before, during, or shortly after the first menstrual period one breast becomes larger than the other" (Bloodgood in "Jour. Amer. Med. Assoc.," March, 1922, vol. lxxviii). Sooner or later the other breast will develop to a corresponding degree. The breast may attain enormous size. In Porter's case the breasts of a woman of thirty-seven were so very large that they were carried hung upon a frame ("Boston Med. and Surg. Jour.," March 3, 1892).

These very large breasts are not composed of true gland tissue, but rather of fat and connective tissue ("Diseases of the Breast," by A. Marmaduke Sheild). Hypertrophy may also occur in the male breast. In some cases hypertrophy occurs so rapidly as to merit the name *acute*. Such cases may perhaps be sarcomatous.

Treatment.—Be sure it is hypertrophy and not sarcoma, adenoma, or lipoma. Try recumbent posture, dry diet, pressure, and iodid of potash (Sheild, Ibid.). If these means fail, amputation is the only recourse. A unilateral enlargement arising at or near the first menstruation seldom attains a size which calls for operation.

Polymastia (*Accessory Mammary Glands*).—Williams says 1 out of 200 women has one or more accessory glands which may be in the neighborhood of the normal gland or in the thigh. An accessory gland may or may not functionate. The condition is due to atavistic reversion.

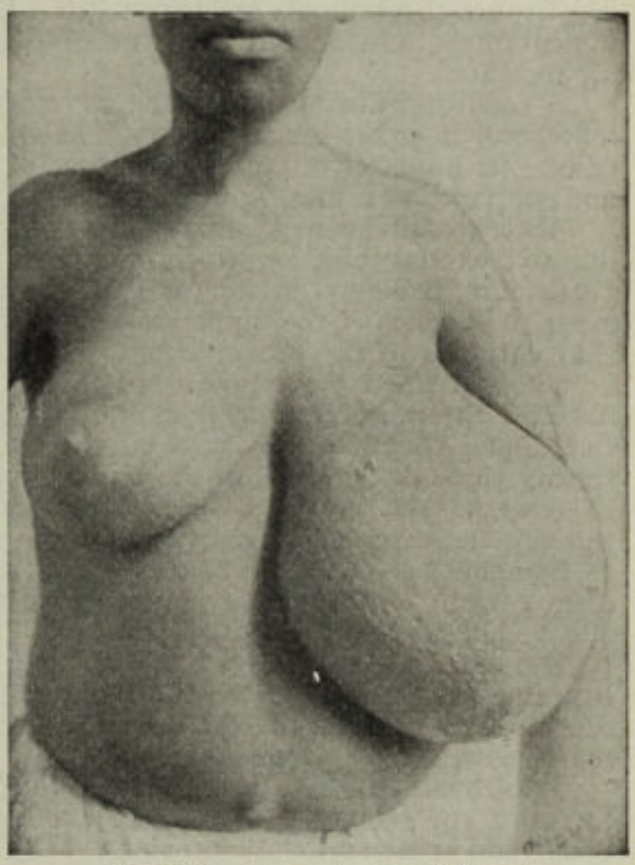


FIG. 1163.—Hypertrophy of breast.

Polythelia (*accessory nipple*) is very rare. Douglas Howat reported his second case in the "Brit. Med. Jour.," June 2, 1923.

Mammillitis and Fissure.—The nipple may inflame as a result of injury, but the condition is rarely encountered except in a woman who is nursing a baby. It is most common after a first pregnancy, when the nipple is deformed or when the skin is delicate. The nipple is slightly injured during nursing, and the epithelium is macerated by the milk and saliva. If the inflammation be not arrested, a spot excoriates or an irritable ulcer forms (a fissure). A fissure is often surrounded by an area of acute inflammation, and nursing causes intense agony. Because of the pain the mother is apt to extend the intervals between nursing, and as a consequence the breasts become swollen with retained milk. The ulcer not unusually bleeds when the breast is taken by the child. Besides the fact that a fissure causes pain to the mother, it often leads to grave trouble. It is a suppurating area, and as such may lead to abscess of the mother's breast, or may impair the health of the nursing child.

Prevention of Fissure.—During pregnancy the nipples should be carefully attended to. They should be washed often in sterile water and bathed in alcohol, and if retracted, ought to be drawn out repeatedly. During the period of lactation the nipples are washed in sterile water, dried, and dusted with borated talc powder as soon as an act of nursing is completed. Washing the nipples regularly with the following solution tends to prevent the formation of a fissure: iodid of mercury, 2 gr.; alcohol, 1½ oz.; glycerin and distilled water, of each a pint (Lepage). If a small abrasion appears, order the woman to wear a nipple-shield during nursing, and after each act of nursing to wash the part with hot sterile water, to dry it, and to dust borated talc over the surface. If a fissure forms, wean the child at once, and dry up the milk in both breasts.

It is useless to try to dry it up in one breast. Milk may be dried up by applying ointment of belladonna locally, and administering iodid of potassium internally; by strapping the breasts with adhesive plaster (Parker); or by applying to the nipples six times a day a 5 per cent. solution of cocain in equal parts of glycerin and water (Joise). The fissure is not treated by ointments. These preparations are septic, prevent drainage, and aggravate maceration. Wash the fissure twice a day with peroxid of hydrogen, dress it with gauze wet in boric acid solution (10 gr. to 1 dram of water), and cover the dressing with waxed paper. If the fissure resists treatment, touch it with lunar caustic.

Acute Mastitis and Abscess.—Acute inflammation of the breast, as a result of injury of the breast or nipple, may occur in either sex at any time of life. Very commonly in both sexes a few days after birth the breast becomes distended with a material which in reality is milk. The fluid is usually small in quantity. The process is physiologic, and, as a rule, ceases spontaneously (Guelliot). If it lingers, the application of belladonna ointment will arrest secretion. If the nurse meddles with the glands and tries to squeeze out the fluid, acute mastitis is apt to arise in one gland, or occasionally in both. The skin of the breast reddens, the gland swells and becomes tender and painful, the child loses its appetite and becomes feverish, restless, and sleepless. Such a condition is treated by the local use of alcohol. If pus forms, the local signs and constitutional symptoms are aggravated. Evacuate the pus, dress with hot antiseptic fomentations, and be sure that the child is well nourished. Tonics and stimulants are indicated.

A condition identical with the secretory activity of the glands of the newborn may occur in either sex at puberty. The methods of treatment are the same in both cases. As a matter of fact, at this time of life rarely more than one lobule inflames, and suppuration is most unusual.

Acute mastitis is most usually met with in a woman who is nursing a child, and is due to bacterial infection which may have ascended the lymphatics. A primipara is particularly liable to develop mastitis. So are women with deformed nipples. In most cases an abrasion of the nipple exists, and through this breach of continuity bacteria gain entrance to the breast tissue. The abrasion may be so slight that it can only be detected when the nipple is examined through a magnifying glass (Marmaduke Sheild). Streptococcic infections are very generally due to inoculation of a fissure of the nipple. Bacteria may pass up the milk ducts, coagulating the milk, and penetrating through the walls of the acini. Staphylococci not unusually pursue this route in reaching the breast tissue. Occasionally causative bacteria reach the breast through the arteries (in septicemia and in septic wounds of the genital organs).

Symptoms.—There are pain, swelling, and tenderness in the breast, and in most cases a fissure or abrasion of the nipple exists. There is a febrile condition. Occasionally a chill ushers in the attack.

If a case supposed to be acute mastitis proves utterly rebellious to treatment the suspicion should arise in the surgeon's mind that the condition is acute or inflamed cancer (carcinoma mastitoides, see page 1423). If such a doubt arises, a piece of tissue must be excised for microscopic study.

Treatment.—Order the patient to suspend nursing. The physician endeavors to arrest the secretion of milk. Treat the nipple as advised above. Support the breast and apply ichthyol ointment.

Mastitis may undergo resolution; it may terminate in organization and induration; it may eventuate in suppuration.

Acute abscess of the breast follows acute mastitis. There may be but one area of suppuration, or multiple foci may exist, which eventually fuse. The symptoms of mastitis, local and constitutional, are greatly aggravated. After a time the skin becomes dusky and edematous. The axillary and superficial cervical glands enlarge. The abscess will eventually open spontaneously at one or more points, leaving branching fistulæ. A superficial abscess is situated just beneath the nipple, and pus may flow from the nipple.

An intramammary abscess is in the depths of the gland. There are often multiple foci of suppuration. Nodules are felt in the gland, pus may run from the nipple, but cutaneous redness is late in appearing.

Retromammary abscess is a rather rare condition. It may occur alone or be associated and connected with an area of intramammary suppuration. It may result from metastasis or from caries of a rib. The breast is lifted up by the fluid beneath it.

Treatment.—Open a superficial abscess by an incision radiating from the nipple.

Treat as any other acute abscess. An intramammary abscess should be opened by a radiating incision, and pockets of pus should be broken into with the finger. An examination is made to determine if a retromammary abscess also exists. If this is found to be the case, an incision is made at the point of junction of the thorax and mammary gland, and at the lower border of the gland. The gland is raised from the chest wall, the pus evacuated, a drainage-tube is inserted, and a few sutures are introduced. If retromammary abscess exists alone, make the last-named incision in the first place.

Blocked Ducts by Epithelial and Sebaceous Matter.—A single duct dilates and can be felt and often seen; the area about its orifice is dry and perhaps crusted (see Sir G. Lenthal Cheatle in "Brit. Med. Jour.," June 2, 1923). He says: Place the arm in sling; use hot fomentations, keeping nipple soaked with hot sterile water applied on cotton wool. In two weeks the surgeon can remove the plug in the duct orifice by wiping the surface and emptying duct by light pressure. The patient will be well in two months. Always keep the nipple clean by water. Avoid soap, powder, alcohol, and hydrogen peroxid.

Chronic Mastitis.—This condition may be present in only a small portion of the breast, or may attack a considerable area (*lobar mastitis*). The ordinary form may arise after weaning a child, or may be due to a blow, to the pressure of corsets, or to numerous slight traumatisms. It may occur in the young, the middle aged, or the old. The patient has slight pain at times in the gland. Examination detects a firm, elastic area, which is somewhat tender and does not possess distinct margins. The skin is not adherent to the mass unless suppuration occurs. If the mass be pressed against the chest by the surgeon's fingers, it becomes evident that no real tumor exists.

Treatment.—Remove any cause of irritation. Support the breast by a spica bandage. Apply ichthyol ointment. During the night employ a hot-water bag. If pus forms, treat as before directed.

Chronic lobular mastitis is a condition in which numerous lobules become indurated. The real cause of this condition is unknown. It may occur at any age after puberty, and often attacks both breasts. Such a breast is apt to be painful, especially at the menstrual periods; it feels unnatural, solid, and careful examination detects numerous indurated areas, each of which is of small size. At the menstrual period the breast enlarges and new nodules may be detected. In some of these cases violent neuralgic pains are present in the gland (*mastodynia*). Chronic lobular mastitis is apt to lead to cyst formation. When cysts form fluid may occasionally discharge from the nipple.

Treatment.—Support the breast and apply ichthyol ointment or belladonna ointment. Examine the generative organs and correct any existing abnormality. Improve the general health by good food, tonics, and open-air life. In cases in which multiple cysts are known to exist the question of treatment is uncertain. There seems to be little doubt that such cases tend in some instances to eventuate in cancer. I believe that the proper treatment when multiple cysts exist is extirpation of the breast.

Tuberculosis of the Mammary Gland.—Sir Astley Cooper in 1829 wrote on "scrofulous swellings" of the breast, and Velpeau also referred to them. Nevertheless, Virchow, in his treatise on tumors, stated that the mammary gland was not subject to tuberculosis. Durbar first proved the existence of the condition by histologic and bacteriologic observations. Primary tuberculosis of the breast is a rare condition. If we are to judge from English and American literature, it is a very rare condition. In 1902 Bindo de Vecchi was able to report 1 case and collect 77 from literature ("Extratis della Clinica Chirurgica," No. 8, 1902). Braendle in 1906 reported 11 cases from the Tübingen Clinic ("Beit. zur klin. Chir.," vol. i, 1906). Powers, of Denver, reported 4 cases ("Annals of Surgery," Feb., 1913). About 80 cases confirmed by bacteriologic findings and histologic study have been reported. It is seldom that both glands are involved. Tuberculosis of the breast may be secondary to tuberculosis of the skin, of related glands, of the rib, etc. It may result from some distant tuberculous lesion of bone, of joint, of lung, etc. It may be a part of general miliary tuberculosis. We consider here primary or, as Geissler named it, solitary tuberculosis, tuberculosis apparently limited to the breast in an individual free from evidences of antecedent tuberculosis, and of tuberculosis elsewhere. It occurs usually in those of excellent general health. The route of infection may be by the blood, by the lymph-ducts, and perhaps by the lymphatics from the skin or nipple. The lesion begins in the periacinous and periductal connective tissue. The ducts and acini become in-

volved later. E. M. Von Eberts ("Amer. Jour. Med. Sci.," July, 1909) states that there is no reported case before the age of puberty, that the most advanced case reported was fifty-three years of age, that maturity of the gland and lactation predispose, and that the reported cases show the proportion of the married to the unmarried as 4 to 1. It is vastly more common in women than in men. In many cases there is a history of antecedent inflammation or abscess during lactation. In some cases there is a history of traumatism. There are two forms of the condition, and in each form, sooner or later, degeneration occurs, and fistulæ from a cold abscess arise (see page 167); these forms are *nodular* and *confluent* (von Eberts, Ibid.). In the *nodular* form a nodule, several nodules, or many nodules arise in the glandular tissue. There is little or no pain. If nodules are under the nipple retraction may occur. The condition is very slow in progress and a year or several years may elapse before degeneration occurs. Degeneration results in cold abscess (see page 167) and often in fistula formation. Schley has pointed out that cold abscess is a termination more common in the confluent than in the nodular type ("Annals of Surgery," 1903). In the confluent form the condition develops much more rapidly, is associated with pain, is most apt to arise during lactation, is particularly prone to abscess and fistula formation, and is liable to acute exacerbation from secondary pyogenic infection. The axillary glands are found enlarged in three-fourths of all cases of primary tuberculosis. Cases have been reported of carcinoma and of adenoma associated with tuberculosis.

Treatment.—In a very slowly developing nodular case, in which it is certain lactation will not arise, it may be considered proper to treat the condition with tuberculin, etc. (see section on Tuberculosis). In the confluent form and in cases of the nodular form in which tuberculin treatment has failed, or in which we cannot exclude permanently the possibility of pregnancy, the breast should be removed and the glands and fat should be removed from the axilla. Most of the cases recover permanently after radical operation (Braendle, of Tübingen, in "Beit. zur klin. Chir.," 1906, Bd. 1). Powers ("Annals of Surgery," Feb., 1913) advises the thorough removal of the breast, pectoral fascia, and axillary contents, and with this recommendation I am in accord.

Cysts and Tumors of the Nipple.—Tumors are rare in the nipple, but do sometimes occur. The following growths are occasionally seen: fibroma, angioma, papilloma, myxoma, myoma, and epithelioma. Sebaceous cysts of the nipple and areola are not very unusual. A cancer of the nipple may be a primary growth, or may be secondary to gland cancer. Primary epithelioma of the nipple presents the same general characters as epithelioma in any other part. It begins as an indurated area in the areola, or an excoriation of the nipple. Ulceration soon occurs. The ulcer is irregular in outline, has hard edges, and furnishes a foul, red, sanious, and fetid discharge. The mammary gland becomes infiltrated at an early period. The subclavian glands enlarge, and later the axillary glands. Such a growth must not be confounded with a chancre of the nipple.

Treatment of Tumors of the Nipple.—Innocent tumors are to be excised and the breast need not be removed.

Epithelioma of the nipple requires the complete extirpation of the breast, and also the clearing out of the lymphatic contents of the axilla, and possibly of the subclavian triangle.

Paget's Disease of the Nipple (*Malignant Dermatitis*).—Sir James Paget made a report upon 15 cases of this rare disease ("St. Bartholomew's Hospital Reports," vol. x, 1874). Over thirty years previous to Paget's paper Velpeau described a like or identical condition ("Leçon orales de Clinique Chirurgicale," 1841). It is a rare condition. Only about 150 cases have been reported (Jopson and Speese, "Annals of Surgery," Aug., 1915). Paget's disease was long held to be a peculiar chronic inflammation of the epithelial layer of the nipple and areola occurring in women beyond middle life, and was regarded as a not unusual precursor of epithelioma of the nipple and of duct cancer. Paget's disease is not a simple eczema, it is not associated with the usual causes and attendants of eczema, either local or constitutional, and is not cured by remedies which control the ordinary disease. It begins in the cells of the Malpighian layer, which grow downward but do not invade tissue like cancer cells, and it causes proliferation of cells of the acini and milk-ducts. Paget held that the disease of the nipple we are discussing was associated with cancer in the substance of the breast. Handley holds that cancer in the breast precedes the nipple condition and causes obstruction beneath the areola with cancer cells. Sir Lenthal Cheatle (epitome of "Brit. Med. Jour.," Dec. 8, 1923) holds that Paget's disease *is* cancer,

that the primary disease is usually of the breast epithelium, that the same irritant is responsible for both conditions, and that the two areas communicate by the milk ducts.

The diseased area is raw and red, with sharply defined margins of a brownish color, and from it exudes copiously a thick yellow discharge. Induration is noted early. In many cases inflammation of the nipple and areola is secondary to or occurs with duct cancer, auto-infection of the nipple having been effected by the fluid flowing from the ducts, or the disease of ducts and nipple having been caused by the same irritant, but true Paget's disease is thought, by most surgeons, to be a primary affection. Practically always cancer follows. In rare cases squamous-celled epithelioma arises on the nipple or areola. Commonly duct or gland cancer follows. Bloodgood says that a warty condition associated with discharge, ulceration or scaling, or any condition "with redness or weeping, or anything suggesting eczema or ulceration of the nipple, which does not heal within a few weeks after simple measures of cleanliness and protection, should be looked on as Paget's disease" (Joseph Colt Bloodgood in "Jour. Amer. Med. Assoc.," March, 1922, vol. lxxviii). Induration below the nipple or a palpable mass in the breast makes the diagnosis of cancer certain.

Treatment.—Removal of the entire breast and clearing out of the axilla.

Tumors and Cysts of the Mammary Gland.—These tumors may be innocent or malignant. Tumors may occur in childhood (angioma, sarcoma, fibro-adenoma). Malignant tumors are very rare before the age of thirty.

Innocent Tumors of the Mammary Gland.—The innocent tumors are: *Periductal fibroma, fibrocystadenoma, papillary cystadenoma, simple adenoma, periductal fibromyxoma, myxoma, angioma, lipoma,* and *enchondroma.* It is maintained by most authorities that any innocent tumor of the gland may and is apt to become malignant.

Periductal Fibroma, Fibro-adenoma.—The nomenclature of fibro-adenomata is in a state of great confusion. The name fibro-adenoma was given by Cornil and Ranvier to the same sort of growth which the younger Gross called a fibroma, Billroth an adenofibroma, and Sir Astley Cooper a chronic mammary tumor. It is doubtful if a pure fibroma ever occurs in the mammary gland. A fibro-adenoma consists of acini surrounded by fibrous tissue. Each of these structures proliferates, but the fibrous tissue does so much more rapidly than the glandular. Bloodgood ("Amer. Jour. Med. Sci.," Feb., 1908) says, "the fibro-adenoma microscopically is nothing more than an encapsulated area of normal breast tissue, in which the parenchyma, in the early stage of the tumor, is greater in amount than the normal breast. Later the parenchyma undergoes pressure atrophy and the tumor may become calcified." A growth of this character is surrounded by a capsule and is movable. It is firm, elastic, lobulated, superficially situated, and of slow growth. It is unassociated with retracted nipple, glandular enlargement, adhesion to the skin, dimpling of the skin, or cachexia, and may occur at any age up to fifty, but is most common between twenty and thirty (Sir. J. Eland-Sutton). Such a tumor is rarely very painful, but it may be tender on rough handling and may be painful at the menstrual period. As a rule, there is but one of these tumors in the mammary gland, but the tumors may be multiple in one gland, or one or more may exist in each gland. It is not very common for sarcoma or carcinoma to arise.

Periductal Fibromyxoma.—It is most common in young women. It may be multiple in one breast or both. It is an encapsulated, lobulated, and elastic growth, which is seldom painful, is usually small, and often remains quiescent indefinitely and may even disappear. (Bloodgood discusses "disappearing tumors" in "Jour. Amer. Med. Assoc.," March, 1922, vol. lxxviii.) It may enlarge and even attain a great size. When it enlarges it is apt to become cystic and may even become sarcomatous.

Treatment of Periductal Fibroma and Fibromyxoma.—Take every care to rule out malignant disease. This is difficult in a fatty breast or if a tumor is deeply buried. The tumor should be extirpated if it is painful or enlarging. If a supposedly innocent growth, removed by a limited operation, has been really the seat of beginning malignancy, and if the wound were not cauterized, the wound will soon thicken after healing and recurrence will be rapid. Halsted has shown that in such a case reoperation, however extensive, will not obtain a cure. Hence, it behooves us in doubtful cases, if we err at all, to err on the side of radicalism. In a case recognized as doubtful, after the growth has been removed the wound should be painted with a 50 per cent. solution of chlorid of zinc, and the surgeon should wait for the laboratory report. If the report shows that the growth is malignant, at once remove the breast radically and clean out the axilla. A tumor known to be innocent may be removed through an incision made along the junction of the mammary gland and chest, at the lower margin

of the gland, as Thomas proposed, or, better, at the edge of the outer hemisphere, as advocated by Warren ("Annals of Surgery," June, 1907). The incision exposes the fibers of the great pectoral muscle, the gland is raised from the muscle, and its posterior surface laid bare. Any growth is exposed by an incision from center to periphery, and this incision is exploratory. Warren removes an innocent tumor, a cyst, or cysts by a V-shaped incision, the apex of the V being at the center of the gland, and he wisely insists that the tumor is not to be dissected out. Several radiating incisions may be necessary to explore a cystic breast. The V-shaped space from which the tumor or cyst has been removed is closed by a double row of catgut sutures. Incisions for exploration seldom need to be closed by suture. The gland is sutured to the outer edge of the pectoral fascia, and a row of sutures is inserted through the deep layer of the superficial fascia. Warren calls this operation *plastic resection of the breast*. It leaves the patient free from deformity.

Fibrocystadenoma or **cystic adenoma** (**adenocele**) is a rare form of slowly growing tumor, which is apt to attain a large size, which is nodular in outline, hard to the touch, and firmly attached to the mammary gland, but mobile upon the chest. A cystic adenoma has a distinct capsule. This form of tumor is painless, and is most apt to occur in women between thirty and forty who have born children. The growth is adherent to the skin, but the cutaneous surface is not discolored, the cutanous veins are not distended, the axillary glands are not enlarged, and the nipple is not retracted. From the walls of the dilated acini papillomatous growths are apt to arise (intracystic vegetations). The growth may be a precursor of cancer.

Treatment.—Radical removal of breast and clearing of axilla.

Papillary Cystadenoma.—This condition is often called villous papilloma or duct papilloma. There is much more epithelial proliferation than in the fibrocystadenoma, and the warty masses project into the cyst cavities. These growths are firm, grow slowly and painlessly, and seldom fluctuate. They do not adhere to the skin, attain a large size, or cause glandular enlargement. They are situated near or under the nipple, and occur particularly in middle life. Discharge of serous fluid from the nipple is a common symptom. In many cases there is a bloody discharge. The condition tends to become cancerous.

Treatment.—The danger that duct cancer will arise is so great that the old operation of excision of the tumor should give way to radical removal of the breast. In any duct growth with a serous discharge from the nipple it is wise to remove the breast and to clear the axilla. If the discharge be bloody that radical procedure is imperative.

Simple Adenoma.—This is a very rare tumor. It occurs in young and middle-aged women. It is soft, nodular, and freely movable. It does not adhere to the skin and does not cause lymphatic involvement. It consists of glandular acini and a very delicate stroma of connective tissue. It tends to become cancerous.

Treatment.—Extirpation of the tumor. Touch the wound with chlorid of zinc solution in order to destroy cells which might lodge and grow.

Myxoma is a rare tumor, and only occurs in a person of middle age or beyond. The growth is solitary, is soft, may be round or lobulated, and occasionally fungates. The nipple is not retracted, the superficial veins are not distended, and the axillary glands are not enlarged.

Treatment.—Removal of the mammary gland.

Angioma.—This form of tumor is very rare. It may arise secondarily to a nevus of the skin (Sir. J. Bland-Sutton). The diagnosis of angioma of the skin is readily made. In a cavernous angioma of the breast it will be found that the tumor can be lessened in size by pressure, and will be increased in size by coughing, laughing, and holding the breath. Pulsation may be detected and a bruit may be audible. I operated on a child eight weeks of age for a rapidly growing cavernous angioma.

Treatment.—For treatment of nevus see page 310. If a cavernous angioma exists in the mammary gland, it will be necessary to extirpate the gland.

Lipoma and *enchondroma* occasionally occur in the breast.

Cysts of the Mammary Gland.—Involution cysts (*cystic degeneration of the mamma*) occur in women who are approaching the menopause. Such cysts occur earlier in those who are sterile than in those who have born children, and may arise after chronic mastitis. The parenchyma of the gland undergoes atrophic change, but the ducts remain, become blocked and dilated. Numerous small cysts form, and both glands, as a rule, suffer. Villous growths may arise in the walls of the ducts. In some cases there is much white fibrous tissue between the cysts (*cystic fibroma*).

The subjects of this disease are often nervous, hysteric, and despondent. One or more ill-defined indurations are detected. Frequently there is a history of discharge from the nipple and of attacks of lancinating pain in the breast. Cystic breasts are dangerous because the intracystic vegetations are liable to eventuate in duct cancer. One-fourth of these cases are cancerous when first seen (Speese, quoted by Primrose in "Amer. Jour. Med. Sci.," Jan., 1913).

Treatment.—In such cases, after confirming the diagnosis by an exploratory incision, remove the entire breast.

Lacteal cyst (**galactocele**) is an accumulation of milk brought about by blocking of some of the milk-ducts. It usually arises soon after the delivery of the child, but may not be noted for months or even several years after childbed. It grows rapidly from the time it is first detected. A large quantity of milk may collect, and rupture of the cyst walls may occur, the fluid passing into the glandular connective tissue.

A galactocele is rounded, fluctuates distinctly, and increases in size during nursing. There is little or no pain. In some cases the contents of the cyst coagulate and a solid mass is formed.

Treatment.—Incision and drainage.

Hydatid cysts are rare, but do occasionally occur. There were 33 positive cases on record twenty-four years ago (Le Conte in "Amer. Jour. Med. Sci.," Sept., 1901). A small, hard, movable, and painless mass appears in the mammary gland. Usually it gradually increases in size, but it may grow rapidly for a time and then remain apparently almost stationary for a period. If rapid growth takes place there is always pain, and pain is usual in any case when the cyst attains considerable size. Fluctuation is often absent and crepitation is never obtained (Le Conte). Suppuration is apt to occur and sinuses may form.

Treatment.—A small and recent cyst may be extirpated. If the cyst is not recent, but is fairly large and adherent, incise, evacuate, and pack with gauze. If the cyst is large and adherent, but is surrounded by considerable breast tissue, partially amputate the breast. If the cyst is large and the breast practically destroyed, or if the nipple adheres to the cyst, remove the mammary gland (Le Conte, Ibid.).

Malignant tumors of the mammary gland are ten times more common than innocent tumors. We should regard every palpable tumor in the gland as malignant until it is proved to be innocent. In other words, we reverse the rule of jurisprudence. We regard every tumor as guilty of malignancy until its innocence is proved. If the mistake is made of regarding an innocent tumor as malignant, the woman loses her breast needlessly. If a malignant tumor is regarded as innocent the woman loses her life needlessly. "The fact that malignant degeneration of benign growths in the breast is of frequent occurrence is obviously another convincing argument for the removal of all breast tumors. A careful study by Speese showed that no less than 26 per cent. of the cases of chronic cystic mastitis (that is, that form of 'abnormal involution' occurring at the menopause) examined by him showed malignancy. So, too, cyst adenomata are found associated with carcinoma, the frequency of such association being placed by some authors as high as 15 per cent. Inflammatory conditions of the breast resulting in mastitis are often found in the early history of cancer cases. All these facts point conclusively to the frequent occurrence of malignant degeneration in benign growths of the breast" (A. Primrose, Loc. cit.).

Sarcoma of the mammary gland is a very rare growth (not over 3 per cent. of malignant breast tumors). It may occur at any period from puberty to old age. It was long thought to be most common from twenty to thirty-five years of age, but Rodman's investigations show that one-half the cases occur in the fifth decade of life (Rodman on "Diseases of the Breast"). The growth may be composed of round-cells or spindle-cells. The spindle-cell growth is the most common. Both round and spindle cells may be present, and myeloid cells may be found. Myxomatous change may occur. Circumscribed sarcoma arises usually between the ages of twenty and thirty; it is firm to the touch, as it contains much fibrous tissue, is painless, does not grow very rapidly, glands are seldom involved, and there is no cachexia. The nipple is not retracted. The growth may adhere to the skin. If it be composed of giant-cells or spindle-cells it will rarely return after extirpation of the breast.

Diffused sarcoma is composed of small round cells, arises in the center of the breast, and grows with great rapidity. It is most commonly met with beyond the age of thirty-five, and a history of injury can often be elicited. The tumor is soft, some parts being softer than others because of cyst formation. It is usually mobile upon the thorax, though it soon becomes adherent to the skin. The tumor reaches a very great size,

and soon fungates through the skin. There is little or no pain. The cutaneous veins over the tumor are distended, the nipple is not retracted, and the axillary glands are not often enlarged. Diffuse sarcoma is apt to recur after removal.

Treatment.—Remove the breast, and if the muscles of the chest wall are infiltrated, remove them. The axillary glands should be removed whether they are enlarged or not. Operation will not cure when metastases exist. If the case be inoperable, we can try the use of Coley's fluid, radium, and *x*-rays. If such methods fail to arrest the progress of the disease, keep the patient as comfortable as possible by the administration of cocain and morphin.

Endothelioma.—This is a very rare tumor. I have had 1 case which Dr. Coplin regarded as endothelioma. The diagnosis cannot be made from carcinoma.

Treatment.—As for cancer.

Carcinoma or Cancer of the Mammary Gland of the Female (Fig. 1164).—The majority of mammary tumors are cancerous (nearly or quite 60 per cent.). Cancer

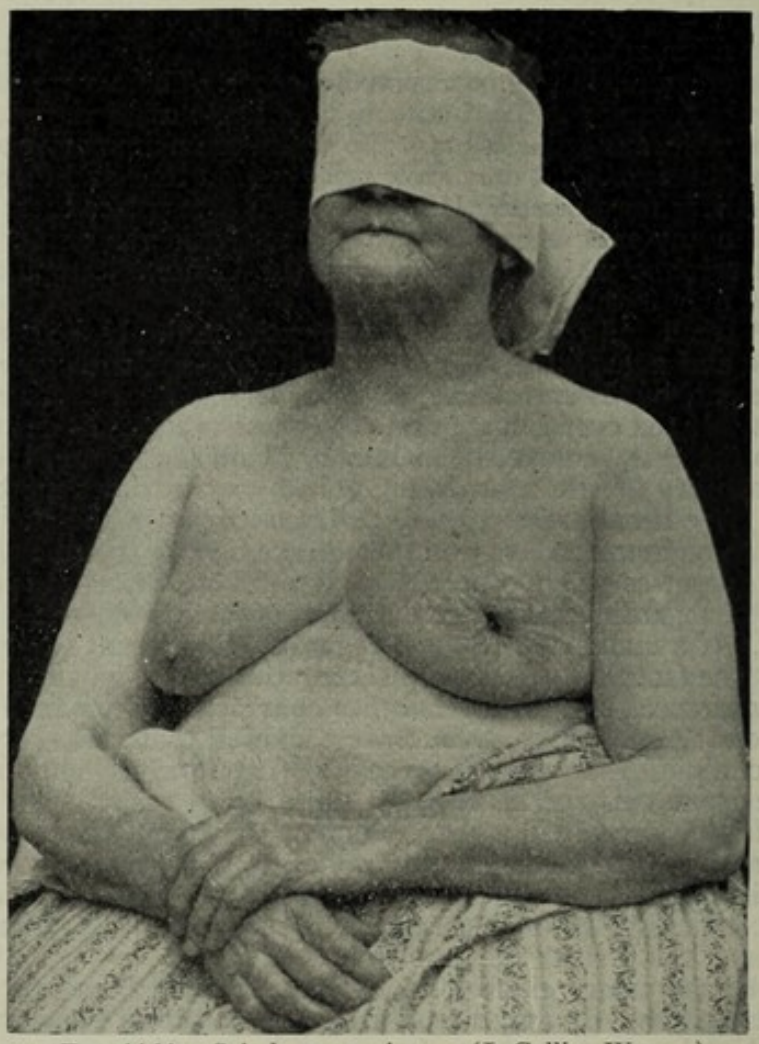


Fig. 1164.—Scirrhous carcinoma (J. Collins Warren).

is due to proliferation of the epithelium of the acini (acinous cancer) or of the ducts (duct cancer).

Acinous cancer is vastly more common than duct cancer. Usually there is much connective tissue and but little parenchyma in the growth (scirrhous cancer). In some cases there is little connective tissue and much parenchyma (encephaloid or medullary cancer). If colloid degeneration of the parenchyma or stroma occurs, the growth is spoken of as colloid cancer.

Scirrhus (Figs. 1164, 1165), the common form of acinous cancer, is almost as hard as stone. On section it is concave, and Sutton says "resembles an unripe pear." The tumor is without a capsule, and nests of epithelial cells are surrounded by masses of fibrous tissue. Portions of tissue, even some distance away from the tumor proper, contain foci of proliferating embryonic epithelial cells. In atrophic or withering scirrhus the fibrous stroma contracts strongly and epithelial cells undergo fatty degeneration.

Halsted in 1898 described *adenocarcinoma*. It is the initial movement in the direction of unrestrained epithelial proliferation, and sections of the tumor show the formation of tubular acini. The most characteristic sections resemble adenoma. Adenocarcinoma is not the common form of breast cancer removed surgically. In the common form the proliferating epithelium attains no resemblance to glandular structure, but multiplies irregularly in connective-tissue spaces or lymph-spaces.



FIG. 1165.—Scirrhous carcinoma of right breast showing retraction of nipple (Dr. Blanck's patient).

Causes and Symptoms.—Scirrhus is more common among women who have born children than among those who have not. Heredity is manifest in only about 10 per cent. of cancer cases. The younger Gross found it in 1 case out of 9. Trauma has been a possible influence in producing cancer in some cases. The disease is rare before the age of thirty-five, and is most common between forty-five and fifty. The author operated for scirrhus of the breast on a woman only twenty-seven years of age. Bloodgood says he has failed to find an authentic case of cancer in a woman under twenty-five years of age, but Henry saw a woman of twenty-one with cancer. It is frequently met with in the aged. These tumors are rare in the negro race. A hard nodule is found in the breast, frequently under the nipple, but possibly far away from it. The growth is nodular, and is immobile from the beginning. In a large, fat breast there is often a deceptive sense of mobility, because some of the breast tissue moves with the tumor. The cancer may have been present for a considerable time before being discovered. Sometimes

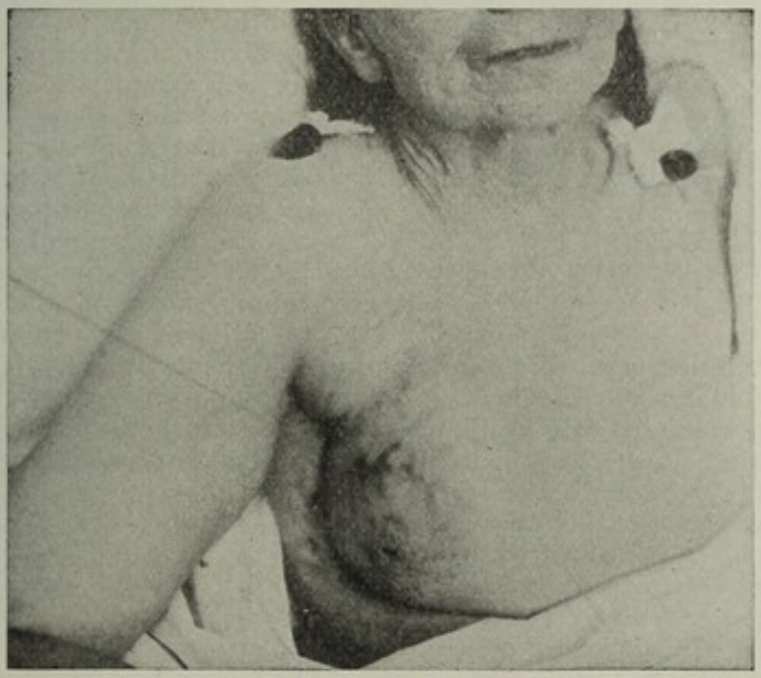


FIG. 1166.—Carcinoma of right breast. Lesion first noticed six months before photograph was made.

wide-spread lesions develop from a small or an undiscovered breast cancer (pleural effusion, enlarged glands of the neck, disease of the spinal cord, of bones of the skull or brain). In obscure lesions of bones and viscera examine the mammary glands, because the trouble may be due to metastasis from an undiscovered carcinoma of

the breast. The glands of the armpit always and soon become diseased, the glands above the clavicle often enlarge, and the arm may swell. Growth may arise within the chest either by lymph regurgitation from the axillary and subclavian glands, or directly through the chest walls to pleura and lung or to mediastinal glands. Oelsner and Poirier show that there is a lymph tract running from the breast to glands within the thorax, passing through the great pectoral muscle and "the fourth interspace at the level of the costochondral articulation" (Primrose in "Amer. Jour. Med. Sci.," Jan., 1913). "Fortunately, these glands are not frequently involved, a circumstance which may be accounted for by the atrophy of this channel in senile mammæ, in which cancer usually develops (Poirier)" (Primrose, Ibid.). Retraction of the nipple is present in over one-half of the cases. It occurs when the growth is near the nipple, and is due to the contracting fibrous tissues of the tumor pulling in the milk-ducts. If the growth be far away from the nipple, a dimple is apt to form in the skin of the breast because of the pulling upon the suspensory fibers which pass to the skin. Neither retraction of the nipple nor a cutaneous dimple proves the existence of cancer. One or both may be noted in a breast containing a scar (from a wound or a healed abscess), in tuberculosis of the breast, and in mammary syphilis. The dimple is not due to adhesion between the tumor and the skin. It is noted even when the tumor is far away from the skin. It may not be obvious unless the gland be moved to and fro or unless the skin over the breast be pushed in various directions. When this is done it becomes evident that the skin, at a certain point, is held inward. The dimple is a very valuable early symptom.



FIG. 1167.—Recurrent carcinoma after excision of right breast (Dr. W. L. Clark).

Glandular carcinoma in the axilla soon follows the appearance of a cancer, although there may be no palpable enlargement for a considerable time. The glands become very hard and adherent. In over 60 per cent. of cases the glands of the axilla are felt to be enlarged when the patient first comes for treatment. Because the surgeon cannot feel enlarged glands is no proof that glands are not diseased. As a matter of fact, the glands are usually involved within two or three months of the beginning of the disease, but the involvement can rarely be detected externally until months later. Enlargement of the axillary glands is followed by enlargement of the glands in the posterior cervical triangle and in the mediastinum. Herbert Snow has shown that the blocking of the axillary glands often leads to regurgitation of lymph containing cancer-cells, the cells being thus deposited in the head of the humerus and in the thymus gland. Cancer in the thymus and in the mediastinal lymph-glands, after a time, causes a projection of the sternum (the *sternal symptom*). When the axillary lymphatics are extensively involved the arm swells from obstruction to the lymph-flow (lymphedema) or pressure upon the vein. If there be lymphatic obstruction the skin of the breast becomes pitted and resembles *pig skin*. The skin is actually cancerous or soon becomes so by infiltration. Each pit is the opening of a sweat-gland. The sweat-duct is held down by contracting fibrous tissue. This condition is termed *peau d'orange*, or pigskin saddle appearance. The tumor usually grows rather slowly unless lactation is established, when it grows with frightful rapidity. As it grows it infiltrates adjacent structures (the pectoral fascia, pectoral muscles, subcutaneous cellular tissue, and skin). When a tumor becomes adherent to the skin the skin becomes congested and of a dark purple hue. When the skin is destroyed, an ulcer forms, and around this ulcer the skin becomes red and filled with cancerous nodules, which feel like shot in the skin. Metastases are apt to occur in the bones, liver, brain, pleura, lung, spine, thymus gland, and rarely the eye. The pleura and lung may be attacked

by direct spread of the growth through the chest wall, from infected mediastinal glands, or by lymph regurgitation from the axillary and subclavian glands.

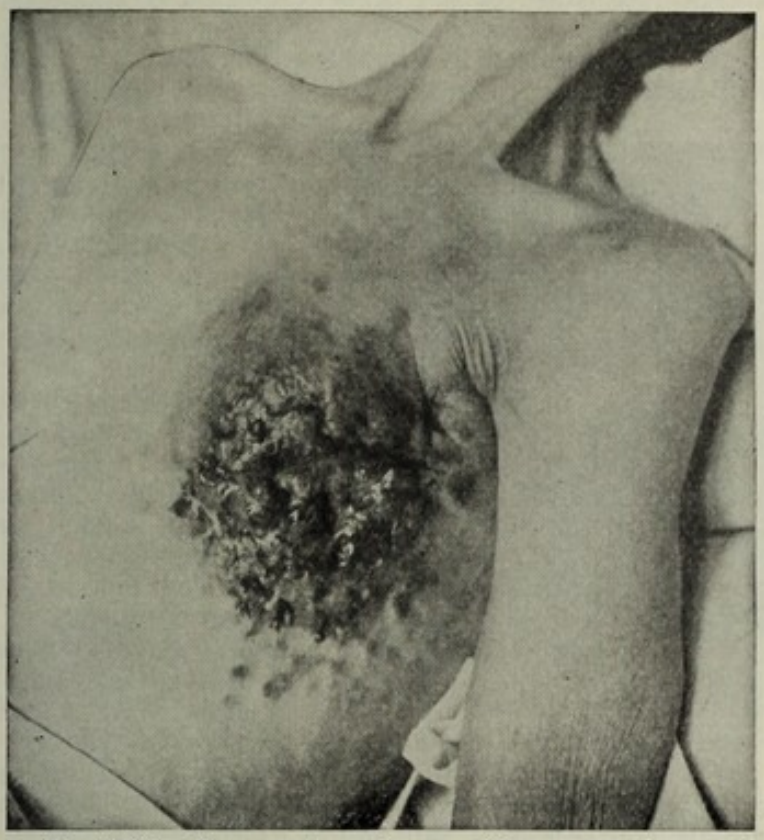


FIG. 1168.—Recurrent carcinoma. Cancer en cuirasse.

Pain, absent at the start, is usually present later in scirrhous carcinoma. It is lancinating, like needle pricks rather than stabs, and neuralgic in character, and not

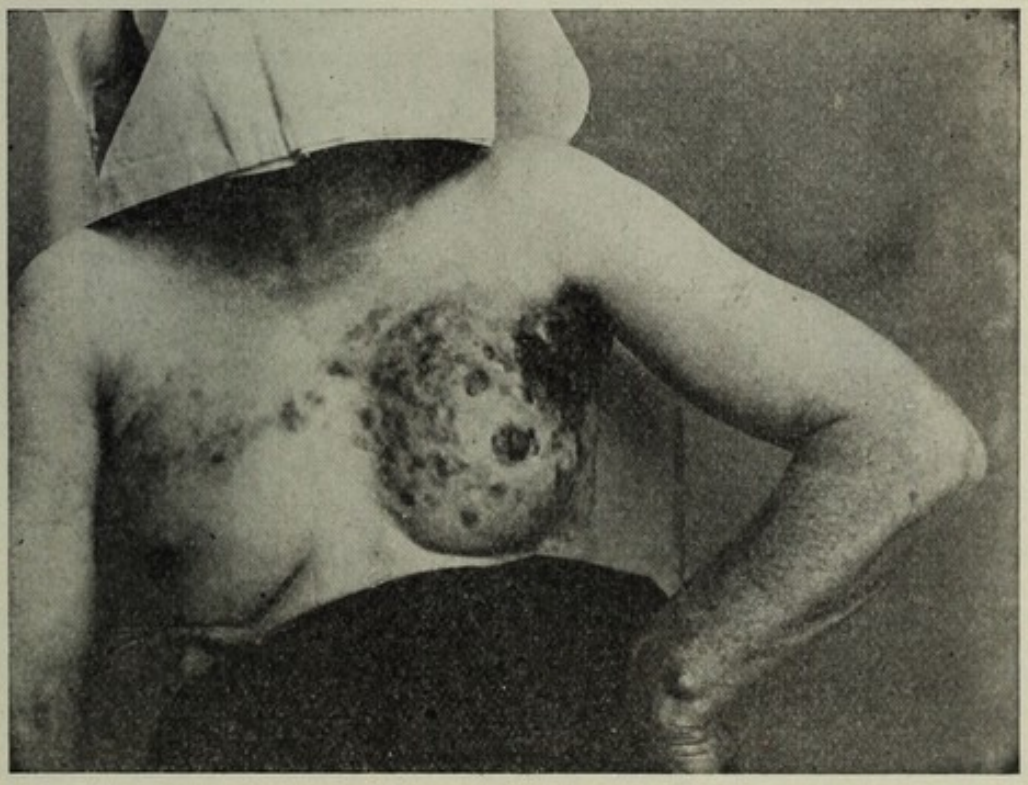


FIG. 1169.—Cancer en cuirasse.

brought on or increased by handling. It ceases if colloid degeneration begins. The general health is usually unimpaired until very late in the case or until ulceration

takes place, when cachexia arises. In 1792 Howard described the condition to which Velpeau called particular attention in 1838, that is, a deep cancer of the integument due to a cancerous state of the deep cutaneous lymphatics. Velpeau named it *ligneous cancer* and also *cancer en cuirasse* (Figs. 1168, 1169). The cancer en cuirasse of Velpeau is a condition in which the lymphatic vessels of the skin are distended because of obstruction. The skin thickens as in elephantiasis. The blocked-up lymph contains cancer cells and the skin early becomes nodular and cancerous. In most cases the condition is secondary, but primary cases have been reported. The condition may arise from cancer in the breast or may follow an operation for cancer of the breast. The skin of the chest becomes thick and rigid like a leather cuirass. The growth adheres and the soft parts, after a while, adhere to the chest wall. The skin is very extensively invaded. In this condition the chest wall is fixed, respiration is difficult, temperature is commonly somewhat elevated, and there is probably a pleural effusion. The corresponding upper extremity is usually the seat of great swelling from hard edema.

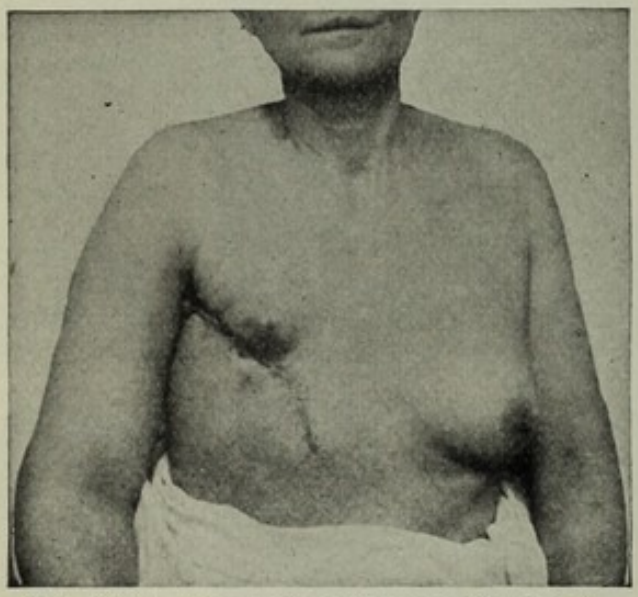


FIG. 1170.—Recurrent carcinoma of the breast.

In *atrophic* or *withering scirrhus* the breast becomes very small. In some cases the contraction is so great that it seems as though the mammary gland had been removed. The duration of scirrhus when left to run its course varies, but the disease generally produces death within two and a half years. Occasionally it causes death within a year. In atrophic scirrhus the patient may live for many years.

Duct cancer is not a common growth. It arises from the duct walls in conditions of cystic degeneration of the mammary gland. The tumor is softer than the acinous



FIG. 1171.—Woman aged thirty-nine. Tumor appeared during the eleventh month of lactation. Growth is now about three months old. Diagnosis: carcinoma mastitoides.

growth and is not nodular. There is no pain, no retraction of the nipple, no skin dimple. Serous or bloody fluid may often be squeezed from the nipple. A duct cancer grows and infiltrates less rapidly, and involves adjacent glands later than does an acinous growth.

Cancer beginning in an *outlying lobule* of the breast may be very deceptive. Such

a lobule may be on the side of the chest in the axillary line, in the axilla, just below the clavicle, over the front of the sternum, or over the lower ribs.

Carcinoma mastitoides, *acute cancer*, *brawny cancer*, or *inflamed cancer* is a condition originally described by Volkmann in 1875 under the name of *mastitis carcinoma*. It comes on almost suddenly, grows very rapidly, causes violent irritation, and hence wide-spread infiltration by small cells. The condition resembles inflammation (Edward A. Schumann in "Annals of Surgery," July, 1911). In this condition the surgeon cannot make out the outlines of a distinct tumor, but the entire breast is hardened and enlarged, and the skin of the breast is reddened, infiltrated and edematous, and adheres to the gland. There is often pain and heat.

Anatomically related glands enlarge. The disease is most apt to arise late in pregnancy or during lactation and is most common in rather young women. It may be limited to one breast, but both breasts may be involved, successively or simultaneously. The nipple may or may not be retracted. Slight elevation of temperature is usual.

There is rapid metastasis, profound toxemia, and early death. Death occurs in less than a year, perhaps in a few weeks. Billroth's case died in six weeks after the discovery of the cancer.

Any persisting case of supposed acute mastitis should make us suspicious. In such a case excise a piece of tissue for examination. In cutting out the piece small abscess cavities may be discovered even when the condition is cancerous. Schumann



FIG. 1172.—Ulcerating scirrhous carcinoma.

(Ibid.) says there are only 13 reported cases of carcinoma mastitoides. Since Schumann's paper Morris Booth Miller reported a case ("Annals of Surgery," May, 1913). I showed a case to the class at Jefferson Hospital in the winter of 1912–13. The woman was pregnant and both breasts were involved. She perished miserably a few months after the onset of the disease and a few weeks after her confinement.

Cancer of the Male Breast.—This condition is seldom met with, though I believe it to be more common than is generally supposed. I have seen 6 cases within the last twenty years. Four patients were in the early forties; one was sixty and one was sixty-two; none complained of pain. In one the breast had been extremely large from early years. In one there was double gynecomastia. In each case the growth was indurated, but in only one was there any retraction of the nipple. The condition in each patient was scirrhous carcinoma. Warfield collected 32 cases from literature and added 5 others ("Bull. of Johns Hopkins Hosp.," Oct., 1901). The patients were between forty and seventy years of age; 8 gave a history of injury; in 9 cases there was pain, and in 12 the nipple was retracted. Palermo has collected 750 cases of tumor of the male breast ("Semaine Médicale," May 20, 1908) and 649 of them were cancerous.

Treatment of Carcinoma of the Mammary Gland.—The treatment is early and thorough operation; the earlier and the more thorough, the better. It is always uncertain as to how long the cancer has existed. A slowly growing cancer begins a considerable time before it is discovered by the patient. It may be discovered early, it may not be found until relatively late. Rapidly growing cases are discovered early

because they soon cause pain and attain palpable size. The older surgeons operated simply to prolong life a few months; the modern surgeon operates with the hope of curing the patient. The mortality of the operation is surprisingly small. It is certainly under 2 per cent. Rodman's statistics (2133 operations performed since 1893 by 21 American surgeons) show a mortality of less than 1 per cent. I have personally lost 5 patients in over 250 operations. In 1878 Billroth's statistics showed only 8 cures in 143 cases. In 1896 W. Watson Cheyne reported 12 cures out of 21 cases (57 per cent.). His enlarged statistics showed 54.8 per cent. alive and well from six to thirteen years after operation. Depage's statistics show that 48 per cent. of cases

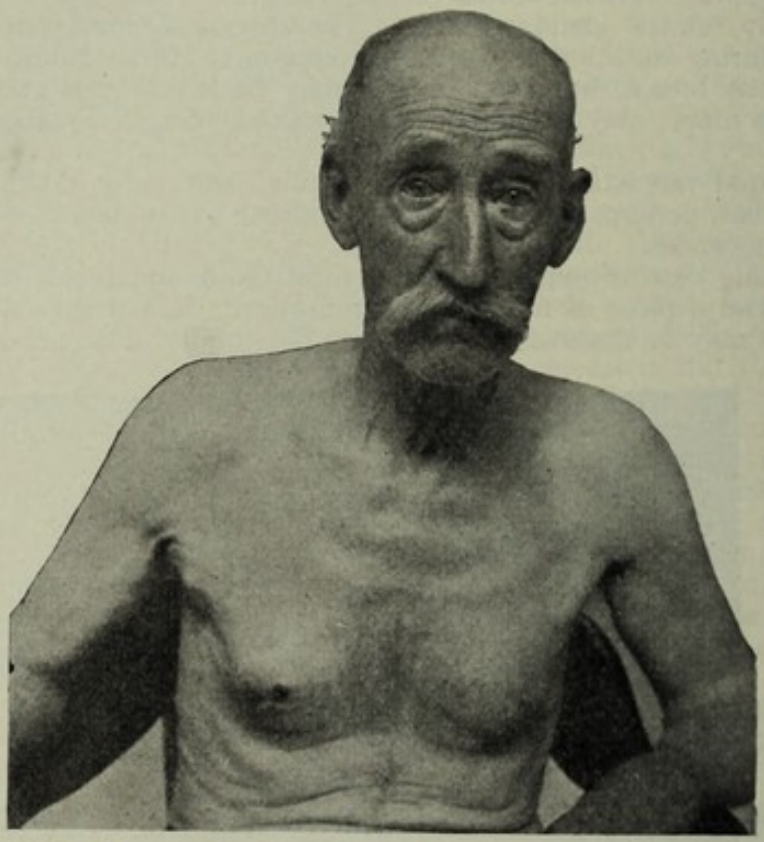


FIG. 1173.—Cancer of male breast with obvious axillary involvement.

passed the three-year limit ("Presse Médicale," Oct. 21, 1908). Greenough, Simmons, and Burney consider 320 cases operated upon radically ("Annals of Surgery," July, 1907); 88 cases passed the three-year limit.

"DATA COLLECTED FROM THE MAYO CLINIC ON 518 CASES OF CARCINOMA OF THE BREAST, From January 1, 1890, to January 1, 1900:

Average age	55 years, 6 months.
Oldest	75 years.
Youngest	21 years.
Number of cases operated on over ten years before:	
Alive and well	21 (23.5 per cent.).
Dead	23
Not heard from	45
Total	89
Number of cases operated on over five years before:	
Alive and well	74 (30 per cent.).
Dead	76
Not heard from	89
Total	239
Number of cases operated on over two years before:	
Alive and well	233 (44 per cent.).
Dead	134
Not heard from	151
Total	518"

E. S. Judd ("Jour. Amer. Med. Assoc.," April 27, 1912) publishes the preceding statistics from the Mayo Clinic. He says: "The prognosis as to the probability of a cure in a case of carcinoma of the breast will depend—1, on the length of time the neoplasm has been developing; 2, on the degree of outlying involvement; 3, on the activity of the gland, which will be determined by the age of the patient and the relation to a period of lactation; and, 4, on the thoroughness of the removal of the gland-bearing fascia.

Bloodgood ("Amer. Jour. Med. Sci.," Feb., 1908) sets forth Halsted's statistics: "The statistics in Halsted's Clinic up to the present time show that among 210 cases, in which three years or more have passed since the operation, 42 per cent. are apparently well. If we consider the cases in which the axillary glands, studied microscopically, showed no evidence of metastasis, 61 cases, or 85 per cent., are well. In cases in which the axillary glands showed metastasis (110), 30 per cent. remained free from recurrence for three years. When the glands in the neck showed metastasis (40 cases), only 10 per cent. remained well for three years. In all of these groups metastasis has been observed after an interval of three years of apparent cure. Such late metastasis may take place up to eight years after operation. Excluding these cases of late recurrence, the number of definitely cured in these three groups is reduced to 75, 24, and 7 per cent. respectively, or, for all cases together, 35 per cent. I have not time to tell the facts, but there is evidence to indicate that when the microscope fails to demonstrate metastatic cancer cells in the lymphatic glands in the axilla, this is not a positive proof that metastasis has not taken place, and for this reason and others, which space prevents me from stating, there should be no restriction in the complete operation for carcinoma of the breast." It will be observed that of these 40 cases, with involvement of neck and axilla, only 4 passed the three-year limit. If they had not been operated upon, statistics would have been bettered. The surgeon who would not operate on such cases would have a higher percentage of cures for his statistics, but he would have sacrificed to statistical glory those 4 cases. L. Tixier ("Lyon. Chirurgical," Nov.–Dec., 1922; Abstract in "Brit. Med. Jour.," June 2, 1923) reports on 211 cases operated upon, 68 died within two years. Fifty-seven were alive six years after operation. Of patients under fifty years of age, only 30 per cent. lived more than six years, of those between fifty and fifth-five years, 43 per cent. lived beyond six years. Ulceration adds much to the gravity of the case. Out of 14 patients with ulceration only 3 lived more than two years. Cases may be discovered early because of pain and rapid growth due to great malignancy. In such cases even early operation gives a bad prognosis. If there be the *slightest* doubt of the diagnosis, make an exploratory incision before making the incisions for the removal of the breast (see Dawbarn's remarks on the deceptive signs given by thick-walled abscesses in the "Annals of Surgery," March, 1908). A frozen section can be made and examined in a few minutes, and this procedure is demanded in a doubtful case. If the mass proves to be cancer, I always pack in a piece of gauze from which boiling water has just been squeezed and go on at once with the removal of the breast. As Dawbarn shows, this method seals up the open mouths of lymphatics. A radical operation should remove the breast and much of the skin above it, the pectoral fascia, the pectoral muscles, the fat and glands of the axilla, and the fascia over the serratus magnus. As Cheyne says, remove all the glands along the axillary vein and lift up the vein at the apex of the axilla and remove the glands and fat behind it. The sheath of the vein should always be removed. Cheyne points out that the line of spread must be traced upward along the vessels and nerves and downward along the external respiratory nerve of Bell ("Lancet," March 12, 1904). Cancer of the male breast is to be treated exactly as is cancer of the female breast. If three years after an operation there has been no return, we regard the case as cured (Volkmann's limit). As previously stated, recurrences are noted after five years, and this limit should be used instead of three years. It is true that 80 per cent. of those passing the three-year limit remain free from recurrence. Over 90 per cent. of those passing the five-year limit remain free. Coley reported 65 cases of recurrence—15 per cent. recurred after three years and 6 per cent. after fourteen years. Ransohoff collected 10 cases of recurrence during the seventh and eighth years, 2 each after the ninth, tenth, eleventh, twelfth, and fifteenth years, and 1 each after various intervals, from fifteen to twenty-five years. I have seen spinal metastasis nine years, regional recurrence fourteen years after operation, and Martin suggests that these later so-called regional recurrences are really new growths in persons predisposed to cancer ("Annals of Surgery," Oct., 1908). Certain cases are unsuitable for a radical operation: cases in which metastases exist;

cases of *cancer en cuirasse;* cases with mediastinal involvement, or pulmonary cases where axillary involvement is very great. Cheyne would also rule out cases in which large glands may be felt above the clavicle, believing that in such cases the mediastinal glands must be cancerous,[1] but in Halsted's clinic 10 per cent. of cases with supraclavicular involvement passed the three-year limit. Operation is well-nigh useless for carcinoma mastitoides. In every case of mammary cancer before operation is decided upon have an *x*-ray study of the chest to find out if the lungs or mediastinum are involved. Involvement of either forbids operation.

Halsted's Operation.—Halsted performed a very radical operation. He removed suspected tissue *in one piece*, and thus prevented carcinoma cells from falling into the wound, for it is well known that if such cells fall into the wound they may grow just as may a graft of healthy epithelium. The neck, shoulder, arm to the elbow, the entire surface of the chest down to the waist, both breasts, the axilla, the side and the back of the diseased side must be sterilized. It is necessary to have, besides scalpels and the ordinary instruments for an operation, a great number of hemostatic forceps (80 to 100). Place the patient recumbent, with a sand-pillow under the shoulder of the affected side. The shoulder is right at the edge of the table and a nurse holds the arm from the side, keeping it at a right angle with the body. Halsted's operation is performed as follows[2]: The skin incision is made as shown in Fig. 1174, and is carried at



FIG. 1174.—Halsted's operation for carcinoma of the breast: The first incision.

once through the fat. The triangular skin-flap (*a*, *b*, *c*) is turned down. The costal insertions of the great pectoral muscle and the muscle are split between the clavicle and costal portions and up to a point opposite to the scalene tubercle, and at this point the clavicular portion of the muscle and the tissue overlying it are cut through close to the clavicle, and the apex of the axilla is at once exposed. The cellular tissue under the clavicular portion of the muscle is dissected from the muscle, and the splitting of the muscle is continued on to the humerus. The part of the muscle to be removed is cut through close to its humeral insertion. The whole mass circumscribed by the first incision (skin, breast, areolar tissue, and fat) is raised with considerable force in order to put the submuscular fascia on the stretch as it is stripped from the thorax close to the ribs. It is well to include the delicate sheath of the pectoralis minor muscle. The lower and outer boundary of the lesser pectoral having been passed and exposed, the muscle is cut at a right angle to its fibers and a little below the middle. The tissue over the pectoralis minor muscle near its coracoid insertion is divided as far out as possible, and is then reflected inward to prepare for the reflection upward of this part of the minor muscle. The upper portion of the minor muscle is retracted upward. Some surgeons do not remove the lesser pectoral muscle. I believe it should be removed, because the axilla can then be more easily and rapidly cleared. The removal of the muscle does not impair arm movements, and its retention leads to the formation, when healing is complete, of a cord-like band in front of the axilla. (See Douglas Drew in "Brit. Med. Jour.," May 17, 1902.) The small blood-vessels under

[1] See "Objects and Limits of Operation for Cancer," by W. Watson Cheyne.

[2] "Johns Hopkins Hosp. Reports," vol. iv; "Annals of Surgery," Nov., 1894.

the minor muscle are carefully separated from it, are dissected out very clear, and are ligated close to the axillary vessels. Having exposed the subclavian vein at the highest possible point below the clavicle, the contents of the axilla are dissected away with a sharp knife, and the vein and its branches are stripped absolutely clean. The sheath of the vein should be removed. The loose tissue about the artery and the nerves should also be removed. When the vessels are cleared, the axillary contents are rapidly stripped from the inner walls of the axilla and the lateral wall of the thorax (Fig. 1175). The fascia which binds the mass to the chest is cut loose from the ribs and the serratus magnus muscle. Just before reaching the junction of the posterior and lateral walls an assistant draws the triangular flap of skin outward in order to spread out the tissue which lies upon the subscapularis, teres major, and latissimus dorsi muscles. The operator cleans the posterior wall of the axilla from within outward. The subscapular vessels are clearly exposed, and are caught before they are cut. In some cases the subscapular nerves are removed, in others they are permitted to remain. Having passed these nerves, the mass is turned back into its normal position and severed from the body of the patient by a stroke of the knife from *b* to *c*, repeating the first cut through the skin. Every bleeding point, however small, is tied with fine silk. From 60 to 100 ligatures or even more may be required.

After the completion of the operation the wound into the axilla is closed with a subcuticular stitch of silver wire; if a cut has been carried above the clavicle, it is

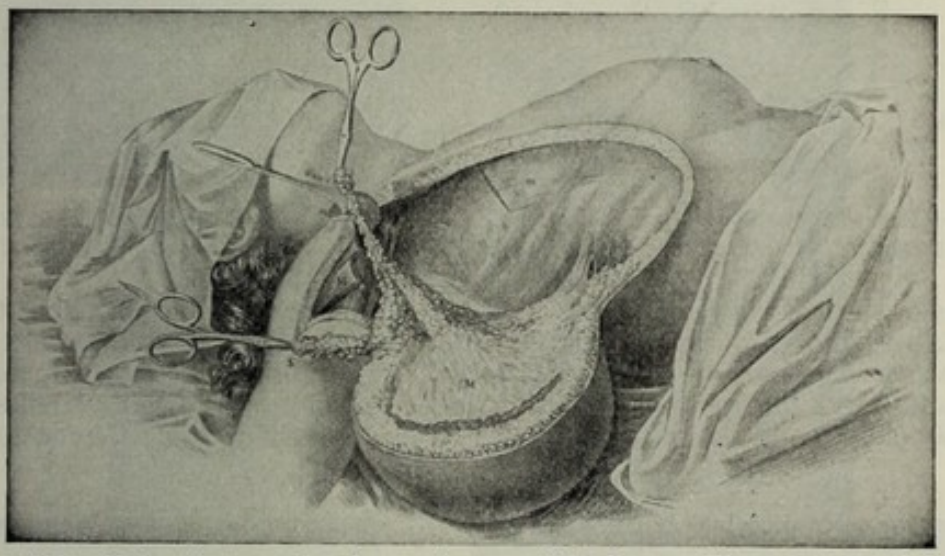


FIG. 1175.—Halsted's operation for carcinoma of the breast: The mass turned down.

closed in the same manner, and the edges of the elliptical opening are brought nearer together by a purse-string subcuticular stitch. Thiersch grafts cut from the patient's thigh are used to cover the gap. Silver-leaf is placed over the wound, this is covered with gauze, bandages are applied, and the dressing is overlaid by a plaster-of-Paris bandage, which includes the head, neck, chest, and arm. The area from which grafts have been taken is dressed with sterile gauze or an ointment containing boric acid. Of recent years most operators have come to use ordinary sutures of silkworm-gut rather than subcuticular stitches of silver wire. Bloodgood no longer cuts Thiersch grafts to cover the open part of the wound. If large grafts are cut the decided soreness of the thigh is added to the discomfort caused by the main operation. Again, even a little bleeding and flow of serum will loosen a part or parts of a graft or grafts. At the time the dressings are changed for the first time anesthetize the skin of a part of one thigh, cut a number of small grafts, and put them upon the wound.

Formerly I did not open the subclavian triangle. I believed that these glands were involved from the axillary lymphatics only, that when they were involved the mediastinal glands were sure to be affected (the route to them being more direct) and that operation was certain to be useless. When the subclavian glands are involved extensively from the axillary lymphatics this is true, but in some cases they are involved by way of the direct lymph paths from the mammary gland. In such a case the mediastinal glands may be free, and cleaning out the subclavian triangle may save the patient. I always open the subclavian triangle and clear out fat and glands if no glands or only a few small glands have been palpable before operation. If there be a large glandular

mass in the triangle, operation is useless. I always open the triangle if the tumor of the mammary gland is in the upper hemisphere, or if I discover enlarged glands at the apex of the axilla, whether there are or are not small palpable glands above the clavicle.

The Younger Senn's Incision.—A very useful incision is that described by the younger Senn, and shown in Fig. 1176. The breast is circumscribed by two curvilinear incisions which meet above, at the border of the great pectoral muscle. The incision is continued a little internal to the outer border of the muscle to about 1 inch above the apex of the axilla, when it is curved outward in the deltoid region, and terminates

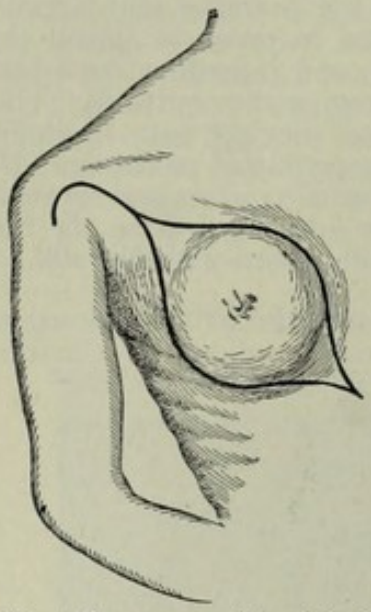


FIG. 1176.—The younger Senn's incision for amputation of the breast.

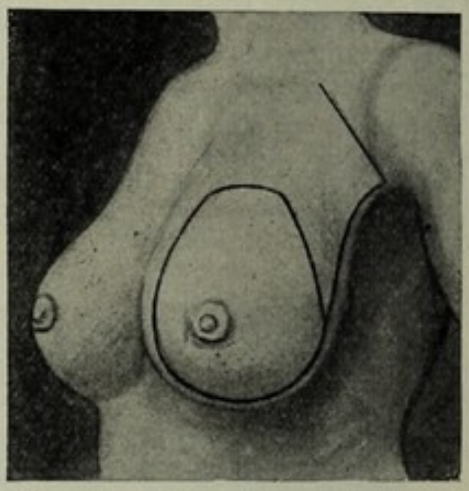


FIG. 1177.—Jabez N. Jackson's incision for removal of the mammary gland.

at the level of the apex of the axilla. The breast is removed from the wall of the chest, and is then suspended by axillary glands and fat, which are removed *en masse*.[1] This incision gives a free exposure, opens the axilla from in front, enables the surgeon quickly to locate and freely to expose the axillary vein, the wound can usually be closed, or at least, nearly closed, and the resulting scar does not materially limit the motions of the arm.

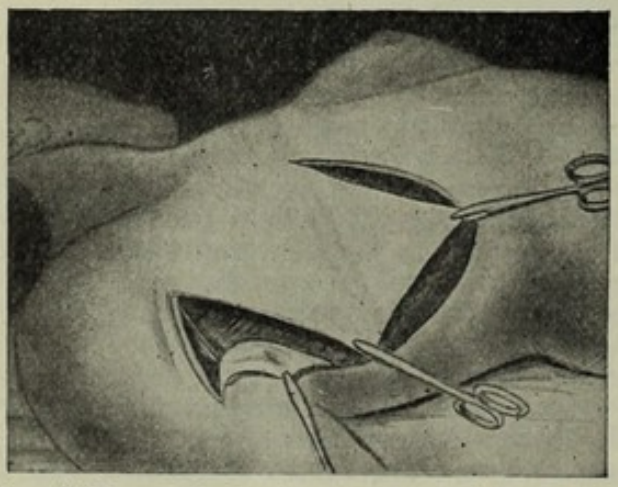


FIG. 1178.—Method of approximating flaps after Jackson's breast amputation.

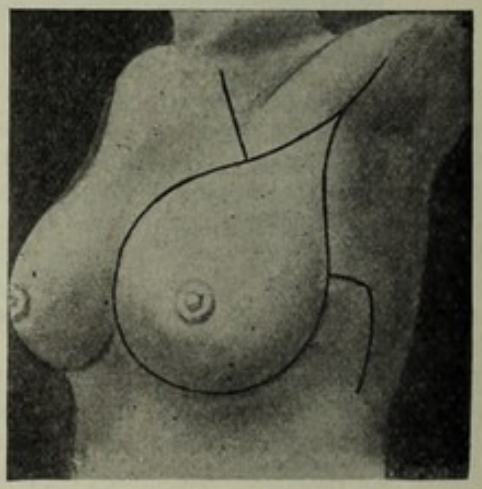


FIG. 1179.—Warren's incision for removal of the mammary gland.

Jackson's incision (Jabez N. Jackson, "Jour. Amer. Med. Assoc.," March 5, 1906) is shown in Fig. 1177. It is very satisfactory. The axilla is entered from above, a quadrilateral flap of skin is raised, and is subsequently pulled down to close the wound (Fig. 1178).

Warren's incision is shown in Fig. 1179. It enables the surgeon to close the wound.

Willy Meyer's Operation ("Jour. Amer. Med. Assoc.," July 29, 1905).—For the

[1] See the younger Senn in "Jour. Amer. Med. Assoc.," May 27, 1899.

last few years I have been performing the operation devised by Willy Meyer. I consider it a most excellent procedure, with distinct points of superiority over other plans. We owe to Gerster the principal of opening the axilla in the beginning of the operation in order to prevent the diffusion of cancer cells and thus diminish the chance of rapid recurrence. Gerster's paper was published in the "Amer. Jour. Med. Sci." in 1888. The younger Gross, in his later years, used to open the axilla first when there was an axillary mass, but he did it in order to determine in the beginning of the operation if the axillary mass was really removable. Willy Meyer emphasizes the value of his procedure in lessening hemorrhage. In Meyer's operation two flaps are formed by the skin incision (Fig. 1180)—a lower and an upper flap. The incision for the formation of the lower flap begins at the point of insertion of the great pectoral muscle on the humerus, and is carried downward and inward ½ inch above the border of the muscle and parallel to it. When the incision reaches the base of the mammary gland, it is carried along the lower margin of the gland, and it ends over the sternum, a little beyond the midline (Fig. 1180). The lower flap is separated and turned down, a quantity of subcutaneous fat being allowed to remain attached to the breast. This

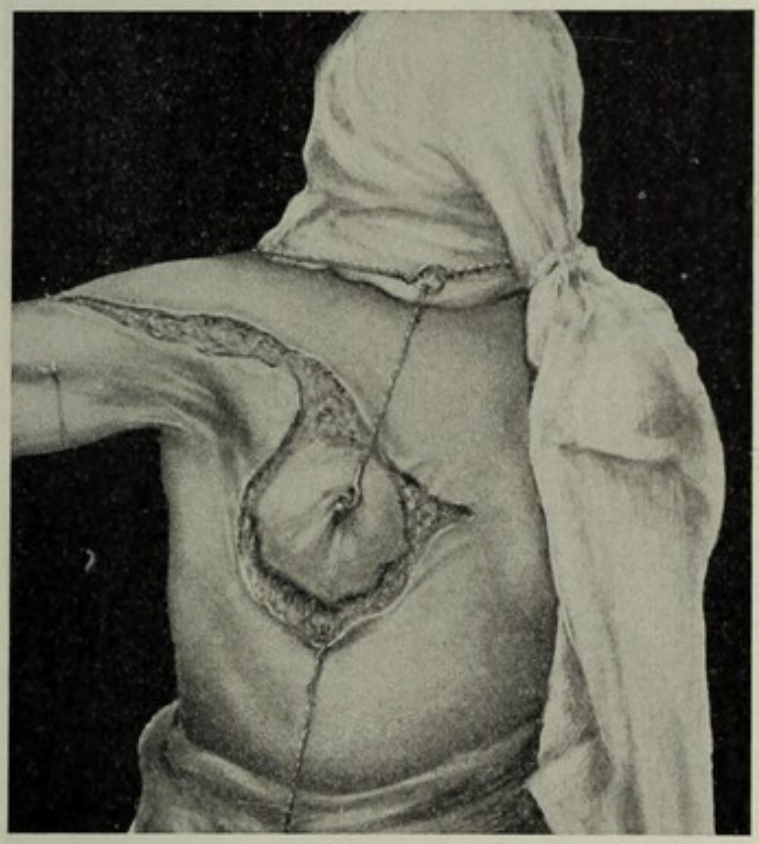


FIG. 1180.—Willy Meyer's operation for carcinoma of the breast. Skin incision as practised since 1898.

turning down is carried to the border of the latissimus dorsi muscle, to the axillary cavity, and to the chest wall. Meyer then directs that the border of the latissimus dorsi be followed down to the serratus anticus major, and upward to the mass of fat that enters the bicipital sulcus of the arm. The fat is removed from the anterior border of the muscle by blunt dissection. This anterior lower wound is then packed with gauze.

The surgeon next forms the upper flap by uniting the inner and outer ends of the first incision with another incision carried along the upper margin of the breast (Fig. 1180). In this flap, as in the other, the surgeon leaves as much subcutaneous fat adhering to the breast as he can spare without inducing the danger of skin necrosis. This upper flap is raised progressively until the cephalic vein is reached and there is exposure of the lower surface of the clavicle with the sternoclavicular articulation. Meyer directs that the tissues covering this articulation shall not be disturbed.

After the formation of these two flaps the next step in the operation is the division of the tendons of the two pectoral muscles and the exposure of the axillary and subclavian veins. Meyer advises that the cephalic vein be followed up until the insertion

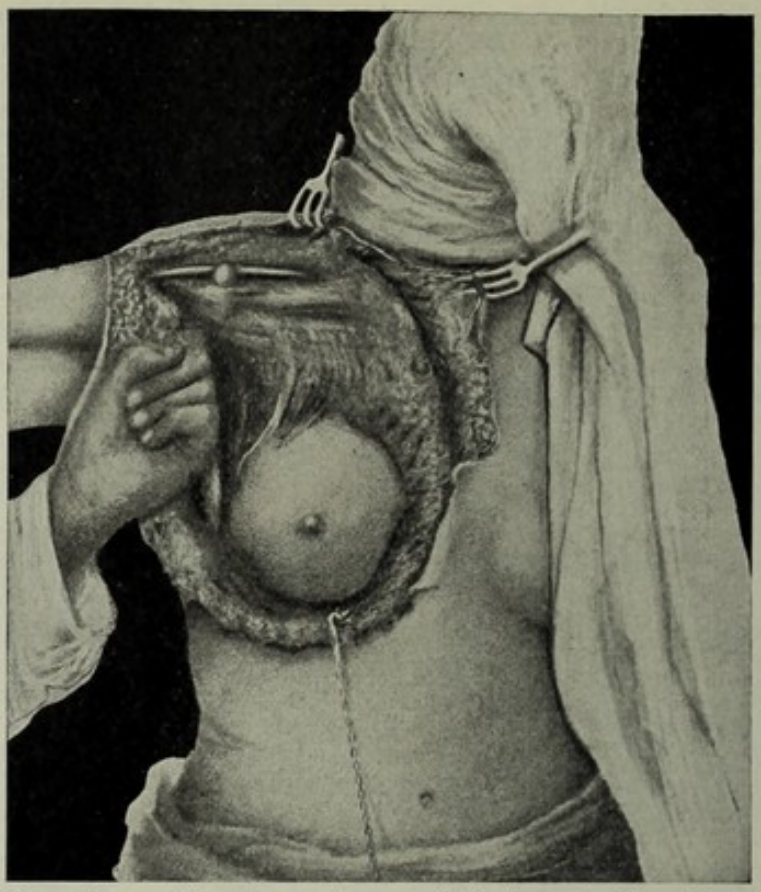


FIG. 1181.—Willy Meyer's operation for carcinoma of the breast. Insertion of pectoralis major muscle exposed. Operator's left index-finger encircling its tendon.

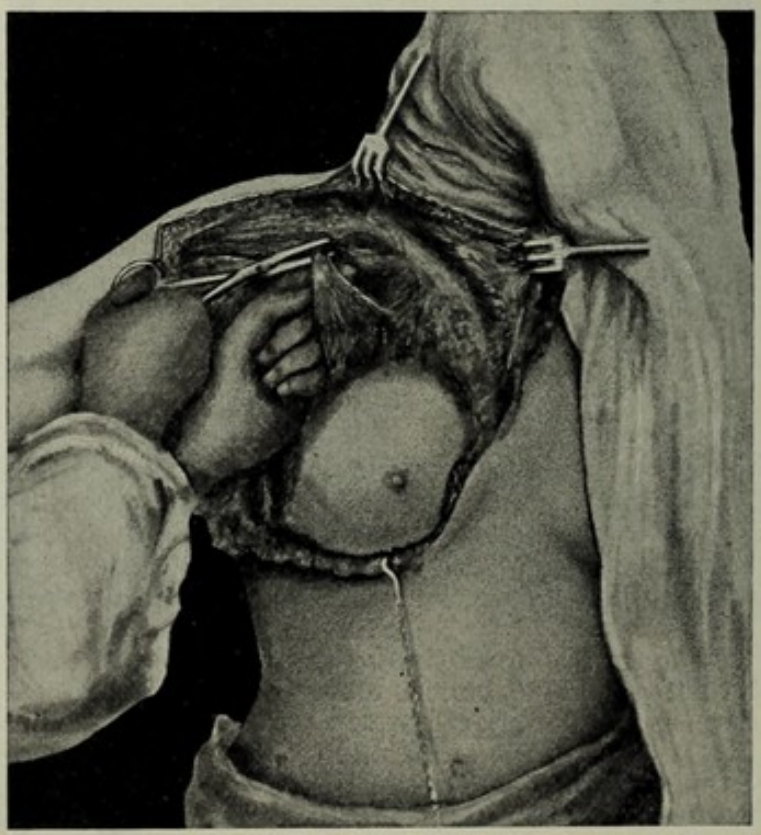


FIG. 1182.—Willy Meyer's operation for carcinoma of the breast. Finger under tendon of pectoralis minor muscle. Above, cut surface of clavicular portion of pectoralis major parallel to clavicle is visible (in the living the belly of the pectoralis major is not so thoroughly detached from that of the pectoralis minor. It is done here to show the latter's tendon).

of the great pectoral muscle into the humerus is found. The tendon is fully exposed, care being taken to bare it of axillary fat. The arm is then carried a little nearer to the side to relax the great pectoral muscle. This tendon is cut off close to the humerus (Fig. 1181). The muscle is pulled downward and inward and is loosened from the cephalic vein. It is then cut off near the lower border of the clavicle and the sterno-clavicular articulation. It is necessary to divide the nerves that enter the pectoral muscle, and all the vessels that come into view are divided between two clamps and tied.

The next step is to divide the tendon of the lesser pectoral muscle near the coracoid process (Fig. 1182). Just beneath this tendon lies the subclavian vein. The surgeon now makes a transverse division of the fascia over the axilla, and thus exposes the axillary and subclavian veins (Fig. 1183).

Meyer's third step is to split the axillary fat over the upper portion of the latissimus dorsi up to the axillary vein, "thus dividing it from the mass of fat that enters the sulcus bicipitalis brachii."

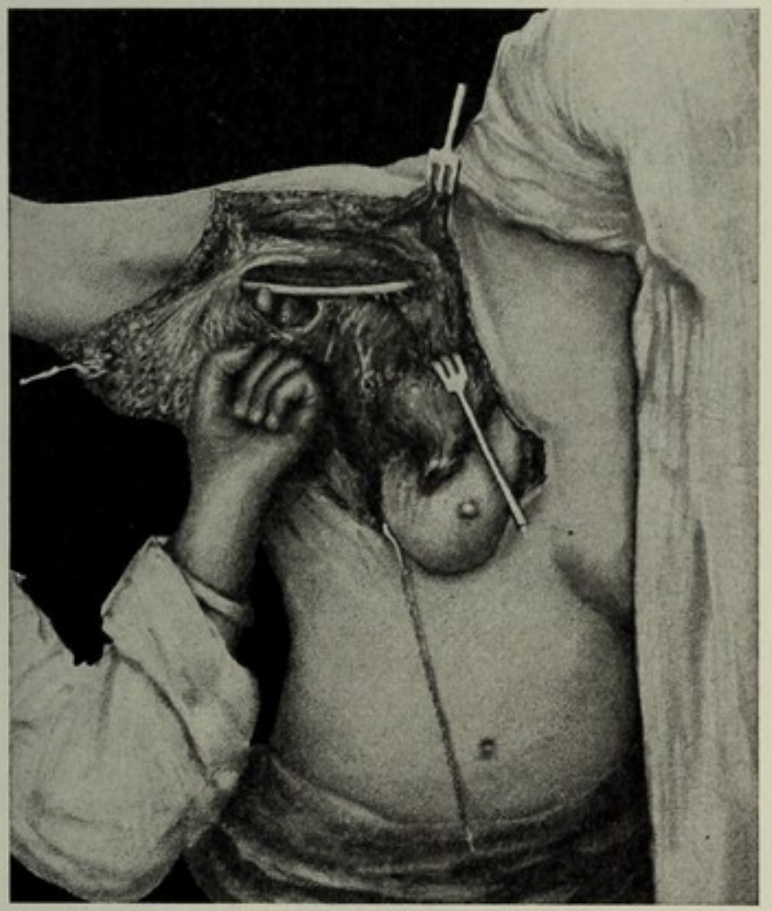


FIG. 1183.—Willy Meyer's operation for carcinoma of the breast Subclavian and axillary veins fully exposed. So far, glands and fat tissue not removed; smaller vessels still in connection with main trunks. Finger under fat toward sulcus bicipitalis, its nail resting on axillary vein.

Next, the axillary and the subclavian veins are followed up to where the subclavian passes below the clavicle, and every vessel that evidently must be cut is divided between two ligatures and tied. This procedure saves a great amount of hemorrhage. Meyer directs us to be careful to preserve the two superior subscapular nerves, although the third subscapular must be sacrificed.

The next step in the operation is to have the assistant hold up the mass of partly loosened tissues without pulling upon them; for if he does pull upon them, Meyer truly says, he is apt to tear off pieces of periosteum or perichondrium; and such bare spots are liable to become necrotic. The surgeon now cuts to the wall of the chest, being careful not to damage the great serratus muscle. Meyer cautions us at this step to hold the blade of the knife horizontal; that is, "perpendicularly toward the thorax." "If he (the surgeon) should not thus turn the blade of his knife, but cut perpendicularly downward toward the subscapular muscle, he would enter the fat covering and enveloping the nerves and blood-vessels of this region, thus running the

risk of unnecessarily causing considerable hemorrhage and of injuring the subscapular nerves. In the general run of cases this region need not be explored; only in very advanced cases did I find a few infected glands in this area."

The pectoralis major muscle is now divided close to the wall of the chest, the cuts being parallel to the ribs, and almost level with them; and the mass being gently drawn toward the sternum. By watching carefully, one may see the perforating arteries and veins drawn out by traction before cutting them, and may usually catch each of them with two clamps and divide between the clamps. If this be impossible, they are divided and quickly picked up. The last tissue that holds the mass to the chest wall is composed of the muscle-fibers from over the sternum. These are divided close to the sternum (Fig. 1184). The final steps consist in tying all blood-vessels, draining, and suturing the wound. The draining is done through a perforation in the posterior flap. It may be tubal or by gauze. Gauze has the advantage of restraining oozing of blood.

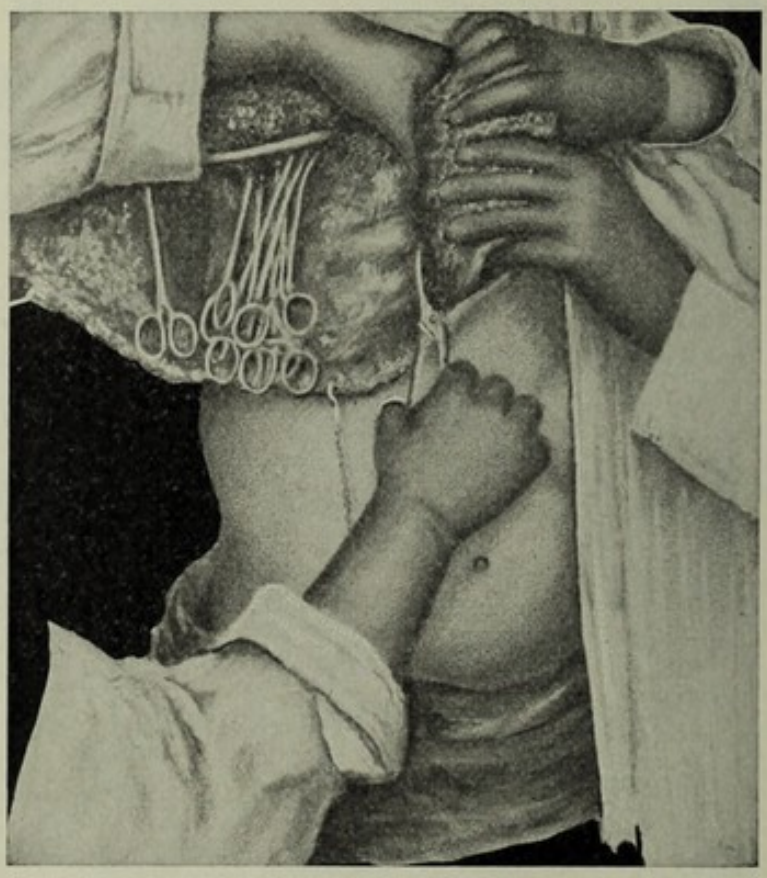


FIG. 1184.—Willy Meyer's operation for carcinoma of the breast. Pedicle of mass over sternum ready to be cut off.

This operation has noteworthy merits. It can be performed far more rapidly than any other method that I have ever employed. The loss of blood is comparatively trivial because in this operation the chief blood-vessels are divided early, are cut close to the axillary artery, and are tied. In removing the mass from the chest wall there is little bleeding, except that which comes from the perforating vessels, hemorrhage from the branches of the axillary being entirely absent; and even many of these perforating vessels are tied before being *divided*. We are far less apt by this method, than by the usual plan, to squeeze lymph which contains cancer cells into the wound, or in aberrant directions through the lymphatics. As Dawbarn says, the squeezing "of the breast by the retractors during its ablation, as also its handling when separated, save for its attachments to the armpit," are real dangers and may be responsible for rapid recurrence of the growth ("Annals of Surgery," March, 1908). The drain is removed in from thirty-six to forty-eight hours. The patient is placed in a sitting posture on emerging from ether and is allowed out of bed on the fourth or fifth day.

Stewart's Operation (Figs. 1185–1189).—My late colleague, Prof. Francis T. Stewart, removed the breast by a transverse incision. He attacked the axilla first. The incision gives free exposure, does not pass into the arm or across the axilla (in either of which

regions a scar may impair function, or press upon vessels or nerves), and, with the aid of extensive undermining, can nearly always be closed ("Annals of Surgery," Aug., 1915).

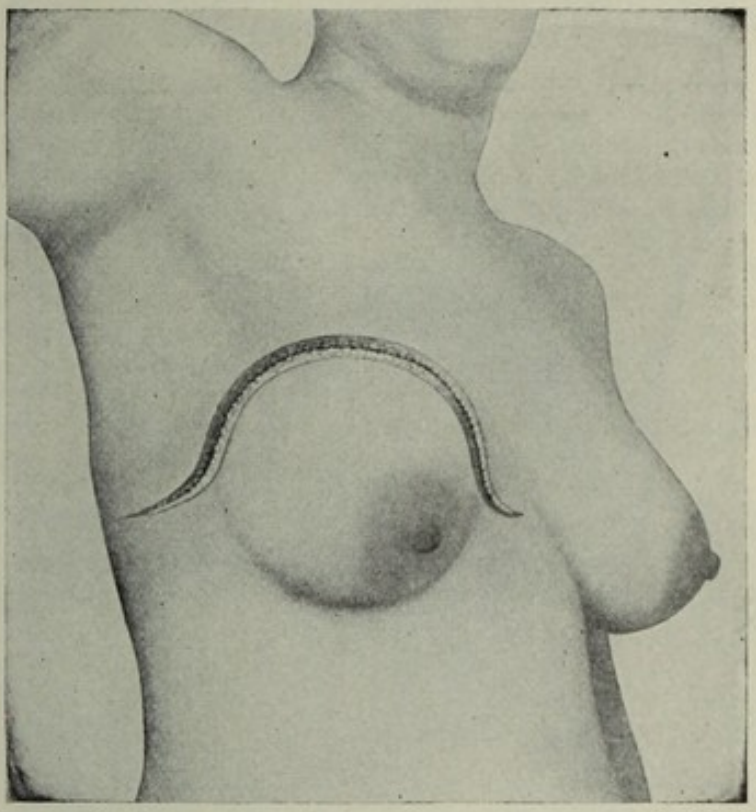


FIG. 1185.—Primary incision. The towels which should be attached to the margins of the wound are not shown (Stewart in "Annals of Surgery").

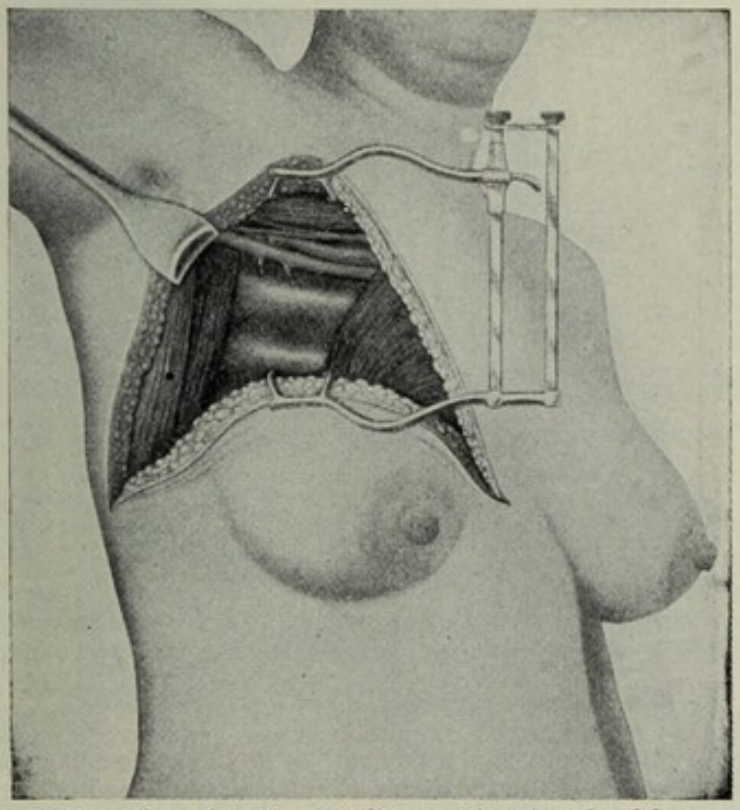


FIG. 1186.—Dissection of axilla (Stewart in "Annals of Surgery").

Dressing and After-treatment.—After operating for cancer the dressing must be wide and ample. Fluffed up gauze is pushed into the axilla to obliterate the dead space and the arm is bound to the side for forty-eight hours. When the binding is

removed, the extremity is placed on a pillow in a position of moderate abduction, and is abducted a little more each day. If the incision has been placed well above the

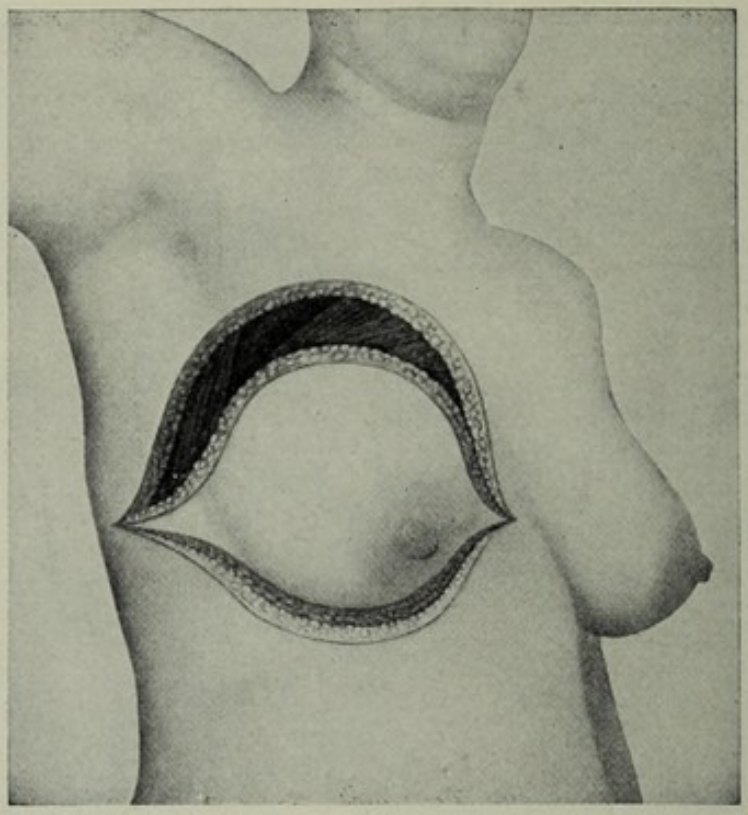


FIG. 1187.—The lower incision is made after evacuation of the axilla (Stewart in "Annals of Surgery").

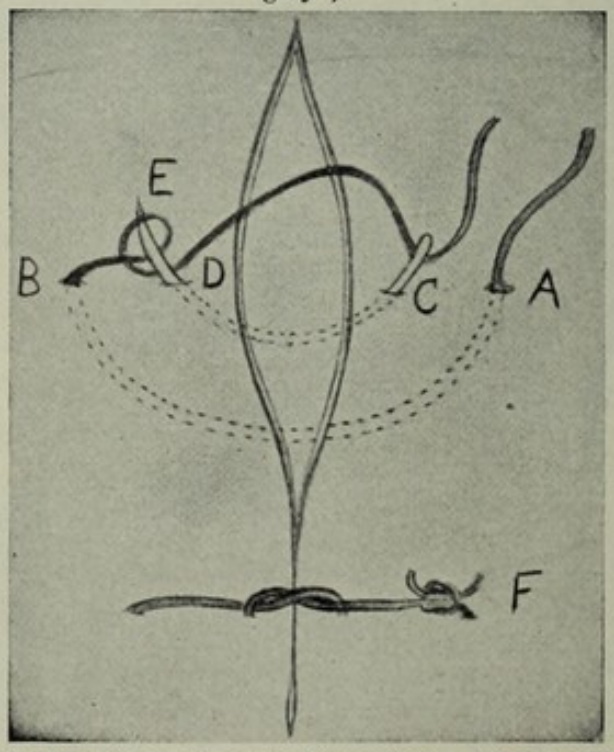


FIG. 1188.—Combined retention and coaptation suture. The needle is inserted a couple of inches from the edge of the wound (A) and brought out at a corresponding point on the opposite side (B). It is then reinserted close to the wound (C) and, on emerging from a corresponding point on the opposite side (D), is passed through the loop E. When the suture is tied (F) the edges of the wound are held firmly together and inversion of the skin does not occur (Stewart in "Annals of Surgery").

axillary border the mobility of the arm will be such that in two weeks the patient can place the hand on the back of the head. Of late I have been placing the arm,

immediately after the operation, in abduction (upon a pillow or a triangular splint which rests upon the side). This is unnecessary if the incision does not run on to the arm but is in front and above the anterior axillary margin. If the old incision in the axilla be used, abduction and all other plans will fail to prevent decided limitation of movement.

Inoperable Malignant Diseases of the Breast.—This term implies that a radical operation looking to cure is impossible. The conditions in which it is impossible have already been specified (see page 1425). Even if the case be judged inoperable from the radical standpoint, it may be wise in some instances to remove the mammary gland in order to free the patient from a hideous, ulcerating area, violent pain, or harassing hemorrhage.

It has been suggested that some cases inoperable by ordinary methods may be subjected to removal of the entire upper extremity or to disarticulation at the shoulder-joint with a prospect of cure. My own view is that when a case has advanced so far that it is not amenable to ordinary operative treatment, neither of the above-mentioned procedures offers any reasonable chance of success. If the pain is extremely violent in an inoperable case the surgeon may relieve it by dividing the brachial plexus, or perhaps by disarticulating at the shoulder-joint.

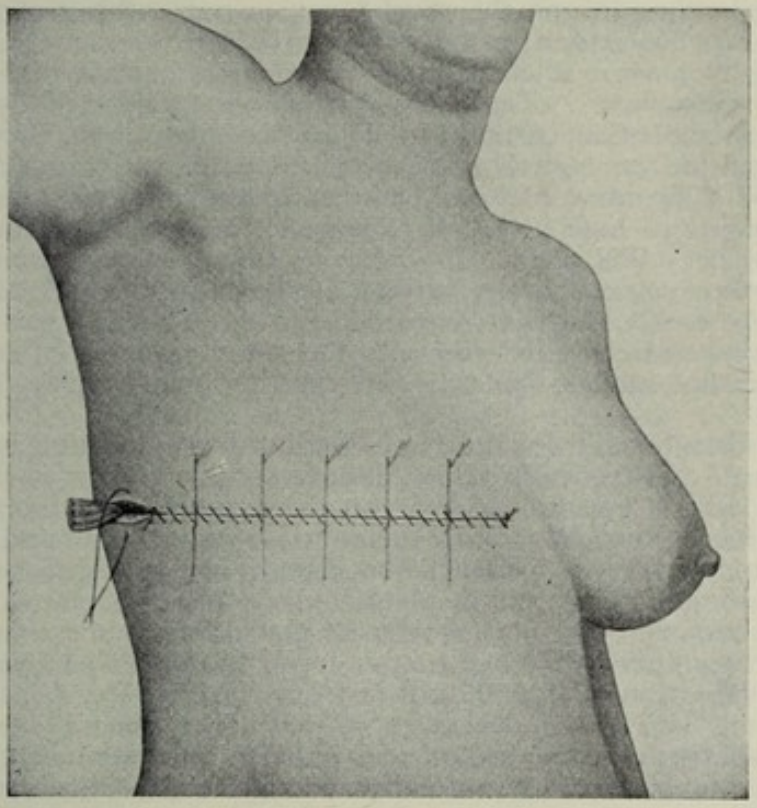


FIG. 1189.—Incision closed (Stewart in "Annals of Surgery").

Some inoperable cases may be greatly improved—for a time at least—by the use of the *x*-rays; and even when the condition is not benefited in other ways, this force sometimes mitigates or greatly relieves the pain. It is said that in some cases radium is more efficient than the *x*-rays, but it is probable that most improvements by radium could have been obtained by the *x*-rays. In cases of lymphatic recurrence it is advisable to administer thyroid extract during the *x*-ray course (Woods in "Brit. Med. Jour.," July 1, 1911).

Beatson's Operation, or Double Oöphorectomy.—It has been pointed out by Sir George Thomas Beatson, of Glascow, that there is a certain similarity between the formation of cancer in the mammary gland and the process of lactation. In each there is an enormous production of embryonal epithelial cells; but in lactation the epithelial cells undergo fatty degeneration, and in cancer formation they do not do so, but penetrate the tubules and the acini and infiltrate the gland structure. Beatson further points out that when a lactating cow is spayed, it continues to give milk indefinitely. This seems to indicate that removing the ovaries favors the fatty degeneration of the epithelial cells. This operation has been performed in cases of inoperable carcinoma

of the breast in the hope of bringing about degeneration in the tumor mass. In the great majority of cases it fails utterly; but now and then it secures a notable improvement, and in a very few cases outward evidence of the disease disappeared, the general health improved, and there was gain in weight. The cure was apparent, but not real. The improvement was only temporary. Abbe obtained an apparent cure in 2 patients. It was at first thought that the operation would only be applicable to persons that had not passed the menopause, but one of Abbe's patients was over seventy years of age. Butlin, however, says that there is no genuine cure secured by this operation on record, and Beatson makes the same statement. The operation is not to be considered if visceral deposits exist. My own view is that the procedure offers but little prospect of success, but that, as it does offer some hope of improvement, the exact facts should be placed before the patient, and she should be permitted to choose whether or not she wishes the operation performed.

XXXVII. THE *x*-RAYS IN SURGERY. ROENTGENOGRAPHY; ROENTGENOSCOPY; ROENTGENOTHERAPY

(Dr. Willis F. Manges, Clinical Professor of Roentgenology in Jefferson Medical College, my colleague, did me the great favor to revise this section.)

History of the Roentgen or *x*-Rays.—In 1858–59 Gessler obtained violet, blue, and red colors by passing alternating currents through glass tubes of low vacuum (1/1000 of an atmosphere). The cathode rays were discovered by Hittorf in 1869 while passing an induction current through a vacuum tube. Crookes, of London, greatly improved the vacuum tube and obtained a rarefaction which left in the tube but 1/1,000,000 of an atmosphere. This last-named observer found that when an interrupted current of high potential is passed through a vacuum which is nearly perfect, fluorescence takes place. In Crookes's tube the positive electrode is placed at some indifferent point, and the current at the negative electrode produces what is known as the cathode stream or cathode rays. These do not flow toward the positive pole unless it be in direct line with the stream of rays, but are thrown directly toward the opposite wall of the tube, and at this point a phosphorescent glow is detected.

In 1895 William Konrad Roentgen, of Wurzburg, while making a study of cathode rays as developed in Crookes's tubes, discovered the energy which he named the *x*-rays. Both Jackson and Lenard were on the very eve of making the discovery a year before. Roentgen while at work was called from the room and laid an energized vacuum tube upon a book. Within the book was a key placed there as a marker and the book rested upon a photograph plate-holder containing plates. He returned to the laboratory, removed the tube, took some plates for a camera trip, departed, and took some pictures outside. When he developed the plates he found the picture of the key. By reproducing the conditions he made the discovery (E. E. Burns in "Popular Science Monthly," 1908). Roentgen showed that at the wall of the Crookes tube opposite the negative electrode a new and hitherto unknown energy was generated. Because of the uncertain character of this energy he gave to its manifestation the name of the *x*-rays or unknown rays. Since then, in honor of their discoverer, these rays are more generally known as the Roentgen rays, and from this root word, Roentgen, the other words used have been derived, and are as follows: Roentgenology, the science of the Roentgen rays; roentgenography, the photographic effect of the Roentgen rays; roentgenoscopy, the use of the Roentgen rays in fluoroscopy; roentgenotherapy, the use of the Roentgen rays in the treatment of disease, etc.

Physical Properties of the Roentgen Rays.—The Roentgen rays or *x*-rays are a form of ethereal vibration akin to light, but of extremely short wave length, which belong to the invisible portion of the light spectrum. They have been refracted by passing through salt crystal, but in practical work they cannot be refracted, reflected, concentrated, or deflected by a magnet. The rays cannot be polarized, they travel with the velocity of light, and cause fluorescence in certain substances, notably in tungstate of calcium (Edison), platinocyanid of barium (Roentgen), and platinocyanid of potassium. The rays have a marvelous power of penetration, and move in a straight line from their source until absorbed. The rays are absorbed by the substance through which they pass in proportion to the density and thickness of the object. The density is measured by the atomic weights of the elements composing the object. For example, aluminum is of low atomic weight, and lead of high atomic

weight. Therefore, aluminum is relatively very transparent to the *x*-rays, while lead is very opaque, but since the thickness of a body comes into consideration in estimating the total absorption it is possible to have a layer of aluminum so thick that it will cast as much shadow as a thin layer of lead.

The Production of *x*-Rays.—The production of *x*-rays depends upon the passage of a high voltage current through a vacuum tube. Such a current is due to projection of negatively charged minute bodies, electrons, from the cathode to the anode or target, where they are stopped very suddenly by the dense metallic target material. It is the sudden stopping of these electrons that produces the ethereal waves which are *x*-rays.

The high voltage current may be obtained from a static machine, an induction coil, or a high-tension transformer. The static machine is obsolete; the induction coil is almost entirely replaced in America by the transformer, but is still used more or less generally in European countries. The voltage ranges from 40,000 to 60 000 for diagnostic work, and up to as high as 200,000 volts for treatment work.

There are two types of tubes, the gas tube and the hot cathode or Coolidge tube. In the gas tube operation the necessary electrons are obtained by the breaking down of atoms of gas (ionization) that remain in the tube. An accessory device called a regulator is required in order that more gas atoms may be admitted from time to time. In the Coolidge tube the electron supply is obtained by heating a tungsten filament to some degree of incandescence by means of a low voltage current (6 to 8 volts). The number of electrons available determines the amount of high voltage current that may pass between cathode and anode to produce *x*-rays. The supply of electrons is under perfect electric control so that one can determine beforehand just what *x*-ray effect will be produced by adjustment of electric devices controlling the temperature of the filament and the voltage applied to the tube terminals. This means that one can reproduce roentgenographic results and also that one can deliver a predetermined dose for therapeutic purposes.

A great amount of heat is generated in the target by the terrific bombardment of the electrons, so that there is a limit to the amount and voltage of current that may be used in a given time. The solid tungsten target of the standard Coolidge tube operates satisfactorily up to white heat, but the high voltage current must all be going in one direction, so that a rectifying device is necessary to change the high voltage alternating current from the transformer into unidirectional current.

The radiator type of Coolidge tube has a heavy copper anode stem and target with a small button of tungsten sealed into the face of the target to receive the electron bombardment. To the external end of the copper anode stem a radiating device is attached to carry away the heat rapidly. This tube is very satisfactory for roentgenographic and roentgenoscopic work. The focal point is small; hence it gives finer detail in the shadows; it gives off less vagrant rays; and up to a certain amount of current and voltage rectifies its own current. This tube may be mounted in the transformer case so that there are no high voltage wires exposed. Still more recently Coolidge has invented a hot cathode tube with a water-cooling device to carry the heat away from the target. This tube is only adaptable to treatment work and can be operated at very high voltage and with a large amount of current.

Properties of the *x*-Rays.—The *x*-rays are not visible to the unaided eye. Their presence must be detected by their action on certain material bodies.

1. They affect the photographic emulsion in the same way as ordinary light.
2. They produce fluorescence in certain crystals, such as barium platinocyanid or tungstate of calcium.
3. They render gases conductive to electricity, or, in other words, produce ionization.
4. They have an effect on living tissue, a biologic action.

The *x*-ray action on a photographic emulsion is similar to that of ordinary light. That is, a photographic plate or film exposed alone to *x*-rays will blacken on development just as if exposed to sunlight. In the case of the *x*-rays the light starts from a focal point, proceeds in a straight line into and some of it through objects, and affects the emulsion according to the amount that passes through. When the plate or film is developed, one has a roentgenogram, a shadow record of the density, arrangement of parts if the object varies in density, and the shape of it in the line of projection. In the production of an ordinary photograph the light proceeds from the surface of the object, is brought to a focus by means of a convex lens and distributed to the surface of the emulsion on the plate. The developed plate is a shadow record of reflection value. White surfaces reflect more light than dark surfaces. By the density

and arrangement of shadows one recognizes the object photographed, and can name it if it is a familiar object.

Fluorescent Action.—Crystals that fluoresce under action of *x*-rays may be finely divided, made into an emulsion, and spread on a piece of cardboard so that one may have a convenient sized fluorescent screen to study the action of the rays. Such a screen mounted with a view to its preservation and to the protection of the Roentgenologist is called a fluoroscope or roentgenoscope. It is necessary to exclude all other sources of light from the surface of the screen when using it in order that one may have the benefit of all the light of the fluorescent screen. On the screen one sees again shadows that depend upon the density, shape, and arrangement of parts under study.

Intensifying Screens.—The fluorescent action of the *x*-rays is made use of in roentgenographic work also. Specially prepared fluorescent screens are made into sizes corresponding to the various sized plates or films. These are called intensifying screens. The emulsion of the plate is placed in firm contact with the intensifying screen in a light-proof holder called a casett. Films coated on both sides may be placed between two such screens. By this means roentgenographic exposure may be greatly reduced in time.

The effect of the *x*-rays on the gas in an ionization chamber affords a most sensitive test for their presence and, as well, in the hands of an expert physicist, a means of most accurate measurement of the amount of rays in a given beam.

Scattered Rays.—A small portion of the *x*-ray beam in passing through an object is deflected from its original path and emerges in all directions from the object. The scattered rays retain their original characteristics regardless of the deflection. They are sufficient in amount to cause blurring of the shadows in roentgenograms of thick parts, and play an important rôle in *x*-ray treatment of deep-seated lesions.

Secondary Rays.—The *x*-rays in passing through tissue produce ionization. Electrons are liberated and set in motion and an entirely new ray is developed which depends for its character upon the intensity of the primary ray and the atomic weight of the atoms affected. It is probable that the secondary rays play an important part in therapeutic results, but have little or no effect on the roentgenogram.

The **biologic effects** of the Roentgen rays and radium are especially important from the standpoint of physiology and therapeutics. If used in like quantities and qualities the effects of the Roentgen rays and radium are very similar, and probably identical. The effect of the rays on the tissues of the human body depends first upon the quantity, second, upon the quality of rays used, and third, upon the sensibility of the cells under exposure. In general, a small quantity of radiation has a stimulating effect upon the cells of the body and even upon the cells of growing plants (Albers-Schönberg), but very quickly the effect passes from stimulation to destruction, and in most instances, when the rays are used for therapeutic purposes, it is the inhibitory or destructive effect which is sought. In general the embryonic cell is the most sensitive to the rays, and this effect is due to the chemical or actinic action of the rays. In general, the glandular cells are the most sensitive of any in the body because they are most highly specialized, and of the glandular cells the most active are the generative cells of the ovaries and testicles. Next to these are the cells of the spleen, the thyroid and thymus glands, the lymphatics, and the liver. Next in order of sensibility are the tissues of the body, the protective covering of the skin and mucous membrane, the connective tissue, and the lining of the blood-vessels. Probably most resistant of all the body tissues is the nervous tissue. It is because the carcinoma cell approaches the embryonic type that it is more sensitive than the surrounding tissues, and it is for this reason that the malignant cells in the body yield more readily and become affected by the rays even though the surrounding tissues show little or no effect. If it were not for this increased sensibility of the malignant cells we would not be able to cause a disintegration or disappearance of a carcinoma except by destruction of the entire tissue. This specialized effect has been seen by almost every one who has had the opportunity of watching the therapeutic action of the rays. In an epithelioma of the skin, for example, one notices under the action of the rays, which are applied at intervals, that the tumor tissue is gradually absorbed, sometimes without breaking down, or the tumor tissue undergoes degeneration and disappears, while the surrounding skin which had been exposed to an equal amount of radiation shows little or no effect. It must be borne in mind that the action of the rays is always greater on the surface of the skin except in so far as the tissues are influenced by the increased sensibility. Almost 50 per cent. of the rays are absorbed in the first centimeter

of tissues. It is therefore readily understood that the greatest effect will be shown on the surface, other things being equal, but because of the greater sensibility of certain tissues, such as the highly sensitive glandular organs, for example, the testicles and ovaries, it is possible in these organs to produce a decided inhibitive or destructive effect without showing the slightest change in the overlying skin. The relative effect on the overlying as compared with that on the deeper tissues can be decreased by present-day filtration and cross-firing. This filtration was begun, so far as the *x*-rays are concerned, in 1906, at which time Pfahler argued that if the greater portion of the rays are absorbed in the first centimeter of tissue, if one should introduce between the skin and the tube tissue resembling the skin that the greater portion of the rays, which would otherwise be absorbed by the skin, would be removed. Therefore, the skin would receive considerable protection. Experiments were carried out with the skin of a living rabbit. In this experiment Pfahler exposed an area on the back of the rabbit about 3 inches in diameter. One-half of this area was covered by a layer of sole leather. As a result of the exposure, which was given sufficiently long to produce a burn, the area unprotected by the sole leather developed a slough which involved the entire skin, while the area protected by the sole leather did not even lose the hair. This was very convincing as to the protective value of filtration. Since that time, however, the power of the Roentgen rays has been increased to such a considerable extent that roentgenologists now use from 2 to 6 mm. of aluminum for filtration and thus increase the value of the deep radiation.

The amount of exposure or treatment that can be given over any area of skin is spoken of as a *skin dose*, referring to the limit of toleration of the skin to a given amount of radiation. This limit of toleration is indicated by an erythema. Therefore, the dose is often spoken of as an *erythema dose*. An "erythema dose" not only produces erythema, but when given over an area of the body covered by hair will produce epilation—*epilation dose*. The amount of radiation that can be given to the deeper tissues is, of course, greatly increased, probably four times, by means of filtration through 6 mm. of aluminum. It is advisable never to produce even an erythema of the skin because of the dangers which may develop a year or more after such exposure. Clinically the changes to be noticed as a result of excessive exposure to the Roentgen rays or radium may be divided into three or four phases. A so-called *x-ray burn* is not really a burn in the sense of a burn produced by fire, but it is a degeneration of the skin. A better term than "*x*-ray burn" is "*x*-ray dermatitis."

Acute x-Ray Dermatitis.—The *first degree* of an *x*-ray dermatitis consists of an erythema indicated by general redness of the surface of the skin, with epilation in hairy areas, and generally this erythema comes on after a period of a few days to two or three weeks, depending upon the severity of the exposure. Generally the erythema may be looked for in about two weeks. It has the appearance of an ordinary sunburn, and disappears in about the same length of time as an ordinary sunburn. That is, the erythema disappears, and very commonly will leave behind a pigmentation or tanning, which is particularly pronounced in a dark subject. Blondes show the erythema effect more readily than brunettes, and a slightly lesser dose can be given to blondes than to brunettes. A severe erythema may disappear completely at the end of ten days to two weeks, and nothing may appear again for a year or two, and for some reason not yet known some of these patients who have had an erythema will then develop a telangiectasis and an atrophic appearance of the skin over the area previously occupied by the erythema. This condition is due to an arteritis with secondary dilatation of the smaller blood-vessels, and in severe cases the whole area may be covered by a spider-web-like distribution of fine blood-vessels in the skin.

The *second-degree dermatitis* is the result of more excessive exposure than that necessary to produce the first degree dermatitis, but less in extent than the third-degree dermatitis. It is likely to make its appearance slightly earlier—at the end of a week or ten days—and shortly after the appearance of the erythema, vesicles, or bullæ make their appearance. The entire area then gradually desquamates and will require from four to six weeks for a complete healing process. These cases are very likely to be followed by extensive telangiectasis after a year or two, and such *x*-ray dermatitis should be avoided. It rarely occurs in these days when filters are used for deep treatment, but even through any amount of filtration a dermatitis of any degree can be produced if sufficient radiation be given.

A *third-degree dermatitis* occurs only as the result of accident, faulty apparatus, or through some lack of knowledge on the part of the operator. The writer recalls a case of this sort in a young man who was used as a subject for demonstration of

the efficiency of a certain *x*-ray machine. The roentgenograms were not satisfactory and the same hip was exposed repeatedly in an effort to get one that was good. The exposures were made in a postero-anterior direction. An extremely painful slough occurred involving not only the skin but also to a considerable depth the subcutaneous tissues. Dr. DaCosta removed the entire slough and later closed the wound by skin-grafting.

Chronic radiodermatitis consists of a degeneration in an area which has been treated repeatedly over a long period of time, say a year or more, after which there is a general sclerotic leather-like condition which may last for several years, and later, as a result of deficiency in nutrient vessels, this area becomes necrotic, very painful, and like the third-degree lesion. After a considerable period of time, extending over six months or a year, it may degenerate into true carcinoma.

Another type of *chronic radiodermatitis* is that found in *x*-ray workers, in those who are constantly exposed to radiation in the manufacture of *x*-ray tubes, or physicians or technicians who have been constantly exposing themselves to radiation in the course of examinations for medical purposes. This dermatitis found in the roentgenologists and in the technicians is also varying in its effect. Generally, the exposures to the Roentgen rays in the roentgenologist produce no immediate effect, or, at most, only a slight erythema of the skin, which is passed over or given no particular attention. After several years the skin presents an atrophic aspect indicated by a glossy, smooth, lacquered appearance. There then develop keratoses, or crusts, or small warts, or perhaps fissures over different parts of the hand. These warts, fissures, or keratoses gradually degenerate into true epitheliomata, and studies show that epitheliomata are of the squamous-cell type, are very malignant, tend to metastasize and to recur, and, in a number of instances, have led to the death of the patient through metastasis to the axilla and to the chest.

Another effect of the Roentgen rays and radium which is of interest to all operators is the production of sterility. This may be produced so gradually and without any knowledge on the part of the operator that it must be especially guarded against. Just how much exposure of the testicles or ovaries is required to produce sterility has not yet been determined. It probably varies with the age. It does not produce impotence. This fact often deceives the operator as to the danger of the rays. Just as it is impossible to tell how much radiation is required to produce sterility, so too it is impossible to know when sterility has been produced or when it is complete, for it is well known that a number of male and female cases which had been sterile for a time became fertile. This fact can therefore serve as encouragement to those who may have been rendered apparently sterile, but it should not lessen, to any extent, the precautions that every beginner should take to provide protection against exposure to the rays by every means possible.

The Treatment of Radiodermatitis.—Try to prevent the condition by the application of all present knowledge used for protection. No one should undertake *x*-ray work unless he has learned how to protect himself and his patients, and *x*-ray work should not be undertaken unless the means for protection have been provided. There should rarely be a dermatitis even of the first degree. Accidents will happen, however, and they happen in inverse proportion to the intelligence and care used in the treatment or examination of a patient. We must keep in mind, however, that there are cases in which occasionally a patient will present an erythema even though only the normal amount of radiation has been used. For the *first-degree dermatitis* or erythema Dodd's lotion, or "white wash," may be used.

Pulv. zinc oxid	℥iv;
Glycerin	f℥j;
Phenolis	♏xxx;
Aq. calcis (fresh)	f℥viij.—M.

Sig.—Apply locally with a cotton sponge.

Pfahler uses this wash in practically all cases immediately after treatment, and then for a period of two weeks daily following the exposure. In place of Dodd's white wash any soothing application, such as is used for sunburn, may be used. When itching and burning are troublesome, Engman ("Interstate Medical Journal," July, 1903) recommends the following preparation: 12 drams of boric acid, 1 ounce of zinc oxid, 1 ounce of chalk, 1 ounce subnitrate of bismuth, 1 ounce of olive oil, 3 ounces of lime-water, 3 ounces of lanolin, and 12 drams of rose-water. The mixture is rubbed in a mortar, the lanolin is added, the olive oil and lime-water are mixed, and are slowly added to the

powder and lanolin. The mixture is stirred, the rose-water is added, the preparation is beaten into a creamy paste. If itching be severe 1 to 2 per cent. of carbolic acid is added. The paste is spread on several thicknesses of gauze and the gauze should be covered with rubber-dam.

The *second-degree dermatitis* is treated very similarly, but protection against the sun's rays or heat or further *x*-ray treatment is to be insisted upon. The above-mentioned protective ointment is useful, or the white wash recommended by Dodd. Occasionally more relief is obtained by the constant application of normal saline, or a 5 per cent. bicarbonate of soda ointment with vaselin as a base.

A *third-degree dermatitis* is a serious condition and is truly a dangerous process. Every means possible should be used to bring about local nourishment and comfort. Sometimes constant application of normal saline will give comfort and help to bring about separation of the sloughing mass. In the early stages a plan of treatment such as follows may give good results: A mixture composed of 2 drams each of zinc oxid and bismuth subnitrate, ½ dram each of liquor potassii and liquor plumbi subacetatis, 2 drams of glycerin, and sufficient lime-water to make 6 fluidounces. This mixture may be applied twice daily. It will relieve decidedly itching and burning, and will control the exudate. It should be applied over a considerable area. Generally it is advisable to make the patient comfortable by whatever local applications will accomplish this, until there is a distinct limitation of the process and until there is neither an extension outward nor a contraction of the ulcer. In other words, when the process has reached a standstill it is advisable, if at all possible, to excise the entire area, and then, if necessary, to do skin-grafting to close the wound. This excision at once relieves the excruciating pain, and also eliminates the tendency toward malignant degeneration, for if these cases are allowed to continue indefinitely they tend to become malignant. One must, therefore, not wait until such malignant degeneration has taken place, for we have then all the dangers involved in an operation upon a malignant process.

The treatment of the late degenerations (the *chronic x-ray dermatitis*) is very similar to that of the third. One may coax the condition into a healing process as long as possible, but ultimately an excision is required, and if necessary skin-grafting should be done.

In the radiodermatitis of the roentgenologist treatment should involve first of all a cessation of exposure to the Roentgen rays. As soon as warts, keratoses, or fissures make their appearance they should be completely destroyed. Pfahler recommends very strongly the destruction of these areas by the high-frequency spark or electrocoagulation. By this method destruction can be controlled most accurately, and the superficial layer only of the skin will be removed, or the area can be destroyed as deeply and as extensively as may be necessary. This destruction is followed by a pronounced reaction, with the formation of new blood-vessels, and healthy skin, or healthy scar. In many instances these lesions can be removed without even leaving a scar, and, if treated early, dozens of them can be removed without any damaging effect whatever. If they are allowed to continue, and especially if allowed to macerate by the application of rubber finger-cots and rubber-dam, which is used to keep the areas soft, they are likely to degenerate into squamous-cell carcinoma, the end of which no one can predict. Radical surgery should not be delayed too long.

In these days, if all the principles of protection are applied, no more exposure to the naked tube or unfiltered rays should be necessary, and the radiodermatitis of the roentgenologist should be a thing of the past. Unfortunately these precautions will not always be taken, for there are always men who consider themselves immune to all physical laws, and they will find out to their sorrow, when it is too late, that they have not used all the protection which science provides. If epitheliomata have developed, local destruction by electrocoagulation should be considered. Otherwise excision, amputation of the finger, or the surgical removal of as much tissue as is necessary to eliminate the disease should be recommended, for unless this carcinomatous tissue be completely removed from the hand there will likely be metastasis to the axilla, after which the chance of recovery will be very slim.

The Roentgen Rays in Diagnosis.—They are used either by means of the fluorescent screen or by means of the photographic film or plate. In either case one sees only shadows and not the actual organs that are being studied. The secret of Roentgen ray diagnosis lies in the interpretation of shadows. Technical skill and abundance of resource tend to produce screen or film shadows that lend themselves to full and accurate interpretation. On the other hand, indifferent technic or lack of re-

source may lead to incomplete diagnosis or even error. For instance, a roentgenogram may reveal a stone in the area of the right upper abdomen, but it may not be clearly determined whether the stone is in the kidney or in the gall-bladder. In either situation the stone may be single, more or less round, or equally dense. And, further, if it is in the kidney, the exact location may not be revealed, and certainly one cannot tell of the condition of the pelvis and calices, even though the roentgenogram be of the best quality. To complete the diagnosis, one must have the ureter catheterized, and then under the fluoroscope inject into the kidney pelvis, at first, a very small quantity of opaque solution, the shadow of which can be seen as clearly as that of the stone. By palpation one can separate these shadows, or they will have unequal excursion on deep breathing if the stone is in the gall-bladder. If the stone is in the kidney, one then continues to inject the opaque solution until the pelvis and calices show faintly in outline. Then the operator learns the actual relation of the stone to the kidney pelvis or calices. This being determined, the injection is continued until the pelvis and calices are comfortably filled or take on definite shape, and then one obtains definite information with regard to the condition of the pelvis and calices. There may be destruction or dilatation. The various steps may be permanently recorded by means of films exposed at intervals during the procedure. In this manner a differential and complete diagnosis can be made. The surgical problems and prognosis are mostly definite before operation.

In a single chapter covering the subject of roentgenology technical details must be almost entirely omitted and interpretation can be dealt with only briefly, but it must be kept in mind that in order to interpret an abnormal shadow one must know what the normal one should be. Interpretation then implies an intimate knowledge of anatomy, especially of those parts that cast distinguishable shadows, and not only as to size, shape, position, relation, and function of the various structures and organs but also as to their development and, especially, as to their density or shadow-casting value. There are many variations in the normal, and these, too, must be known or errors in diagnosis will be made. Disease or departure from the normal is recognized by the roentgenologist when the parts under study cast shadows that vary from the normal, and in order to interpret such shadows correctly the *x*-ray operator must know regional anatomy, morbid anatomy, and pathology. Certain diseases in certain stages cause structural changes that produce shadows that are easily recognized as characteristic, and the diagnosis becomes immediately positive. This is true of many of the bone diseases as well as of some of the visceral diseases. But it so often happens that abnormal shadows of one disease may resemble those of another and entirely dissimilar disease that one cannot depend upon the shadows alone for complete diagnosis, but must have also the clinical facts. For instance, in certain stages of osteo-arthritis and of Charcot's joint, the structural changes, in so far as the roentgenographic shadows are concerned, may be very similar. When one realizes that in the former condition there is usually pain and limitation of motion, while in the second pain is a negligible factor and motion is entirely free, and, further, that structural changes take place slowly in the former, whereas in the latter they are rapid, one understands the value of the clinical observation and history in making interpretation of shadows of structural changes that are not characteristic. Of course, in the later stages of Charcot's joint, the large deposits of osteoid material in the soft parts around the joint, and the extensive destruction of joint surfaces, as well as parts of the bone, the shadows are so strikingly characteristic that one can make a correct interpretation immediately.

Both the roentgenographic and roentgenoscopic (fluoroscopic) methods have their advantages and limitations. Frequently both are used in the same study. To make a roentgenogram one places a plate or film, protected from ordinary light by means of light-proof paper or cardboard envelope, on a table, and on top of this the part to be roentgenographed, *e. g.*, the hand. The *x*-ray tube is then adjusted so that it is directly above the hand at a suitable distance, which should be about 24 inches. The *x*-rays are made to pass through the hand and strike the plate or film, which is then developed in the same manner as an ordinary photographic plate. The roentgenogram needs a very short exposure, frequently only a fraction of a second; requires absolute freedom from motion, shows very fine detail in the shadows, and is a permanent record. It can be studied indefinitely, used for demonstration to others, or for reproduction. Views may be had from various angles. With the aid of the stereoscope and plates or films made at proper angles, one may study the shadows in perspective and thus see the actual relations of the parts casting the shadows. Subsequent exposures may be made for comparison to determine progress of the

condition under study. The location of metallic foreign bodies can be plotted and measured with the utmost mathematical accuracy in relation to some point on the surface. (See Localization of Foreign Bodies.)

During the past five years there have been a number of important developments in apparatus and films so that the quality and, therefore, the diagnostic value of the roentgenogram is greatly enhanced. The radiator type of Coolidge tube, with its relatively small focal point, rapid cooling of the target, its self-rectifying properties, and comparative freedom from vagrant rays, is a distinct improvement over the standard tube. Hollis E. Potter has developed the Bucky diaphragm into an extremely valuable and practical piece of apparatus which filters out a large portion of the scattered rays coming off from the patient, so that shadows of even the thickest parts are clear. It is of especial value in the study of the spine, the urinary tract, the pelvic bones, the head, and other dense parts. Intensifying screens have been improved so that they are practically free from grain. And the duplitized film, that is, the film coated with photographic emulsion on both sides, has been made very sensitive, giving excellent results with very short exposures.

The Roentgenoscopic (Fluoroscopic) Method.—Modern apparatus permits of study of the patient in all conceivable positions. Sometimes a separate apparatus is used for upright and horizontal postures, but the so-called "tilt table" is becoming more and more popular. As a rule, this table is adapted both for roentgenoscopic and roentgenographic use. It possesses the advantage that when a desirable position is found by means of the screen, one can then make a roentgenogram for more detailed study and for permanent record.

The *x*-ray tube is enclosed either in a heavy black lead glass shield or a lead-covered box for protection of the operator, and filters are supplied for protection of the patient. The patient may be placed in any position from the upright to an extreme Trendelenburg posture. The table is mechanically tilted either by means of a crank or an electric motor. The screen and tube maintain a constant relation with the table.

The hood fluoroscope of early days is seldom used now except in connection with studies made with a portable *x*-ray apparatus in the patient's room or in the surgical operating room. During the war a bonnet fluoroscope was developed, which is attached to the head of the operator much in the same manner as he wears a head mirror. This was used at the surgical operating table to guide the instruments to embedded foreign bodies. The hood and bonnet fluoroscopes have the screen mounted at the base of a four-sided cone-shaped box, and at the top is mounted a padded plush-covered head-piece that fits snugly over the eyes so as to exclude external light. The use of these instruments should be restricted as much as possible because of the difficulty in affording protection to the *x*-ray operator.

The advantages of the roentgenoscopic (fluoroscopic) method are that one may study motion, such as the contractions of the heart and aorta, the excursions of the diaphragm and the peristalsis of the gastro-intestinal tract. Only a small amount of current is necessary, so that the study may be continued over a considerable time and views from all conceivable angles and of many postures may be had. One does not see fine details in the shadows, and the record is not permanent unless notes or tracings are made at the time, but the information is immediate when it is obtainable, and one can palpate or manipulate and note the effect. Foreign bodies can be localized with a fair degree of accuracy, and, more important still, one can guide the extracting instrument to the foreign body. To do this to the best advantage one should have two *x*-ray tubes that can be operated independently, and so mounted that the fluorescent screen may be placed either above the patient or at one side so that one can fluoroscope at right angles. For such work it is extremely desirable to have the *x*-ray tubes mounted within the transformer case, since this eliminates the danger of high voltage electric injury to the operator or his assistants while working in the dark, and also does away with the danger of igniting the fumes of ether, because there are no high-tension wires exposed and hence no sparks.

At the Jefferson Hospital we have two such transformers and tubes especially designed and mounted, primarily for use in connection with removal of foreign bodies from the air-passages, esophagus, and stomach, but it is equally useful to guide the instrument to foreign bodies in other parts, such as the brain, lungs, or any other soft tissue.

The stereoscopic fluoroscope perfected by the late Dr. Caldwell has not yet become available for general use, but doubtless it will sooner or later.

Injury and Diseases of the Bones and Joints.—Fractures.—The diagnosis of fracture is usually possible by means of the history, physical signs, and clinical facts, especially when the fracture is complete and some displacement is present. But the roentgenographic study is supreme in determining the variety, degree of displacement, separation, complications, as well as the effect of manipulation and the practical efficiency of the dressing. The fluoroscope is of value in fractures of the long bones, especially as an aid in reduction of displacements, but it should never be depended upon to make a negative diagnosis. Roentgenographic exposures should always be made in two positions at right angles, when it is possible to do so, without manipulating the parts in such a manner as to change the relations of fragments. This procedure should be carried out, especially in such regions as the wrist, elbow, ankle, knee, vertebræ, and long bones generally, except the forearm, the upper fourth of the humerus or femur, the proximal phalanges, the metacarpals, the metatarsals, the clavicle, and ribs. When it is neither possible nor practicable to make exposures at right angles, stereoscopic views should be made. The stereoscopic technic is especially adaptable in such regions as the hand, foot, forearm, shoulder, hip, pelvic bones, ribs, and bones of the head.

In children and youths one must keep constantly in mind the fact that the epiphyseal lines cast less dense shadows than bones and may be mistaken for fractures. On the other hand, epiphyseal separation, though only very slight, may be a more serious injury than a fracture through the compact bone tissue, especially if not recognized and treated properly. Frequently a small fragment is torn from the diaphysis or possibly the epiphysis, and this may serve to make certain the demonstration of fracture and epiphyseal injury. One should hesitate to make a negative diagnosis of epiphyseal injury, and should always examine the same joint of the opposite side for comparison.

Fractures at the base of the skull are sometimes difficult or even impossible to demonstrate because of the irregularity of the bones and the limitations in the angles of exposure. A negative diagnosis cannot be made.

As a rule, a fracture should be studied at intervals during the course of treatment to assure maintenance of good apposition and alignment, and to determine the progress of repair.

In reporting on the *x*-ray study of fractures the *x*-ray operator should describe the type of fracture, whether linear, transverse, oblique, spiral, comminuted, T-shaped, impacted, or multiple; he should note the location in definite anatomic terms of the portion of the bone involved, as head, neck, trochanter, tuberosity, shaft in thirds or fourths, condyle, process, base, etc.; he should describe the relations of the fragments in terms of percentage of apposition, displacement, amount of separation, overlapping, shortening, degree of angulation, the alignment, extent of impaction, the effect on an interosseous space, or interference with adjacent bone; he should state definitely whether or not the fracture line extends into a joint. In the case of the skull it is of the utmost importance to determine whether or not the fragments are depressed. Great care is necessary to distinguish between blood-vessel markings and linear fractures of the skull.

Dislocations.—The congenital variety is common at the hip and rare in other joints. One hip or both may be involved. The condition is sometimes not recognized clinically until after the child has attempted or learned to walk or even later. Such failure of recognition is due, largely, to lack of attention on the part of the parents. The clinical diagnosis is usually easy to make. The importance of roentgenographic study lies in determining the amount of displacement, the degree of development of the acetabulum, and, especially, the depth of the acetabulum or the size of its upper lip. Exposures should be made following any method of treatment to determine the result.

Acquired dislocation may occur in any joint, and is frequently complicated with fracture, so that roentgenographic study is always in order—at least after reduction if not before. Roentgenograms should be made in the anteroposterior and lateral views of all joints except the shoulders and hips, in which regions stereoscopic views are necessary.

Diseases of Bone Due to Infection.—It is most important to know that acute osteomyelitis and acute periostitis may not give any positive Roentgen ray signs. A negative diagnosis should never be made. Diseases of bone are recognized roentgenographically when there is actual destruction, and still more positively when there is some repair. The changes in the bone shadows due to repair furnish the best evidence of the limits of the area involved. By repair we mean new bone formation,

and this may be evident in the periosteum or in any portion of the bone. All of the chronic bone infections give positive roentgenographic signs. Chronic periostitis without bone involvement is recognized by the more or less dense new bone formation on the surface of the bone, with no recognizable change in the depth. History and clinical findings are essential to differential diagnosis as between the different types of infection. In syphilitic periostitis there is some tendency for the new layer of bone to assume a more or less "lace work" appearance, while in other infections the new bone is rather in thin layers parallel to the osseous surface. Radiating lines of new bone usually indicate periosteal sarcoma.

Chronic bone abscess or localized destruction of bone is recognized by its more or less sharply defined and fairly dense line of demarcation, due to the surrounding wall of repair. It is sometimes difficult to differentiate from cyst or new growth.

Chronic osteomyelitis is also recognized by the shadows of dense repair, as well as by the absence of bone shadows in destroyed areas. The greatest importance of the roentgenographic study lies in determining the amount of destruction, the extent of repair or involucrum formation, and in determining the presence, size, location, and number of sequestra. It is not possible as a rule to distinguish between the various types of chronic osteomyelitis by the roentgenographic study alone. One should know of the nature of any operative procedure before making interpretation of shadows of bone destruction.

Rickets, while not primarily a bone disease, does produce bone changes, the shadows of which are rather characteristic—thin cortex, bowing of the long bones, expanded diaphyseal ends, poorly developed epiphyses, and general decalcification. Fractures frequently occur.

Scurvy is recognized early by a dense line shadow at the diaphyseal ends of the bones, and later by calcification of subperiosteal hemorrhage. The epiphyses are not involved and the diaphyseal ends are not expanded, and an end may show a narrow zone of destruction. There is but little change in density in the shaft. The shadow of organized subperiosteal hemorrhage is strikingly characteristic.

Osteitis deformans gives a characteristic roentgenographic record. In the long bones the sharp outline of the medullary canal is absent; the even density of the cortical portion is changed to a very irregular density; the bone is increased in diameter and length, and frequently the long bones, such as the femur and tibia, become markedly bowed. Many bones are involved, as a rule, although the condition may be limited for a time to a single bone. In the skull the diploic layer becomes widened and contains deposits of new bone that may be small and round or irregular in shape. Irregular changes in density and increase in thickness also occur in the outer and inner table, and the bones at the base show the same changes, though they usually cast denser shadows than the bones of the vault. In the early stages the diagnosis is only possible by means of the *x*-rays. It is a disease of adult life.

Osteitis fibrosa cystica, a disease of early life, also gives a rather characteristic roentgenographic appearance, in some respects like Paget's disease—that is, many bones are involved and they become bowed, due to rarefaction. The bones are enlarged and elongated, but, unlike Paget's disease, the medullary and cortical shadows are those of multiple cystic areas.

Infectious diseases of joints are recognized either by changes in the bone shadows, as compared to the normal side, by evidence of distention of the joint capsule with exudate, or both of these. Tuberculous infection, especially in the hip-joints of children, can be diagnosed early because of the decrease in osseous density, due to lime salt absorption, before there is actual destruction of bone. It is apparent before there is marked lameness or other definite symptoms, and extends for some distance into all the adjacent bones. In pyogenic infection the decrease in density is much more localized. When actual destruction of adjacent bone is established, the history and clinical findings are necessary for diagnosis as to cause, and it is probable that pyogenic infection soon follows tuberculous or other primary types, so that in advanced stages the lesion is one of mixed infection.

Congenital syphilis attacks the joints or, at least, the bones adjacent to the joints, and most commonly on the diaphyseal side. The shadows of the destroyed area are usually pretty sharply defined because there is but little decalcification outside the destroyed area, and there is usually considerable density in the new bone formation of repair, and periosteal new bone formation along the shaft. This is a disease of the first few years of life.

Charcot's joint is a disease of adult life and of acquired syphilis. Extensive de-

struction of articular ends of bones occurs, and the deposite of osteoid tissue in the adjacent soft parts together with the bone destruction gives a characteristic *x*-ray picture. The changes are due to trophic disturbances.

Exudate in a joint gives a shadow that is homogeneous in density and usually pretty sharply outlined by the distended capsule or overlying tendons.

The shadows of thickened synovial membranes without excess of exudate show some variation in detail, especially at the knee-joint. It is usually possible to differentiate between intra-articular exudate and peri-articular exudate.

Chronic arthritis, hypertrophic osteo-arthritis, is probably a late stage of infectious arthritis. The roentgenogram shows exostoses around the articular margins, at times thickening of the synovial membrane or exudate, or there may be thinning of the articular cartilages. There may also be some destruction of bone. Ankylosis usually follows.

In atrophic arthritis the joint cartilages are thin and the bone shadows indicate decalcification.

Gout gives shadows of deposits in the soft parts about the joints. At the articular ends of the bones the roentgenogram shows small, sharply circumscribed areas of decalcification due to deposits of urates. Joint cartilage may be destroyed.

Bone Tumors.—It is always desirable, if possible, to determine whether a bone tumor is benign or malignant, and, as a general rule, this is possible from the roentgenogram, but to avoid misinterpretation the roentgenologist should know the general pathologic characteristics of the various types of tumors. For instance, carcinoma of bone is always metastatic, never primary. Sarcoma of bone is usually primary, but may be metastatic. Carcinoma is common after the age of forty; sarcoma is more common before the age of forty. New bone formation does not occur in the growth of metastatic carcinoma, but does occur in certain forms of sarcoma. And so there are many general rules that may help one in the interpretation. Baetjer and Waters[1] give four points as a basis for classification and roentgenographic analysis of bone tumors: 1. Origin of the tumor. 2. Presence or absence of bone production. 3. The condition of the cortex. 4. Invasion.

By point of origin is meant whether the tumor arises from the cortex or periosteum, or in the medullary canal. If it springs from the cortex or periosteum, it is a primary growth; therefore not carcinoma.

It may be benign, as osteoma, osteochondroma, enchondroma, cyst rarely. It may be osteal or periosteal sarcoma. If it arises in the medulla it may be either metastatic carcinoma, primary or secondary sarcoma, myeloma, or benign growth, such as giant-cell tumor, cyst, or enchondroma.

Presence or Absence of Bone Production.—If bone production is present, metastatic carcinoma is absent. In the osteoplastic type of metastatic carcinoma, the bones become very dense from deposits of lime salts, but there is really no new bone production. Bone production is present in osteoma, osteochondroma, periosteal sarcoma, and osteosarcoma.

The condition of the cortex is a most important consideration. It may be thinned or expanded by a relatively slow-growing tumor, such as cyst, enchondroma, giant-cell tumor; or may be destroyed by a rapidly growing tumor from within, such as medullary sarcoma, myeloma, and metastatic carcinoma, or from without by osteosarcoma or to some extent by periosteal sarcoma.

The manner of invasion is perhaps the most striking and most reliable sign to distinguish between benign and malignant growths. If invasion is by pressure alone or is along the line of least resistance, the growth is benign, such as cyst, enchondroma, or giant-cell tumor. The line of demarcation casts a fairly dense and sharply defined shadow. When the tumor invades by actual destruction in all directions regardless of the density of the bone, breaks through the cortex and invades tissues outside of the bone, it is more nearly malignant or is completely so. This occurs in meduallary sarcoma, myeloma, metastatic carcinoma, etc.

There are certain more or less characteristic shadows in the roentgenograms of many of the bone tumors. The osteoma casts an extremely dense shadow and grows more or less like a cauliflower, or as dense smoothly outlined bony projections usually multiple. The osteochondroma has areas in which the shadows have very little density due to cartilage predominating. Bone cysts, usually unilocular, but at times multilocular, cause the bone to expand, thin the cortex; the shadow of its interior outline is sharply defined and smooth, as are also the septa. The growth may be mistaken for

[1] "Injuries and Diseases of the Bones and Joints," Paul B. Hoeber, New York, 1921.

giant-cell tumor. Spontaneous fracture is frequently responsible for its discovery and it is a growth of early life, and may be at the end or in the shaft of a bone. Dentigerous cysts may show a portion of a tooth or teeth or one or more teeth in the interior.

Enchondroma has much the same appearance as cyst, but is almost always multiple, and most common in the bones of the hands.

Giant-cell tumor may have much the same shadow characteristics as cyst and enchondroma, but frequently shows a tendency to invade the bone tissue and break through the cortex. It does cause expansion, but is often difficult to differentiate from a more malignant type of tumor. Fortunately it responds readily to Roentgen ray treatment or surgery.

In the malignant growths that destroy there is no line of demarcation. The shadows give one the impression that the bone tissue has been dissolved. Metastatic lesions are multiple, primary lesions single, and when they invade the soft tissue they cause enlargement. Periosteal sarcoma is recognized by the characteristic striæ of new bone perpendicular to the surface of origin.

Surgical Diseases of the Head.—Accessory sinus disease is subject to Roentgen ray diagnosis because any exudate or inflammatory thickening casts shadows more dense than the normal air-filled sinus. When only one side is involved the interpretation is largely a matter of comparing the shadows of the normal side with the more dense shadows of the diseased side. Careful technic is required in the roentgenographic procedure. A variety of angles of exposure is of advantage for the various sinuses and cells. In the study of mastoid disease the advantages of comparison of the two sides are as obvious as in the accessory sinuses, but a great deal more is to be gained than merely to confirm a clinical diagnosis which is usually evident. In acute mastoiditis contrast in the cell area is lessened because of the exudate that replaces air. The cell walls may be intact. In necrotic mastoid the cell walls are destroyed and there is absence of detail in the shadows. In chronic mastoiditis there is more or less absence of cell detail and the bone shadows are more dense because of sclerotic changes in the cell area. All of the cells may be removed by this process or between attacks a few air-containing cells may be present. Necrosis may occur in the sclerotic type, and then areas of bone destruction will appear. These areas are usually in fairly close relation to the lateral sinus and constitute perisinus abscess. The entire cell area or portions of it may be hollowed out and filled with cholesteatomatous material. There is quite a variation in the normal, and a real change in chronic mastoid disease in the relations of the lateral sinus, as well as in the size and position of the emissary vein. This relation can be determined by means of stereoscopic roentgenograms and it is a great help to the surgeon to have this information. Also there is in the normal great variation in the size of the cells and in the size of the cell area. The cells may project as far forward as the external angle of the orbit, as far upward as the parietal bone, or as far back as the occipital region. The two normal mastoids of an individual are of the same cell and area type. The variation is between individuals.

The bones of the skull are subject to practically all of the diseases of bone in other parts of the body, and the same evidence can be shown.

Intracranial Lesions.—Lesions within the skull depend, for their recognition, upon some increased density in the substance of the lesion, or upon some local or general change in the thickness of the skull, or by means of *x*-ray pictures made after removing fluid from the ventricles or subarachnoid space and replacing it with air, a procedure known as ventriculography.

A considerable percentage of brain tumors and cysts contain calcareous material, the shadows of which lead not only to diagnosis but also to localization. This is particularly true of endotheliomata. A tumor in contact with the inner table of the skull or some process at the base of the skull will cause pressure atrophy or destruction of the bone, the roentgenographic shadows of which may even give some idea of the nature of the growth. For instance, a glioma with a smooth surface produces a depression that is smooth and has a very abrupt edge on a portion of its outline. A more dense tumor, like fibrosarcoma, produces a more irregular depression. A cyst in contact with the inner table produces an even, smooth depression and the edges are abrupt throughout the circumference. At the base of the skull changes in the thickness of the bone process are diagnostic of pressure, but cannot always be depended upon for localization nor even for definite diagnosis of tumor, as the same result may follow internal hydrocephalus from any cause. The clinoid processes and sella turcica are particularly susceptible to pressure effect. Intrasellar growth

enlarges the sella turcica and may destroy the clinoids, as well as the floor of the sella turcica. Enlargement of the sella turcica is also the result of hypertrophy of the pituitary body in acromegaly. Other bone changes, such as thickening of the skull, prognathism, and, in later stages, enlargement of the bones of the extremities occur and are necessary to differential diagnosis. In acromegaly the posterior clinoids are usually intact, but thinned and elongated.

Internal hydrocephalus produces pressure in all directions and causes the convolutions of the brain to make depressions on the inner table of the skull. The skull sutures also show evidence of separation. These are signs of increased intracranial pressure, but not necessarily of brain tumor.

Ventriculography is a combined surgical and roentgenographic procedure, by means of which one is able to determine the location of an obstruction in the interventricular passages, and frequently to show in profile the outline of the tumor causing the obstruction, as well as the extent of the dilatation of the various ventricles. It is the function of the surgeon to remove fluid from some portion of the ventricular cavity and replace it with an equal volume of air. The air, being lighter than the remaining fluid, naturally seeks the highest possible level. Roentgenograms are then made at various angles and with the patient's head in different positions, so that the fluid and air exchange places when the passages are clear. The shadows of the air stand out in contrast to those of the rest of the head, and in this way one is able to outline the various ventricles and passages and determine whether or not they are of normal size and shape, and also a point of obstruction by the failure of the air to pass that point.

Surgical Diseases of the Chest.—The bones of the chest wall are subject to the general diseases of bone and present the same roentgenographic appearance as other bones. Intrathoracic lesions amenable to surgery are always demonstrable either by means of the fluoroscope or the roentgenogram and should be studied in both ways. The fluoroscope is of advantage because one can view the lesions from many angles and localize the massive ones more satisfactorily than by means of roentgenograms. Then, too, one can note the effect on the diaphragm, the displacement and mobility of the mediastinal structures, and the presence or absence of pulsation in the lesion.

Pleural effusion casts a dense homogeneous shadow through which no lung tissue detail can be seen. The serous type is always found at the base, and in the early stages at least does not show a sharp line of demarcation, but the density is greatest at the base and gradually diminishes toward the apex, and from within upward and outward. The upper border of fluid shadow is more nearly definitely defined in the erect posture than in the recumbent. Later the fluid shadow may become more sharply defined along its upper border.

Purulent effusion (empyema) tends to become more or less rapidly encapsulated due to adhesions between the parietal and visceral pleura. When this occurs, the shadow of the outline of the effusion is sharply defined. Empyema may be located in any portion of the chest where two pleural surfaces are normally in contact. The effusion may be massive, filling one side of the chest cavity, or it may remain a small collection of pus, encysted in any position, and there may be one or more encapsulations. When the pus is in an interlobar fissure it is sometimes difficult to differentiate from lung abscess because of its central location. As a rule, however, interlobar encysted empyema is more or less oval in shape, while lung abscess is either irregular in shape or more rounded, and usually casts a less dense shadow. During the flu epidemic of 1918 empyema was a frequent complication, and in a considerable number the lesion involved the mediastinal aspect of the pleural cavity.

In chronic empyema the Roentgen ray study is indispensable to determine the location, direction, and number of sinuses, as well as the extent of the cavity, and from time to time the progress. Such cavities are demonstrated by the injection of some opaque mixture, such as bismuth paste, bismuth in oil, or an opaque solution, such as sodium iodid. Special technic is necessary to obtain the best results.

Pneumothorax.—Free air in the pleural cavity gives a very characteristic shadow. The outline of the compressed lung is sharply defined, and between it and the chest wall there is a transparent area in which there is entire absence of tissue detail. If there is a large amount of air, the compressed lung shadow is rather dense. When hydropneumothorax, pyopneumothorax, or hemopneumothorax is present there is a sharply defined shadow of fluid level which changes with change in position of the patient. When examining the patient with the fluoroscope one can see waves on the surface of the fliud by shaking the patient. One should remember that with the patient

in the recumbent posture fluoroscopy or roentgenography in the anteroposterior or postero-anterior direction will not show the fluid level and the pneumothorax element may be missed entirely. In other words, the central ray must pass parallel to the surface of the fluid.

Lung abscess regardless of its cause or location casts a definite shadow on the roentgenogram, and all but very small ones are readily recognized by means of the fluoroscope. In the early stages it may be impossible to differentiate between abscess and central pneumonia because in both the abnormal shadows are due to exudate and it is quantity alone in a given area of lung tissue that determines the density of the shadow. In abscess the exudate increases and the shadow becomes more dense, while in pneumonia the shadows tend to decrease and do not become extremely dense at any time.

The important function of the roentgenologist is to localize the abscess with relation to the chest wall. The fluoroscope is a great help in making the localization, as the lesion may be viewed from many different angles. Stereoscopic roentgenograms are very helpful, and exposures at right angles sometimes give the best information.

The abscess that occurs as a complication of pneumonia presents a more or less localized, somewhat rounded, and fairly uniformly dense shadow surrounded by the irregularly dense shadows of a recent inflammation or a partly resolved pneumonic area. When the abscess breaks down, forms a cavity, and communicates with a bronchus so that air may enter, the roentgenogram shows an air shadow in the center of the dense area. When both pus and air are present in the cavity, a fluid level shadow will be seen, which shifts with change in position of the patient. The abscess that occurs as a result of aspiration of food or foreign body is usually in the lower portion of a lower lobe, or at least in that portion of the bronchial distribution distal to the foreign body. It may appear like an area of bronchopneumonia at first, but soon shows the characteristics of abscess. Abscess as a result of hematogenous infection may occur in any portion of the lung, but is most frequent near the surface and more often in the upper lobes. This is true particularly of the lung abscess that follows tonsillectomy. Its shadow characteristics are the same as in other forms of lung abscess.

A localization with the patient in the erect posture will not serve for an operation which is to be done with him in the prone or recumbent posture. This is because in the erect posture the diaphragm is drawn down by the gravitating abdominal viscera, and the lungs and chest wall change in shape, so that a small abscess may vary its relation with the chest wall as much as from one to three intercostal spaces. The localization should always be made with the patient in the selected operative position.

In the later or chronic stages of lung abscess the shadows of fibrosis are more or less characteristic, and one or many cavities may be recognized. These may be outlined satisfactorily by the injection of some opaque mixture or solution through the bronchoscope. It is difficult to differentiate between chronic lung abscess and bronchiectasis. The appearance is much the same.

Intrathoracic tumors cast very positive shadows because the normal lack of density of the lung tissue is in such great contrast to the density of the growth, regardless of its nature. The benign tumors within the chest that, because of their location and more or less characteristic shape, are recognized by the Roentgen ray examination are substernal thyroid, enlarged thymus, enlarged lymphatic glands, and cysts. These are practically always along the mediastinal aspect of the lung.

The thyroid projects into the chest from the neck, may be larger on one side than the other, and is narrower at the lower end than at the upper end. It is always a single mass, but is usually evident on both sides.

Enlarged thymus is common in early childhood and is best seen at the end of expiration. The shadow of the enlarged thymus is rather characteristic.

Enlarged lymphatic glands are usually multiple, and, when due to some lymphatic disease, such as Hodgkin's disease, the glands are very sharply defined and are not easily mistaken.

A cyst is single and the striking character of it is that it is round like an orange and not hemispheric like many mediastinal tumors. Transmitted pulsation from the aorta may complicate the diagnosis, but, as a rule, with the fluoroscope one can see almost the entire cyst outline and thus make the diagnosis positive.

Malignant tumors within the chest may be either primary or metastatic. Of the primary forms, lymphosarcoma is the most common. It springs from the mediastinal region and projects into one or the other side of the thorax—occasionally into both

sides. The border is sharply defined and the surface, while smooth, may be undulating as if there were a multilocular mass. The tumor may be small, of moderate size, or very large. It usually responds very quickly to *x*-ray treatment.

Primary carcinoma usually presents a definite tumor mass the shadow of which is fairly homogeneous and quite dense, but not necessarily smooth in outline, as the lesion is apt to infiltrate. One must depend upon the physical examination and history to differentiate between the primary and the infiltrating type of metastatic carcinoma. Primary carcinoma may completely block a large bronchus and produce atelectasis of that portion of the lung distal to the obstruction. Then, in addition to the dense shadow of the atelectatic lung, there is displacement of the heart toward the side of the lesion due to contraction of the lung.

A primary sarcoma or a primary endothelioma springs from the chest wall or even from the pleura. The tumor shadow is usually sharply defined, but less dense, as a rule, than the shadow of fluid. There is usually some destruction of bone to make the diagnosis positive.

Metastatic carcinoma may be either in the form of enlarged glands or of areas of infiltration springing from the region of the hilus, or of the miliary type characterized by large numbers of small tumor masses throughout the lung field, or by involvement of the pleura, in which case there develops rather rapidly fluid in the pleural cavity. These shadows are characteristic, especially in view of the history of primary growth.

In metastatic sarcoma the nodules or tumor masses are always multiple and scattered throughout the lung field. The tumor masses are usually very sharply defined and almost perfectly round. They may vary as to size in the individual cases or there may be large numbers of tumors of the same size. The appearance is quite characteristic and is not to be mistaken for any other lesion.

Aneurysm of the Aorta.—In the Roentgen ray diagnosis of aneurysm of the aorta the fluoroscope is of the utmost importance to determine the presence and character of pulsation, and to view the shadows from all angles, in order to determine definitely the size and the direction in which the aneurysm is pointing, and its access to the chest wall. Roentgenograms should be made both in the postero-anterior direction and in the lateral direction. As a rule, one is able to determine the type of aneurysm that is present.

Aneurysm of the innominate artery is very much more difficult to demonstrate than aortic aneurysm. One should never make a negative diagnosis from the Roentgen ray examination if there is clinical evidence of aneurysm of the innominate.

Gross lesions of the heart are also readily demonstrable, and especially effusion in the pericardium. At the fluoroscope, in addition to the enlargement of the heart shadow together with the fluid, one fails to note the contractions of the separate chambers of the heart. Instead the motion is wave-like and it is difficult to distinguish systole from diastole.

Alimentary Tract.—Lesions of the gastro-intestinal tract are demonstrated by means of an opaque mixture either swallowed by the patient or injected. The opaque mixture casts an extremely dense shadow and outlines the lumen of the tract. When organic changes are present there is a filling defect. The character of the filling defect and its location and extent usually determine the diagnosis.

Esophagus.—In the esophagus foreign body is a common lesion. In childhood a large and obstructing foreign body is relatively common, whereas, in the adult, small, non-obstructing foreign bodies, such as fish bone, small fragment of bone, splinters of wood, and so forth, are relatively more frequent. When the foreign body is sufficiently dense to cast a distinguishable shadow the diagnosis is made either by means of the fluoroscope or by roentgenograms. Exposures should be made both anteroposteriorly and laterally. Foreign bodies in the esophagus have their long diameters in a transverse direction—that is, a foreign body like a coin would have the flat side forward and the edges would present laterally. This is exactly the opposite of the arrangement of the foreign body in the trachea. When the esophageal foreign body is not sufficiently opaque it may be visualized either by means of a liquid bismuth mixture or by means of a capsule filled with bismuth. Even small splinter-like foreign bodies have the effect of stopping the capsule in the esophagus.

Other benign lesions of the esophagus, such as diverticulum, non-malignant strictures, and phrenospasm, are clearly demonstrated when the esophagus is filled as nearly as possible with the opaque mixture. In benign lesions the barium shadow, regardless of its shape, is smooth in outline, and, when stricture is present, as, for example, from the swallowing of lye, the lumen may be very narrow and there may be multiple

strictures, but still the barium shadow will be fairly smooth on the surface. The proximal portion of the esophagus shows more or less dilatation, according to the length of time the lesion has existed, and the degree of obstruction.

In phrenospasm dilatation of the esophagus is a striking feature and this sometimes reaches to enormous size. The flow of the opaque mixture into the stomach is intermittent and occasionally one sees a fairly large quantity pass when the spasm momentarily relaxes (see Cardiospasm).

In malignant or infiltrating lesions of the esophagus the outline of the barium column is always irregular. The lesion may be located in any portion of the esophagus. Dilatation is, as a rule, not striking, for the reason that by the time marked obstruction begins the disease has almost reached the terminal stage.

Stomach.—The lesions of the stomach that are demonstrable by means of the Roentgen ray are ulcer, hour-glass contractions, new growths, and perigastric adhesions, or, in other words, such lesions as cause some irregularity in the stomach wall.

In penetrating ulcer the opaque mixture enters the crater of the ulcer and produces a projection beyond the rest of the outline of the stomach shadow. In chronic perforation of an ulcer the opaque mixture projects through the sinus in the stomach wall into the perigastric tissues, where, as a rule, a cavity of more or less extent exists and in which there is always present a small quantity of air or gas. Cicatrization from ulceration may materially shorten the lesser curvature and also interfere with peristalsis in the region of the scar tissue. Hour-glass contractions may be present as a result of local spasm or as a result of cicatricial tissue formation. Physiologic doses of antispasmodic drugs, as a rule, help one to differentiate the organic hour-glass contraction from the functional hour-glass contraction. The study should be made by means of the fluoroscope in all conceivable positions and roentgenograms should be made in the positions that show the lesion to the best advantage and to detect small lesions that are not readily recognized at the fluoroscope.

New growth of the stomach is recognized by the presence of a constant irregular filling defect in the opaque mixture shadow. Any portion of the stomach wall may be involved, and, in order to detect a high percentage of early lesions, it is necessary to study the stomach from many angles. The location and extent of the lesion can be fairly well shown, and upon this depends in great measure the advisability of surgical interference.

In addition to the organic lesions the position and size of the stomach and intestines, their motility, and character of peristalsis are readily demonstrable and often furnish valuable corroborative diagnostic information.

Duodenum.—Ninety-five per cent. of all duodenal ulcers occur in the first portion or that portion known as the cap. Normally, this portion of the duodenum has a smooth, more or less cone-shaped outline when filled. When ulcer is present there is deformity due either to contraction of the scar of the ulcer or to spasm, or both. One sees the deformity, regardless of the position of the patient, when there is a sufficient amount of the opaque mixture in the cap. The deformity is always the same, regardless of the number of roentgenograms. The cap may be deformed by adhesions or by pressure from the surrounding structures, in which case a shift of the position frequently gives a difference in shape to the cap. Diverticulum may be present in any portion of the duodenum. It is more common in the second and third portions. The position of the duodenum, especially of the second and third portions, is apt to be altered in the presence of periduodenal adhesions. In the rest of the small intestine one may demonstrate evidence of obstruction either acute or chronic. When the obstruction is acute, one sees at the fluoroscope marked peristalsis and reversed peristalsis, as well as dilatation of that portion of the intestines proximal to the obstruction. The higher up the obstruction and the more nearly complete the obstruction, the more marked are these signs. *x*-Ray study of acute intestinal obstruction should be avoided, if possible, because of the tendency of the barium mixture to become hard when it does not keep in motion. Chronic obstruction of the small intestine of mild degree is common in the region of the terminal ileum, due to kinks and adhesions. One may or may not be able actually to demonstrate the point of narrowing of the lumen. Adhesions may follow **appendix disease.** For a Roentgen ray diagnosis of appendicitis one depends upon a visualization of the appendix by means of the barium mixture and palpation under the fluoroscope to determine whether there is tenderness, fixation, or abnormal position. Delay in emptying is another means of determining that the appendix is abnormal.

The **colon** varies greatly as to position and length. There is also considerable variation in motility within normal limits. As in other portions of the gastro-intestinal tract, one tries to demonstrate a normal lumen regardless of function. To do this it is commonly necessary to fill the colon with an opaque mixture by means of injection per rectum. In this way one is able to demonstrate the presence of diverticulitis, of tuberculosis, of carcinoma, or even of colitis. Differentiation is sometimes difficult in the surgical lesions of the colon.

Liver.—The size, shape, and position of the liver may be determined roentgenographically. The linguiform lobe, when present, casts a rather characteristic shadow.

Gall-bladder.—The Roentgen ray diagnosis of gall-bladder disease requires special technic and very careful search for both direct and indirect evidence. We assume that the normal gall-bladder does not cast a distinguishable shadow, so that a positive shadow of the gall-bladder constitutes a diagnosis of some degree of pathology. A certain percentage (probably 50 per cent.) of gall-stones contain sufficient calcareous or phosphatic material to produce distinguishable shadows. When these are present the evidence is direct and positive, except that single gall-stones always present a problem of differentiation from kidney stones.

Indirect evidence of gall-bladder disease, such as signs of adhesions in the right upper quadrant, crescentic-shaped depressions in the barium-filled stomach, duodenum, or colon, hypermotility of the intestines during the early hours of digestion, or multiple-wave gastric hyperperistalsis in the absence of pyloric or duodenal obstruction, are of considerable help in establishing a diagnosis of gall bladder disease, providing that a number of these signs are present, or if, in addition to one or more of them, there is clinical evidence, on the one hand, and absence of organic lesion of the stomach or duodenum, on the other hand. A negative Roentgen-ray diagnosis of gall-bladder disease is of comparatively little value.

Urinary Organs.—The kidney shadows as a rule can be seen in properly exposed roentgenograms. Their position, size, and shape can thus be determined. The entire urinary tract should always be included in the study. Stone shadows in the region of the right kidney may be mistaken for gall-stones unless they assume the shape of the calices, as in the branching kidney stones, or unless the stones are multiple and are not facetted as are multiple gall-stones. It is probable that practically all kidney stones large enough to be considered surgical can be satisfactorily demonstrated by roentgenograms. Kidney stones may be single or multiple, may vary in size from very small to extremely large, and in 15 to 20 per cent. of the cases they are bilateral.

Ureteral stones vary also in size from very small shot-like bodies to rather massive stones, especially at the lower end of the ureter. The vast majority of ureteral stones cast distinguishable shadows. Small particles of gravel mixed with mucus, casts, and so forth, may cause ureteral colic, but have not sufficient size or density to cast distinguishable shadows.

The lumen of the ureters and of the pelvis and calices of the kidneys can be visualized by means of the injection of some opaque solution, and in this way surgical lesions and anomalies of the kidneys can, as a rule, be demonstrated. Such injections should be done under fluoroscopic control if possible. A 20 to 25 per cent. solution of sodium iodid gives very satisfactory shadows. Great care should be taken not to overdistend a kidney pelvis.

The normal kidney pelvis and calices may hold from 5 to 30 c.c. of fluid. Regardless of size, in the normal, the shadows of the terminal calices are always sharp, angular, or pointed. In hydronephrosis the shadows of the terminal calices become rounded and bulbous and smooth, possibly even before the pelvis proper becomes dilated, and the capacity may be anything above the normal. Comparison should be made with the opposite kidney, as the two kidneys as a rule have the same type and size of pelvis and calices. In pyonephrosis the calices and pelvis enlarge, but the shadow of the opaque material filling them is irregular instead of rounded and smooth and one portion may be more involved than another. Also, there may be pockets or cavities communicating with the calices, and when these fill with the opaque solution the diagnosis becomes quite positive. In hypernephroma the calices of some portion of the kidney become distorted and elongated so as to lose their natural shape. The edges of the opaque shadow are sharp, angular, and irregular, but not, as a rule, dilated or bulbous. Much or little of the kidney pelvis and calices may be involved.

The kidney may be palpated and manipulated under the fluoroscope while the pelvis and calices are filled with the opaque solution. One is able in this way to determine the degree of mobility or manner of rotation.

A stone in the urinary bladder may be composed almost entirely of uric acid and not have sufficient density to cast a distinguishable shadow. The percentage of such stones is very small. Bladder stones are usually round or oval and may be facetted when numerous fairly large stones are present. They may be single or multiple. The bladder may be filled with an opaque solution or even distended with air and thus outlined, as in the case of the other hollow viscera, so that diverticula or tumors of the bladder can be readily located.

Pancreas and Spleen.—Enlargements of the pancreas can at times be diagnosed by demonstrating certain characteristic displacements of the barium-filled stomach or duodenum. Likewise the enlarged spleen can as a rule be differentiated from other abdominal masses by the manner in which it displaces the stomach and colon.

Pneumoperitoneum (Injection of Air or Gas into the Peritoneal Cavity).—This is a combined surgical and roentgenologic procedure. Such an injection in conjunction with a Roentgen ray examination enables one to visualize in shadow various abdominal organs, showing their size, shape and position, and is of special value in the diagnosis of subdiaphragmatic lesions or adhesions in any portion of the abdomen. It is a procedure which should be carried out only in carefully selected cases.

Foreign bodies may enter either the natural passages, such as the nose, mouth, gastro-intestinal tract, the trachea or bronchi, the ear, rectum or urethra; or they may enter any portion of the body by violence.

In the upper alimentary tract or in the respiratory tract the foreign body can usually be diagnosed and localized by means of the Roentgen ray, whether it is opaque or not, but in other parts of the body diagnosis and localization can only be made when the foreign body is of sufficient density to cast a positive shadow. Clothing and dressings must always be removed from the part under study to exclude extraneous foreign bodies and afford opportunity for marking the skin when necessary.

Localization.—Opaque foreign bodies in the pharynx or esophagus are best localized by roentgenograms made in the anteroposterior view and in the lateral view. If the width of the foreign body is greater than the thickness of it, then the foreign body will have its width distributed from side to side and its thickness from front to back. Such a foreign body in the larynx or trachea would have its width distributed anteroposteriorly and its thickness laterally, with, of course, the length vertical. Thus, an open safety-pin in the pharynx or esophagus would have the point to one side and the keeper to the other side, whereas, in the larynx or trachea, the point and keeper would be anteroposteriorly distributed.

One should obtain a clear shadow of the trachea in the lateral view, especially in children, and the shadow of the opaque esophageal foreign body is posterior to the shadow of the trachea.

When the foreign body in the pharynx or esophagus is not opaque, it may be diagnosed and localized by means of an opaque liquid mixture or a gelatin capsule filled with bismuth. Large foreign bodies give an abnormal shadow with the liquid mixture spreading over and adhering to it, or obstruct the passage of the capsule, and even small splinter-like foreign bodies partly embedded in the walls of the esophagus will interfere with the passage of a No. 00 capsule, as a rule.

Opaque foreign bodies in the air passages are best localized by means of anteroposterior and lateral roentgenograms. It is possible as a rule in this way to determine the position of the foreign body with relation to the larynx or bifurcation of the trachea or even to the various lobe bronchi.

Non-opaque foreign bodies in the air passages are diagnosed and localized by means of *x*-rays because of disturbance in the function of the part distal to the foreign body, either due to mechanical obstruction or to the products of inflammation. As a rule, the non-opaque foreign bodies are organic and, therefore, more or less irritating. Peanut kernel is by far the most common. When such a foreign body lodges in a bronchus it produces a local inflammatory reaction and edematous swelling of the lining membrane. At inspiration the bronchus expands and allows a small quantity of air to enter. At expiration the bronchus contracts and the swollen mucous membrane fits tightly over the foreign body and prevents the exit of air, so that there is constant overdistention of that portion of the lung distal to the foreign body. At the fluoroscope one sees the unaffected lung fill with air at inspiration and empty at expiration, whereas the shadows of the obstructed lung remain constantly bright due to expiratory obstruction. There is depression and partial fixation of the diaphragm on the affected side, whereas, on the unaffected side, the diaphragm makes

increased excursions. The heart moves laterally, so that at the end of expiration the heart has moved to the unaffected side, and at inspiration toward the affected side.

A foreign body of this type in the trachea and which is large enough to produce partial obstruction creates evidence of overdistention of both lungs. This condition has been called obstructive emphysema.

If the foreign body in a bronchus or branch bronchus is of such shape and size as to completely obstruct the bronchus to inspiration as well as expiration, atelectasis will follow, and the lung distal to the foreign body will become contracted and cause displacement of the thoracic viscera, according to the amount of lung involved.

When one finds positive evidence of obstructive emphysema or positive evidence of atelectasis the diagnosis and localization of a foreign body becomes positive in the absence of evidence of other cause.

Roentgenograms should always be made in the anteroposterior direction at inspiration and at expiration. The signs are especially striking at the end of expiration, in the case of obstructive emphysema, and especially striking at the end of inspiration, when atelectasis is present.

Foreign Bodies That Have Entered Some Portion of the Body by Violence.—Localization may be either by means of the fluoroscope or by means of roentgenograms. There are a large number of localization schemes or methods. Many of them require special apparatus and special technical skill. In all of these special localization plans the foreign body is localized with relation to a point on the skin surface. The depth and direction from this point are indicated in the report. A number of those which proved to be of most value during the World War are described here, and are taken from the U. S. Army *x*-Ray Manual (Paul B. Hoeber, N. Y.).

The Nearest-point Method.—This method has the advantage of simplicity, great speed, and a fair degree of accuracy. The method consists in palpating under flouroscopic observation the soft tissues surrounding the projectile. The instrument used for this palpation is a wooden rod about 10 inches long with a screw or some similar piece of metal at each end. Under the screen the wood is almost invisible, and the only clearly defined shadow is that cast by the metal. By the movement of the projectile under pressure on the tissues surrounding it, and the amount of pressure used, the operator is able, with care and ability, to judge what point of the skin is nearest the projectile and also the depth of the latter. Obviously, palpation at a very near point will ordinarily cause much greater movement of the projectile than will palpation at a more remote point. Likewise, palpation will cause greater displacement in the very soft tissues than it will in the more firm structures. Skill in this method increases with use, and a pressure sense is developed that proves a valuable aid to speed and accuracy. To the beginner in this method it is recommended that he combine with palpation the principle of Method B by shifting his tube and observing relative displacement of the projectile and the palpating stick. The nearest-point method is applicable to localization of projectiles in the soft tissues, the extremities, the axilla, scrotum, and buttocks, but not to the more vital and less palpable regions of the head, thorax, and abdominal cavity. By practice one becomes accustomed to palpating the soft tissues around a foreign body, and by what is termed light and deep palpation can determine the depth of the projectile from the nearest point on the skin surface. Even if the foreign body cannot be displaced by pressure with a palpating stick, the information is often of great value, showing that the projectile must be in a joint, against a bone, or embedded in deep tissue. An indelible mark is, of course, placed upon the skin at this "nearest point," and a statement is given to the surgeon as to the probable depth at this point. This method is, in brief, adapted to localization in the extremities and soft parts of the body under advanced hospital conditions where a rapid examination of the patient is a matter of great importance.

The other methods adapted for use in the army have been designated in the Army Manual by letters instead of by the names of those responsible for their development. This is not done with any idea of discrediting the author, or of indicating novelty, but for the sake of brevity, and the same idea will be carried out in these paragraphs. The more accurate methods are as follows:

A. Two-wire double-tube shift method.
B. Parallax method.
C. Tube-shift method, with mechanical triangulation.
D. Profondometer.
E. Hirtz compass with accessory devices.
F. Cannula and trocar, with harpoon.

Method A (Strohl).—Briefly, the method consists in fixing the hole in the screen directly over the central vertical ray. A mark is then made through the hole upon the skin. A diamond-shaped diaphragm or opening on the top of the tube box has a small wire stretched across each of two opposite corners. The tube is then moved either right or left in the line connecting these two corners, first in one direction until the shadow of the wire on the tube box coincides with the shadow of the foreign body. The tube is then moved in the opposite direction until the opposite cross wire coincides with the shadow of the foreign body. The distance between these two displacement shadows is then measured and the depth of the foreign body is then found according to a scale which is furnished with the outfit. In all fluoroscopic studies it is an advantage to mark the point of entrance and the point of exit of the vertical ray. This can be done by means of the skin marker, designed by Bowen, which can be pushed under the part of the body examined until the entrance of the vertical ray coincides with the shadow of the foreign body, and similarly pushed under the screen until it coincides with the exit of the vertical ray.

Method B.—This method utilizes the optical principles of parallax and may be carried out with extremely simple apparatus, although a more elaborate device has been provided by Jordon and by Lane. If one observes the shadow of a projectile upon the fluoroscopic screen while the tube is moving and the projectile be very close to the screen, the shadow movement for a given tube shift will be very slight, and the part of the body removed from the screen, or in other words, the greater the depth, the greater will be the extent of the shadow motion. If we adjust a suitable opaque body outside of the patient until the shadow moves the same distance for a definite tube shift as has been moved by the shadow of the projectile for the same tube displacement, the auxiliary body must then be in the same plane as the projectile whose depth is sought. For this purpose one may use the stick with the screw in the end described under the nearest-point method, and, for example, if one is localizing a foreign body in the thigh, the screen is placed over the top of the thigh, the central ray found, and indelibly marked at its entrance under the thigh and on top of the thigh. The screw-head of the stick in the "nearest-point method" is then held in the same vertical plane and moved upward and downward until it is found that the shadow of the screw-head moves equally with the shadow of the foreign body. This necessarily indicates the depth of the foreign body. The apparatus devised for this method of localization is provided with three horizontal arms, one of which passes under the patient and is fixed in the position of the entrance of the central ray; another arm is adjusted on top of the part under examination so that the opening in the end corresponds to the exit of the central ray; and the third arm, attached to a vertical post, is adjustable in this vertical plane so that when the depth of a foreign body has been determined its depth from above, below, or laterally can be read off from a scale marked on the rods and vertical posts.

Method C.—This is a single tube-shift method with mechanical triangulation. Fluoroscopically one again locates the vertical ray, and marks its entrance and exit on the part under examination. The exact distance between the target of the tube and the fluorescent screen must be recorded. The tube is then moved a definite measured distance. The amount of movement of the shadow of the foreign body is then recorded. By means of two crossing straight lines drawn upon paper, or by means of two cross strings attached to the wall, or by a special apparatus with adjustable arms, one replaces the positions of the tube and the two shadows on the screen as above recorded, and at a point where these two lines cross is located the depth of the foreign body. The depth is then measured on the vertical post or vertical string. If the screen be not in direct contact with the skin, the amount of separation of the screen from the skin must be subtracted from the depth as above determined.

Method D.—The profondometer (Flint). This method consists effectually in securing three lines of sight through the part under examination, each of which is to pass through the projectile. In other words, on the fluoroscopic table the vertical ray is marked at its point of entrance and exit as previously. The part of the body is then rotated, and another line of entrance and exit of the vertical ray is obtained in the same plane as before, and a third similar line, all of these lines to pass through the foreign body. Two pieces of flexible metal, such as tin, are hinged together in the middle and then molded around the part of the body in the plane indicated by the skin marks and made to conform to the shape of this part of the body. The skin marks are transferred to this metallic band. After removing the latter from the body they may be laid down on a card or a sheet of paper, and by bringing the overlapping ends

to the original position, a tracing with a pencil will show the outline of the body in the plane of examination. The skin mark positions are then transferred to the diagram, and we have an approximate duplicate of the shape of the body, and the location of the external skin markings. An atlas of cross-sections of various parts of the body is used conjointly.

Method E.—The Hirtz compass with accessory devices. Twenty-seven pages are devoted to the description of the Hirtz compass, its accessories, and its use in the U. S. Army Manual, or the *x*-Ray Manual, and a careful study of these twenty-seven pages is recommended to any who intend to use this method of localization. Briefly, the method consists in finding the location of a foreign body fluoroscopically by one of the first three methods previously described. The Hirtz compass consists of a central rod, to which is attached three adjustable arms standing on three adjustable legs, or rods used as legs. At the top of the central rod is attached an arch, and at the outer edge of this arch is attached an indicating rod, which is used to point to the foreign body. After the depth of the foreign body has been determined this central rod on the compass is adjusted in line with the vertical ray passing through the foreign body, and the three legs on this Hirtz compass are adjusted so as to conform to the shape of the body, and three marks are made to record the positions on the skin, or metallic washers are attached to the skin at the point where these legs touch. After careful adjustment the compass is fixed in position and is sterilized to be replaced on the skin of the body at the time of the operation, and it gives the surgeon the advantage of using the arch at the top of the compass to move about the central axis through 360 degrees, and in an area measured by the extent of the length of the arch at the top of the central pin. It gives the surgeon the advantage of choosing many points for his incision, and always having the indicating pin directing to the foreign body and at the same time indicating its depth from his chosen point as measured by the indicating rod. The preparation of this record by the roentgenologist is rather complicated. Its use by the surgeon is simple. If any of the adjustment screws become loosened or any of the arms displaced between the time of localization and the time of operation, all the work is lost, and must be repeated.

Method F.—Cannula and Trocar with Harpoon.—This method is considered as the least desirable of all of the methods adopted, and it is urgently advised that it never be used except by an *x*-ray operator who will either work under the direct supervision of a competent surgeon or by one who has acquired that degree of anatomic knowledge and surgical judgment which will permit him to use it without danger to the patient. The method consists in finding the projectile as in the first three methods described. Then in direct line with the vertical ray, and never at an angle to this, a trocar is inserted through the skin. A cannula is then pushed down directly in the line of the vertical ray until it touches the foreign body. A piece of piano-wire bent at one end in the form of a hook is then passed into the cannula until it passes through the opposite end against the foreign body. The hook then catches in the flesh, the cannula is withdrawn, the piano-wire is bent over and attached firmly to the skin. This serves as a guide to the surgeon in hunting for the foreign body. The method is considered dangerous and is very faulty unless the cannula be kept absolutely perpendicular and in direct line with the vertical ray passing through the projectile.

Double Plane Fluoroscope at Operation.—When the foreign body is at any considerable depth from the surface and not in close relation to any surgical landmark one of the most satisfactory means of localization is by means of the fluoroscope at the operating-table, or rather, that the operation be done on a horizontal fluoroscope with the *x*-ray apparatus so arranged that one can fluoroscope in two directions at right angles to each other. In this way one is able to guide the forceps to a foreign body at any depth and the surgeon is at liberty to select the point of incision with considerable freedom. The *x*-ray Department of the Jefferson Hospital has apparatus especially designed for fluoroscopy in two planes at right angles.

When the foreign body is in close relation to some definite or fixed surgical landmark, as, for instance, some bony tuberosity or process of articulation, one of the most satisfactory forms of localization is by means of stereoscopic roentgenograms. The surgeon is told that the foreign body is in contact with or in close relation, and in a definite plane or direction from the surgical landmark.

Depth of Anatomic Landmarks Beneath the Skin.—Metcalf and Keys-Wells have published the following table[1] in the "Lancet," of May 26, 1916, for the purpose of giving

[1] These depths were given in inches in the original table, but were converted into centimeters for publication in the United States Army *x*-Ray Manual, from which this table has been copied.

surgeons assistance in determining the exact position of a foreign body in relation to points on the skeleton. By reference to this table the surgeon will better grasp the structure to which a certain depth will lead him when the depth is given to him by the roentgenologist, as measured from the surface of the skin. These measurements have, of course, been calculated for the average soldier, and soldiers are generally neither very fat nor very thin. This fact must be borne in mind in considering these measurements.

HEAD: LATERALLY *Incision*	DEPTH OF ANATOMIC POSITION
Just above zygoma	2.5 cm. to sphenosquamosal suture.
Just below zygoma	4 cm. to sphenoidal bone.
To coronoid process or condyle of mandible	2.5 cm.
NECK: ANTEROPOSTERIORLY	
Through center of larynx	5 cm. to body of vertebra.
3 cm. to side of center of larynx	4 cm. to transverse process of cervical vertebra.
3 cm. to side of center of larynx	7.4 cm. total depth of neck.
Through middle line of trachea just below cricoid	4 cm. to body of vertebra.
3 cm. to side of center of trachea	4 cm. to transverse process of vertebra.
From center of suprasternal notch	3 cm. to posterior border of manubrium.
NECK: LATERALLY	
From center of middle of neck	4 cm. to transverse process of vertebra.
From center of middle of neck	6 cm. to body of vertebra.
From just below tip of mastoid process	6 cm. to body of 1st cervical.
CHEST: SUPERIORLY	
From a point midway between root of neck and tip of acromion	5 cm. to apex of pleura, downward.
From a point midway between internal and external extremities and just behind posterior border of the clavicle	5 cm. to apex of pleura, downward.
CHEST: ANTERIORLY	
From center of lower border of clavicle backward to subscapular fossa just clear of ribs	7.5 cm.
From a point just over tip of coracoid to subscapular fossa backward	7.5 cm.
From a point 2.5 cm. external to sternoclavicular joint just below clavicle	3.5 cm. to 1st rib.
From a point 2.5 cm. external to sternoclavicular joint just below clavicle	2 cm. to pleura.
From a point 5 cm. external to sternoclavicular joint just below clavicle backward	3 cm. to 1st rib.
From a point 5 cm. external to sternoclavicular joint just below clavicle backward	4.5 cm. to pleura.
From a point 5 cm. below center of clavicle	5 cm. to pleura.
CHEST: POSTERIORLY	
To supraspinous fossa	2.5 cm.
To intraspinous fossa	2 cm.
To transverse process of seventh cervical vertebra	4 cm.
To pleura level of seventh cervical vertebra	5 cm.
To anterior level of body of seventh cervical	7.5 cm.
To transverse process of twelfth dorsal vertebra	3.5 cm.
To pleura level of twelfth dorsal vertebra	5 cm.
To anterior level of body of twelfth dorsal vertebra	8 5 cm.
ABDOMEN: THICKNESS OF WALL FROM FRONT	
1 cm. to either side of middle line just above umbilicus	2.5 cm.
1 cm. to either side of middle line just below umbilicus	3 cm.
Just internal to anterior-superior spine to iliac fossa	7.5 cm.
Midway between anterior-superior spine and pubic crest to front of acetabulum	5 cm.

ABDOMEN: THICKNESS OF WALL FROM SIDE	DEPTH OF ANATOMIC POSITION
On level of tip of twelfth rib in line upward from anterior-superior spine	2.5 cm.
ABDOMEN: THICKNESS OF WALL FROM BACK	
To transverse process third lumbar	4.5 cm.
To anterior level of body of third lumbar	11 cm.
To anterior level of psoas muscle	13 cm.
HIP AND THIGH FROM FRONT	
8 cm. below anterior-superior spine to head of femur	6 cm.
8 cm. below anterior-superior spine to neck of femur	5–7 cm.
15 cm. below anterior-superior spine (level of lesser trochanter) to front of femur	4 cm.
To greater trochanter	11 cm.
To lesser trochanter	9 cm.
Brim of pelvis 2.5 cm. in front of sacro-iliac synchondrosis	9.5 cm.
To anterior-inferior spine	3 cm.
To spine of ischium	12.5 cm.
To ischial tuberosity	13 cm.
To anterior surface of line of junction of ascending ramus of ischium and descending, of pubis	7 cm.
HIP AND THIGH FROM BACK	
To ischial tuberosity	6 cm.
To spine of sacrum on level of posterior-superior spines of ilia	3 cm.
To sacral groove	5 cm.
To head of femur	5 cm.
To great trochanter	9 cm.
To lesser trochanter	7.5 cm.
To brim of pelvis 25 cm. in front of sacro-iliac synchondrosis	10 cm.
To anterior-inferior spine	15 cm.
To spine of ischium	5 cm.
To posterior surface of junction of ascending ramus of ischium and descending ramus of pubis	11 cm.

The Localization of Foreign Bodies in the Eye.—This involves the most accurate localization. A knowledge of the exact position of the foreign body is necessary for the ophthalmic surgeon to determine whether the eye can be saved or not. For this purpose the previously described methods of localization are too crude, and the use of the perfected Sweet localizer or the more simple Sweet-Bowen localizer is recommended, and for the use of these special skill is required of the roentgenologist and a familiar knowledge of the detailed technic which can be found either in the United States Army *x*-Ray Manual or in the articles written by Drs. Sweet or Bowen.

Roentgenotherapy in Surgical Diseases.—The field of roentgenotherapy is very wide, but in this chapter will be considered only those diseases which are generally treated by the surgeon, and in which roentgenotherapy has been found beneficial. There will, therefore, be no reference made to skin diseases excepting epitheliomata. Reference to the paragraph of this chapter on the biologic effect of the *x*-rays will give the reader an idea of the theory of the action of the rays on the various diseases under consideration and will help him to understand the effects produced (pages 1438, 1460).

High Voltage Treatment.—During the last decade apparatus and tubes have been developed to operate at a voltage as high as 200,000. Formerly only about 100,000 volts could be used. By means of this modern apparatus the intensity of the *x*-ray beam is greatly increased, and, with increased filtration of the rays, greater effect can be produced in the depth without increasing the effect on the surface. These rays of high penetration and great intensity are especially adaptable to deep-seated tumors in the abdomen and pelvis and to bone tumors. It is necessary to exercise great care in measuring the dose and selecting the areas for exposure, as it is quite possible to do damage in the depth without producing any visible surface effect.

The following notes on measurement of intensity and penetration of *x*-rays were made by Mr. J. L. Weatherwax, Physicist to the Radiologic Department of the Philadelphia General Hospital:

Apparatus for Measuring the Intensity and Penetration of *x*-Rays.—The roentgenologist is interested in the intensity and quality of *x*-rays in *x*-radiation treatment. The *x*-ray intensity determines the dosage given and the quality of *x*-rays determines the percentage of *x*-radiation reaching any desired depth in the tissue.

In obtaining a quantitative measurement of the intensity of *x*-rays it is necessary to obtain the changes produced by *x*-rays in bodies, the quantitative measurements being proportional to the intensity. There are two practical methods employed to measure the intensity, namely, chemical effects produced by *x*-rays and ionization of gases by *x*-rays.

It has been proved in the United States and abroad that the chemical effects, as manifested in the blackening of a photographic film, are not in direct proportion to the intensity of *x*-rays producing them. This method should only be used as a rough comparison of the intensities of *x*-rays.

The chemical effect of *x*-rays on lowering the resistance of a selenium cell is used by Furstenau, but the action of *x*-rays causes the selenium cell to become fatigued. It is claimed that a correction is made for the fatigue.

The method of measuring the *x*-ray intensity by ionization of gases is reliable, and measurements can be made directly, thereby eliminating personal errors arising from the photographic method, or any error due to the fatiguing of selenium cells.

Ionization measurements of *x*-ray intensity should be divided into two classes: (1) measurements made of the constancy of the output of *x*-radiation during routine treatments by *x*-rays; (2) measurements made of penetration of the field *x*-rays, using some phantom to represent the tissue.

Considering measurements of the constancy of *x*-ray intensity, it is necessary to obtain an apparatus to be constantly in the field of *x*-rays, to be so rugged that the roentgenologist can operate it. It permits direct reading.

The Duane ionization system fulfils a part of the specifications, but fails because the ionization chamber is movable and the galvanometer is very sensitive, so sensitive that the services of an expert are required to keep the ionization system in operation.

The Furstenau intensimeter is a direct reading instrument, but the ionization chamber is movable and is only used occasionally to check the output of *x*-radiation.

The Solomon ioniquantimeter and the Friedrich and Kroenig ionization system are not direct reading, but function by the *x*-rays discharging an electroscope, the time of discharge being recorded by a stop-watch. The ionization chambers are both movable.

Failla, of the Memorial Hospital, and the writer, at the Philadelphia General Hospital, have constructed apparatus embodying the foregoing specifications. The ionization chamber is fastened in line with the direct radiation at a point where the *x*-rays emerge from the filter. The ionization chamber is constructed of 1 mm. of aluminum and takes the place of the secondary filter. A rugged galvanometer erected in the booth of the operator projects a beam of light on a scale. The position of this beam of light on the scale is proportional to the intensity of *x*-rays. A reading is always registered on the scale of the galvanometer whenever *x*-rays are passing through the filter. The operator, therefore, reads the voltage and milliamperage of input of electric energy and reads the output of *x*-radiation on the galvanometer scale. The advantage of having a fixed position for the ionization chamber is that the apparatus always functions, and the advantage of having a continuous direct reading of output of *x*-radiation is that it is impossible to use the wrong filter, or to ever omit a filter. There is also the satisfaction of knowing the output of *x*-radiation is remaining constant.

The measuring devices with movable ionization chambers are reliable, but they are like a new toy in that the newness soon wears off and fewer and fewer checks are made on the *x*-ray machine, so that eventually the apparatus is soon covered with dust.

Failla reported at the January, 1924, meeting of the Eastern Section of the American Roentgen Ray Society that in visiting hospitals in Europe, that in only a very small percentage of *x*-ray machines in use, did he see any intensity measurements being made. Most of the roentgenologists had measuring instruments, but were not using them.

Measurements of penetration cannot be obtained by the apparatus just described. Here a small movable ionization chamber connected to an electroscope or electrometer is preferable, the idea being to be able to measure small changes in *x*-ray intensity in a phantom representing the tissue. Measurements of penetration to any degree of

accuracy should be left to the electric engineer or to the physicist, for the average roentgenologist does not have the time to make the great number of painstaking measurements necessary to obtain accurate results, and he has not had sufficient training along physical lines to make it possible for him to differentiate between accurate and inaccurate measurements.

Malignant Diseases.—Under this heading may be included by far the greater number of surgical diseases in which roentgenotherapy has been found beneficial. The Roentgen rays have their greatest effect upon the cells which approach the embryonic type, or those of recent origin or rapid growth, and least effect upon the normal tissue cells which usually make up the surroundings of the malignant tissue. Much experimental work and much microscopic study have been done upon malignant tissue to determine the effects of the Roentgen rays and radium rays.[1] Contamin did a number of experiments on the tumors growing upon mice. They were carcinomata of a granular type, and as a result of these observations Contamin drew the following conclusions: First, the action of the *x*-rays is the greater in younger and more actively growing tumors; second, the disappearance of a large tumor caused the death of the animal probably from intoxication. The disintegration products of the cells which have been injuriously affected by the rays are eventually absorbed by the body. When this absorption is excessive it leads to a state of intoxication.

Nogier, Jaubert de Beaujeu, and Contamin removed an adenocarcinoma from a mouse. It was then exposed to the *x*-rays, after which it was inoculated into normal mice to see whether it would grow. Under exposure to the soft rays, in which 50 per cent. of the rays were absorbed by the tumor, these inoculations gave no positives or "takes" and 15 negatives, while the controls gave 14 positive inoculations and one negative. The authors conclude from these, and similar observations, that the action of the rays is rather to hinder the subsequent growth of the tumors and to prevent their "taking" on inoculation. This is quite analogous to the effect of radium emanation upon the cells of rat sarcoma as shown by Jensen. In many cases where the histologic features of the irradiated tumors were under investigation only a small portion of the growth was exposed to the rays, the remainder being protected by a stout lead screen. In one tumor examined by Contamin only a small area, the size of a pea, was so exposed, the remainder of the neoplasm thus showing as a convenient control. Two exposures of one hour were given on two consecutive days. Four days after the first irradiation the tumor was removed and prepared for histologic examination. The non-irradiated part of the growth presented the character of a granular carcinoma, the cells having comparatively little cytoplasm, and the nuclei being round or oval. In the irradiated area the most marked change was the formation of cavities resembling cysts which originated in the center of cellular masses constituting the acini of the growth. Their walls were formed by the neoplastic cells themselves, which in consequence of the pressure exerted upon them by the contents of the cysts had become flattened and otherwise more or less distorted. The cyst contents, after treatment with the usual histologic fixing agent, presented a finely granulated appearance, while in the larger cysts hemorrhages were of frequent occurrence. In addition to this cystic stage a commoner feature was the marked increase in the amount of stroma. The constituent fibers were densely packed together and, in addition, the nuclei of the connecting tissue cells were elongated and abnormal in contour. A considerable diminution in the number of neoplastic cells was observed, and those which survived were more or less segregated into small groups by the greatly hypertrophied stroma. The cell groups were, however, observed not to be compact, but, on the contrary, here and there were clear spaces and islands of degenerated cells. Another feature of the cell groups was that they were retracted from the stroma so that they did not come in contact with it, a condition of marked contrast to that obtained in non-irradiated areas, where the connection between the neoplastic cells and the stroma was remarkably close and intimate.

In the case of tumors removed eight days after the initial radiation cysts were, generally speaking, absent; the main feature was the enormous increase in the stroma and the consequent subdivision of the cell masses into yet smaller islets, the section presenting an appearance as if the cells were undergoing strangulation by the fibrous tissue.

If the mouse bearing a tumor be exposed to *x*-rays the tumor excised, and subsequently grafted into normal mice, then after slight irradiation the grafts develop into tumors, but do not grow so quickly as the untreated tumor. After longer ex-

[1] "Radium, *x*-Rays, and the Living Cell," Colwell and Russ.

posure the graft may remain in the animal for weeks without showing any signs of growth, and may then very slowly develop into a tumor. After still more prolonged exposure no growth at all takes place.

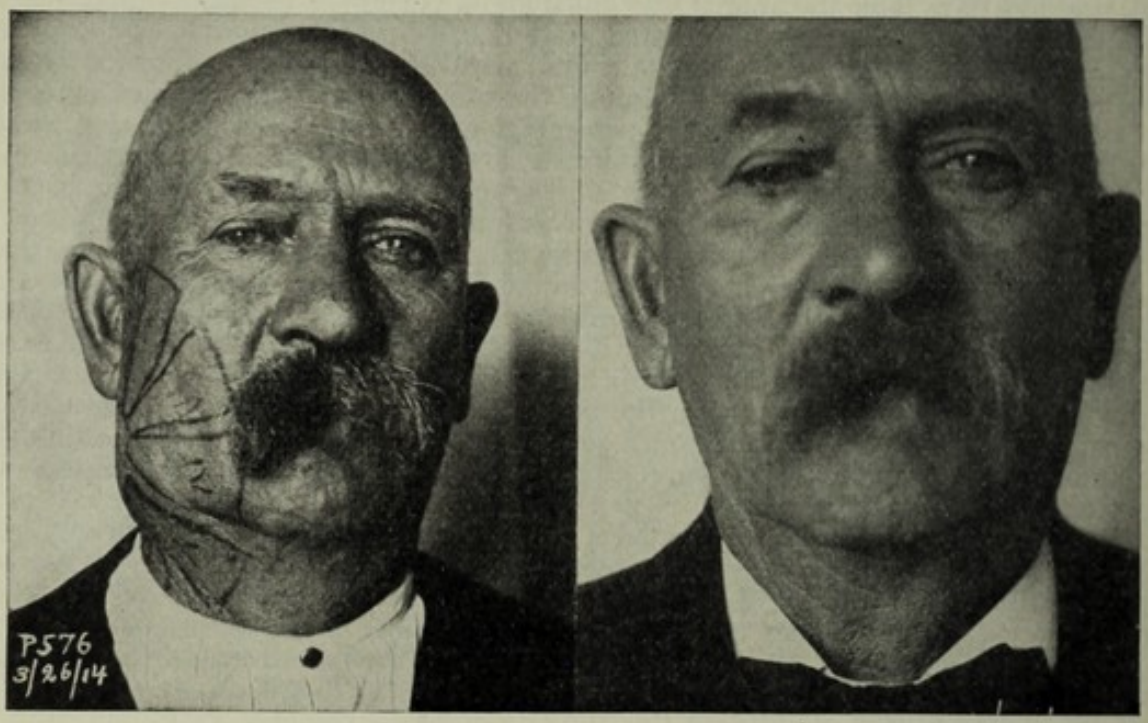
These observations become a strong factor in favor of anteoperative treatment. By that I mean treatment just preceding the operation, the *x*-ray treatment to be followed by operation in a few days. A tumor which has received a lethal dose shows no histologic changes if it be examined at once, that is, a few hours after the exposure, but if it be left in the animal and portions be removed on succeeding days certain degenerative changes begin to make their appearance, and these changes are quite generally well established by the fifth and sixth days, the time depending upon the type of tumor and the amount of radiation.

Marie, Clunet, and Raulot-Lapointe made a study of the effect upon the heredity of the characters imposed upon tumors when they are exposed to the *x*-rays. The mouse bearing the tumor (a sarcoma) was exposed to a strong dose (30 H) of unfiltered rays, and five days later the animal was killed and a portion of the tumor grafted into a number of mice. When this irradiated graft had grown to a suitable size a mouse with the tumor was treated the same as the first, and this process was kept up for twenty months. The new characters imposed upon the tumors were found to consist mainly of, first, the reduction in the number or percentage of successful grafts; second, a reduction in the malignancy of the tumor; third, a slower rate of growth and certain histologic features of which the following were the most important: (*a*) The presence of giant-cells, some of the cells being as much as four or five times their original diameter; (*b*) atypical mitosis; (*c*) basophil (giant-) cells, having multiple nuclei. In order to determine whether these characteristics would be transmitted through a number of generations, even if entirely removed from the rays, they took one of these tumors and grafted it onto a mouse, and when it had attained sufficient size the mouse was killed and a section again grafted onto a new mouse, no rays being applied. It was found that there was a tendency on the part of the tumor gradually to return to its original condition, but even in the sixth generation there were many cells showing the characteristic abnormalities, (*a*), (*b*), (*c*), produced in the tumor cells by the previous exposure to the *x*-rays.

Clunet and Raulot-Lapointe treated a number of cases of carcinomata and sarcomata, and at various stages of the treatment removed portions of the growth for histologic study. As a result of observations of this nature upon 19 cases of squamous cell carcinoma of Malpighian type in the human subject they state that before the ultimate disappearance of the growth the cells passed through at least five successive phases, which have been characterized as follows: (1) The latent phase, which varies from six to fifteen days and during this time no cytologic changes are to be seen; (2) the development of monstrous characters, (*a*) an enlargement of all parts of the cells which may be increased in diameter as much as two or three times, (*b*) an increased number showing a typical mitosis, (*c*) appearance of enlarged nuclei, markedly chromophilic, (*d*) the appearance within the cells of forms having a pseudoparasitic character; (3) keratinization may be either disseminated, total, or antipodal (if disseminated each cell undergoes keratinization independently of its neighbor in contrast to those effects appearing to influence all cells alike); (4) disintegration and phagocytosis (the disintegration of the degenerating cells appears to be caused mainly by the polynuclear cells and the fibroblasts of the stroma which are in an active condition. Macrophages and plasma cells appear at a later stage and accumulate around the vessels, remaining in the vicinity long after the disappearance of the malignant cells. At the periphery of the keratinized masses plasmodia are sometimes found simulating the type presented by the cells of the neoplasm, but they are rarely found in great numbers. The masses of degenerate cells before they are entirely destroyed may cease to give color reactions of keratin, and remain encapsulated in the dermis for prolonged periods); (5) formation of the connective-tissue scar (as a general rule this is not brought about by the formation of fibrous masses, but the tissues assume the structure of healthy skin except for the absence of hair and of glands. The elastic fibers are also less numerous and more attenuated than they are normally. No neoplastic masses are to be found in these supple scars which appear to be quite healthy; on the other hand, at a depth below the skin cells may be found which have been acted upon by the *x*-rays, but are not yet destroyed; such cells remain in a latent condition, and if the treatment be not continued they give rise to recurrences. They are distinguished by a very chromophilic nucleus, though not pyknotic, a reduced amount of protoplasm and an avidity for basic coloring material).

Sarcoma.—Clunet and Raulot-Lapointe[1] found when sarcomatous growths are exposed to *x*-rays that a somewhat similar transition in the cellular characteristics occurs, but the latent phase, during which no changes are observable, is very much shorter than in the other types of malignant growth considered; instead of being from six to ten days it is generally one or two days.

Of a spindle-cell sarcoma after having been exposed to a rather small quantity of unfiltered *x*-rays (9 H), their description is as follows: "The fibrosarcomatous zone separating the granulation tissue from the normal dermis on one side and from the pure sarcoma on the other seems to show that at a certain depth the rays, although too feeble to destroy the neoplastic cells of the connective tissue, have nevertheless caused a profound alteration in the biologic evolution of these cells; the rays have caused the cells to secrete collagen and to take on the morphologic characters of a fibroma, a benign tumor." Dominici found similar changes in a fibrosarcoma exposed to the gamma rays of radium (Dominici, "Archives de Médecine Générale," 1909).



a *b*

FIG. 1190.—(*a*) Sarcoma of the neck illustrating the manner of crossfiring upon this disease. Patient was considered inoperable. Treatment was begun March 26, 1914, and finished April 9, 1914. There has been no treatment since. The patient has remained well six years.

(*b*) Photograph made October 23, 1915, showing complete disappearance of the tumor. No damage to the skin. No difference from the normal side (Pfahler, "Jour. Amer. Med. Assoc.," May 1, 1915, vol. lxiv, pp. 1477–1485).

These and other experimental and pathologic studies of the effects of the Roentgen rays upon malignant disease should convince the most skeptical of the value of the Roentgen rays in the treatment of malignant disease. The evidence is especially convincing when taken together with the mass of clinical observations made by various authors upon the disappearance of malignant disease.

Skill in the application of the Roentgen rays for therapeutic purposes is no less important than skill in the application of surgery in the treatment of disease, and unless one keeps in mind continually the object to be obtained and pays the most careful attention to all details, the results are likely to be disappointing. All cases of malignant disease do not react in the same manner: there is some difference even in the same type as shown microscopically. The results obtained probably depend, too, in part, upon the general resistance and power of reaction as shown in the individual patient. In a general way sarcomata are more responsive to *x*-ray treatment than carcinomata. And of the epitheliomata, those made up of the basal cells are more responsive than those made up of the spindle-cells.

Lack of skill in the use of roentgenotherapy may do much harm. Harm may be done by insufficient treatment which will permit the disease to invade the surrounding

[1] "Radium, *x*-Rays, and the Living Cell," Colwell and Russ.

tissues and extend to deeper tissues, or harm may be done by destroying the surface of a growth and even the surrounding healthy skin without destroying the deep part of the tumors. At times, even under insufficient treatment, the surface of an epithelioma, for example, may heal, the ulcer be closed, but the deeper lying cells remain, and if insufficiently treated will invade other tissues, and bring about a recurrence or metastasis. In this respect roentgenotherapy resembles any other form of meddlesome or insufficient treatment of carcinoma.

Harm can result from too long treatment. In these cases, of which many have occurred, *x*-ray treatment has been applied with superficial effect, and, carried over a long period of time, leads to the development of telangiectasis and a thick fibrous scar tissue with secondary degeneration into carcinoma. The treatment of epithelioma may produce a severe burn indistinguishable by the untrained from the original carcinoma, and thus treatment may be prolonged with the hope of controlling the carcinoma and conditions be made worse. Harm will always result from the treatment of cases which are not suitable for *x*-ray treatment.

In most cases *x*-ray treatment can be combined to great advantage with other forms of treatment for malignant disease, of which we mention first surgical excision, second, local destruction by electrocoagulation, and third, the application of radium to the inside of cavities, the *x*-rays being applied externally. Radium and *x*-rays should not be used at the same time or within the same month over any one area of skin or mucous membrane, for the action of the two agents is very similar, and overdosage is likely to result.

Epithelioma.—The epitheliomata involving the skin can nearly all be cured by skilful treatment with the Roentgen rays, and when combined with electrocoagulation (see page 1468) all can be cured if treated early. Most of this group of epitheliomata can also be cured by excision, and unless a specialist can be obtained who has skill in the application of roentgenotherapy they had better be excised. Of the epitheliomata the basal-cell variety is much more respondent; the squamous or spindle-cell epitheliomata are much more resistant to the Roentgen rays, as well as to any other form of treatment. The majority of the epitheliomata occurring on the skin are of the basal-cell type. Those occurring on the mucous membrane and on the back of the hand are more likely to be of the squamous-cell type, and are very resistant to treatment. Generally in these cases I believe radiotherapy alone cannot be depended upon, but should either be combined with surgical excision or, better, electrocoagulation.

The advantages of the Roentgen rays in the treatment of epithelioma are, first, the painless applications; second, the absence of deformity, and this is especially important when in the neighborhood of the eyelid or the side of the nose. The disadvantages of the treatment of these growths by radiotherapy alone are, first, the slowness of the result to be obtained; second, the inability to examine the growth microscopically. In the treatment of recurrent or advanced epithelioma the keenest judgment and the greatest skill are required. In these cases generally the treatment should be combined with some other form of treatment, either with surgical excision or local destruction by electrocoagulation. The metastatic glands should be thoroughly excised. Surgical excision should also be used when the disease involves the neighborhood of vital organs or nerves, such as at the angle of the jaw in which the disease is liable to overlie the carotid vessels. In other cases where the disease involves areas overlying structures which are less vital the disease can be destroyed by electrocoagulation first, active deep roentgenotherapy being applied immediately after.

Deep-seated Malignant Disease.—In the treatment of deep-seated malignant disease the Roentgen rays can be thought of chiefly as an adjunct to surgical treatment. When, for some reason, surgical excision is impossible, skilful application of deep roentgenotherapy is undoubtedly the next best choice. In the treatment of deep-seated malignant disease surgical excision should, when practical and when there is an opportunity, always be followed by roentgenotherapy.

The Treatment of Recurrent and Metastatic Carcinoma.—There is a great variation in the results obtained from the treatment of recurrent and metastatic carcinoma, and at present no one can decide which cases will respond to roentgenotherapy, and which will progress in spite of treatment. In nearly all cases treated there will be some improvement, and in many cases the local evidence of disease will disappear, at least so far as visible evidence is concerned. The patients may be free from local symptoms and in some of these cases they are free for a year or more, when the disease recurs with more extensive distribution. Generally a second recurrence is uncontrollable.

In some few cases one may obtain a permanent disappearance or cure. In general, thorough skilful application of the Roentgen rays, according to modern technic, will give more satisfactory results in the treatment of recurrent carcinoma than any other known method. Metastatic carcinoma may be made to disappear in many instances, but here again there is some peculiarity in the nature of the disease which will cause some cases to yield to treatment, while others only show improvement for a time, but do not get well. Pfahler has reported 4 cases in which metastatic carcinoma of the spine, secondary to carcinoma of the breast, showed complete healing of the lesions

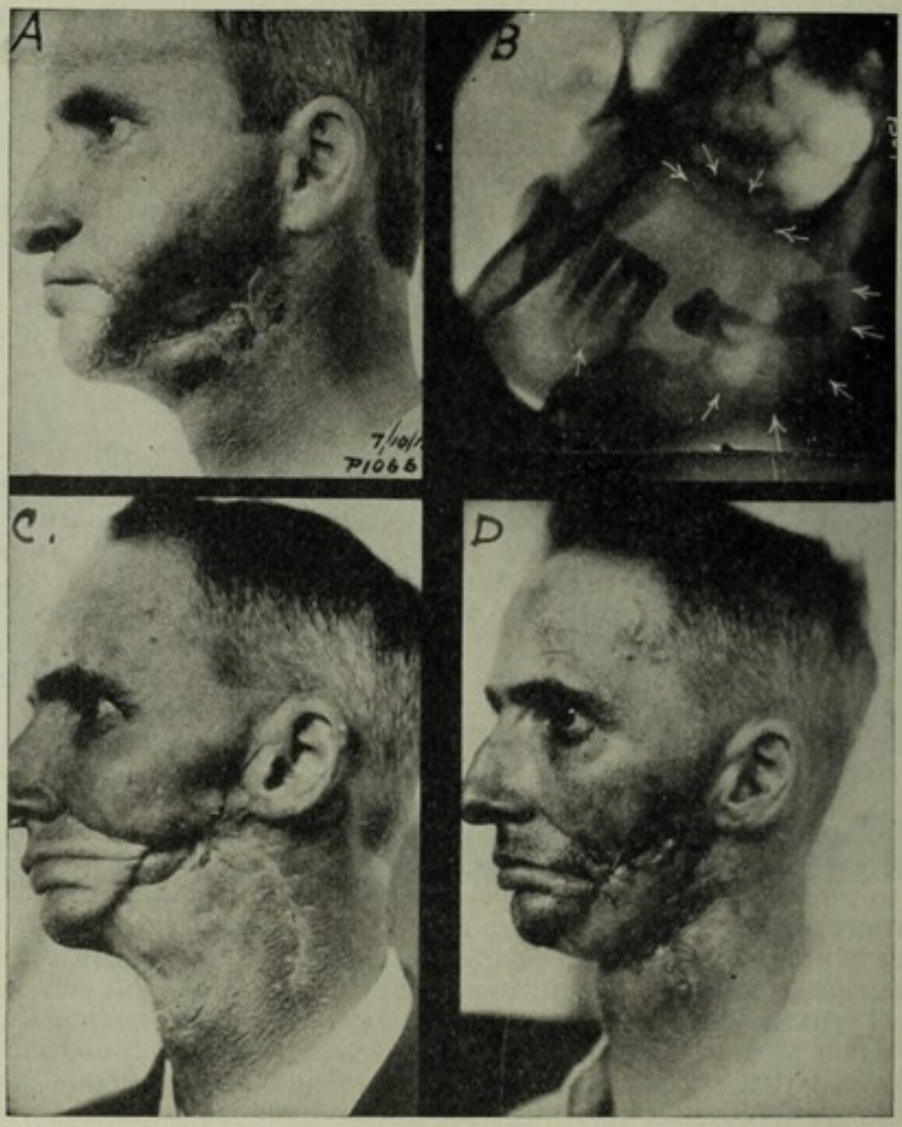


FIG. 1191.—A case of carcinoma involving the left cheek, the alveolar process in the left upper molar region, the anterior pillar of the fauces, the posterior two-thirds of the inferior maxilla, with a mass of metastatic lymph-nodes the size of a small hen's egg. The disease in the mouth was destroyed by electrocoagulation, the metastatic glands were dissected out, and the left half of the inferior maxilla resected June 10, 1915. This was followed by radium applications inside the mouth and *x*-ray treatment externally. The patient is still well May 10, 1919 (Pfahler, "Jour. Amer. Med. Assoc.," Nov. 18, 1917). *A*, Area destroyed after the slough has separated. *B*, Rontgenogram showing the destruction in the jaw by carcinoma, with the projection forward of one of the molar teeth. *C*, After first attempt to close the mouth. *D*, Showing mouth closed. The patient is a traveling salesman and is at work daily.

which had caused total destruction of one or more of the vertebræ, and the patients have remained free from symptoms for from one to two years. Metastatic carcinoma of the spine is, however, only a part of a general carcinomatosis, and sooner or later we believe that the victims must succumb to a general carcinomatosis, and this has been Pfahler's experience in all but one of these cases.

Ante-operative *x*-Ray Treatment.—It has been shown in the preceding pages (see pages 1460, 1461) that in experimental work application of the Roentgen rays to a tumor reduces its malignancy, reduces the power of transplantation, and

causes destruction especially of the more actively growing cells. This is accomplished when skilfully done without damage to the healthy tissues because of the hypersensibility of the malignant cells. For this reason Pfahler recommends a thorough application of the rays before any cutting operation is performed. Up to the present time no ill results have followed such ante-operative application. The wounds heal normally, and while we have only followed this method for about three years, and are therefore unable to draw definite conclusions, the results seem to justify it.

Boggs and Pfahler have each recorded cases of inoperable carcinoma of the breast made operable by roentgenotherapy, but in those cases the treatment was not given with the object of actually destroying the cancer. It was given with the idea of destroying or sealing off the lymphatic extensions, and causing a shrinkage in the growth by the action of surrounding fibrous tissues as is indicated in the paragraph

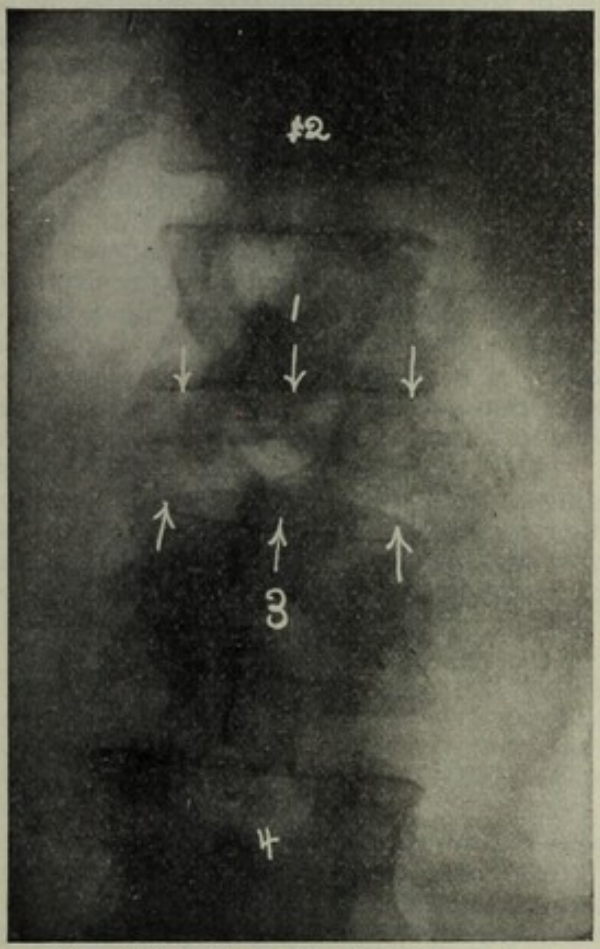


FIG. 1192.—Case of metastatic carcinoma, probably present before operation for carcinoma of the breast. Patient became bedfast three months after the amputation of the breast. Remained in bed fifteen weeks. Roentgenogram was made March 17, 1918. In four months the patient was able to attend to her housework with the support of a brace (Pfahler).

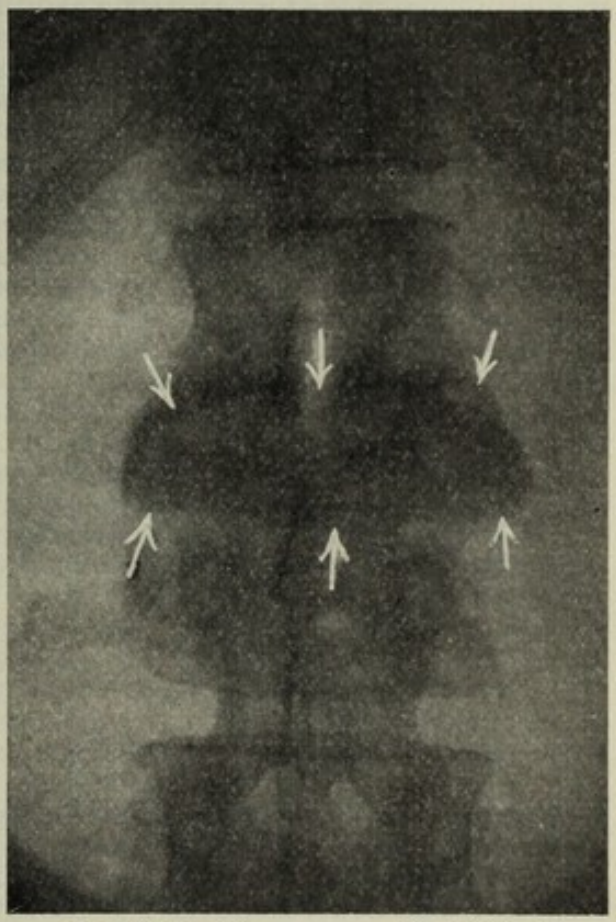


FIG. 1193.—Same case as Fig. 1192. Showing complete recalcification of the second lumbar vertebra. Roentgenogram made March 17, 1918, one year after the first, and one year after beginning treatment. Patient is doing all the general housework, including washing and ironing. Is wearing no brace, and is apparently well (Pfahler).

on experimental and pathologic studies of carcinomatous growths. The cutting operation was then done with the idea of removing the fibrous tissues, including the encapsulated malignant cells. Such prolonged ante-operative treatment requires much skill and good judgment, and it should not be used in an operable case. The ante-operative treatment which Pfahler believes can be applied with advantage to every case of deep-seated malignant disease requires only a few days during which a thorough course of treatment can be given with the Coolidge tube technic. The disease is cross-fired upon from every angle, and all the outlying lymphatic areas are included in the field of treatment. If the dose be carefully measured no harm can result. The postoperative treatment can then be started four weeks later.

Postoperative Roentgenotherapy.—This should be applied in all cases of malignant disease. It should be applied with the object of reaching any cells which may have

extended beyond the palpable growth even before the operation, and of devitalizing any malignant cells that may have been transplanted or dissipated or disseminated during the operation. When practical it can be applied to advantage in the open wound immediately following the operation. This is generally not practical for various reasons. Therefore, this treatment should be given as soon after the operation as it is found practical to move the patient to the Roentgen laboratory, but if ante-operative roentgenotherapy has been used, and full doses given, it must not be undertaken in less than four weeks from the preceding treatment. This treatment should be given from every angle possible, and over every area to which the disease is likely to have extended, or is likely to extend. The amount of treatment required depends upon the amount of disease, the duration, the rate of growth, but generally, in a breast case for example, a single course or series of treatments will occupy two or three different days. Such a course of treatment, or series of treatments, should be repeated in a month, and repeated at intervals of a month or more from three to ten times, depending upon the stage of the disease and the degree of malignancy at the time of operation. In abdominal carcinoma more treatments are usually required, first, because the disease is more deeply situated, and second, because the lymphatic distribution of the disease is more likely to be extensive.

Sarcoma is more sensitive to the Roentgen rays than carcinoma, and unless one is quite sure that the disease can be completely excised it is better treated by *x*-rays than by excision, but it is likely that a combination, ante-operative roentgenotherapy, excision, and postoperative roentgenotherapy, will give the most satisfactory results. When the rays are depended upon alone massive dose therapy and treatment from every angle possible cannot be urged too strongly.

Cervical adenitis can be treated successfully by roentgenotherapy. These lymph-nodes are more responsive the earlier the applications are made. According to modern technic the applications are made from as many angles as possible, cross-firing upon the disease, and this is done once a month. If the treatment be begun after there is localized tenderness or softening, the softening process will be hastened. When any of the cells become softened they should either be excised or drained away, or, probably better, the area should be aspirated and an injection of the following solution used, as has been recommended by Phender:

Olive oil	70	parts
Ether	30	"
Creosote	3	"
Guaiacol	1	"
Iodoform	10	"

In some cases in which the disease has persisted for some time, and in which there is much fibrous tissue, the nodes may not disappear completely under roentgenotherapy, but they may become calcified, so that one may obtain a complete chain of calcified lymph-nodes as a result of this treatment. Therefore treatment should not be prolonged too much with the hope of causing a complete disappearance. Calcification indicates healing, for we well know that tuberculous lesions heal in this manner. The quickest and best method, however, is complete excision, in which small and large lymph-nodes are removed, and this should be followed by thorough deep roentgenotherapy. These applications should be made two or three times at intervals of a month. This is usually sufficient to prevent other glands from becoming enlarged as so frequently happens after an operation upon the area.

Enlarged lymphatic glands, from whatever cause, can be made to disappear under skilful roentgenotherapy. In the treatment of cervical adenitis by this method a dermatitis should always be avoided, and the treatment should never be carried to the point of producing a reaction in the skin nor should it be continued too long. If this be done, there is very likely to result at some time later, possibly at the end of a year or two or three, telangiectasis, together with an atrophic scar-like condition of the skin. A dermatitis is always hastened by the local application of other agents, such as liniments, poultices, etc., so that when a patient is sent for *x*-ray treatment no other local application should be made at least within a month after its completion. Roentgenotherapy is usually chosen in these cases because it is supposed to produce better cosmetic results by preventing unsightly scars which sometimes follow surgical excision, but if a dermatitis be produced the end-result may be worse than that produced by a surgical operation. The *x*-rays have been used in certain infections and

George G. Ross reported a case of facial carbuncle treated by them ("Annals of Surgery," July, 1917).

Exophthalmic Goiter or Graves's Disease.—The thyroid gland is especially sensitive to the Roentgen rays. In very small doses there is the possibility of stimulating the thyroid gland, but as the rays are applied in modern deep therapy technic and in massive cross-firing doses there is an atrophic action upon the cells. The secretion of the gland is diminished, the secreting cells being the first to be affected. Then there is a gradual atrophy of the gland with consequent diminution in its size. By modern technic the gland is treated by massive doses, cross-firing from two to six different directions, or fields of entry, and this series is given about once a month. As a result there is first noticed a decrease in the nervous symptoms which can sometimes be seen at the end of a month, but will be seen almost certainly at the end of two months. With this there is a decrease in the pulse-rate and increased weight, and gradually there is a reduction in the size of the gland, although the disappearance of the thyroid enlargement and of the exophthalmus occurs last. It usually requires from six to twelve months to produce a cure. The pulse-rate at times returns to normal, but generally it remains slightly above normal, either due to some permanent damage to the heart, or because the treatment has not been carried on long enough. Generally at the end of six months or a year the condition has been restored to normal so far as the patient can recognize. This treatment has the disadvantage of slow results because to produce results one must wait for an atrophy of the gland. It has the advantage, however, of avoiding the shock of an operation, and can be applied especially to inoperable cases. It can be applied to those cases in which operation has not brought about sufficient benefit, or the treatment can be applied with the idea of reducing the secretion and preparing the patient for any later operation. By operation one reduces the size of the gland, thereby diminishing the secretion. By roentgenotherapy the amount of secretion is reduced by a reduction in the secreting surface or secreting area of the entire gland.

Simple goiter should not be treated by the Roentgen rays until after a careful study has been made as to the etiology of the enlargement, for in many cases the enlargement of the thyroid is purely compensatory, and in such instances either operation for its removal or treatment by roentgenotherapy is in direct opposition to Nature's efforts to relieve the patient of other more serious conditions. When there is a distinct hypertrophy of the thyroid gland, which cannot be accounted for by the theory of compensation, and operation is contraindicated, it can often be treated successfully by the Roentgen rays, but the results obtained will be more satisfactory and more prompt the earlier in the stage of the disease the applications are made. Cystic goiter is not likely to respond to roentgenotherapy, and unless there be some contraindication the patient should be sent for operation at once.

Fibroids of the uterus can be successfully treated by roentgenotherapy, just as a hyperplasia or tumor formation anywhere in the body can be reduced by thorough application of *x*-rays. When the tumors are large or when there are no contraindications they had better be removed surgically. Generally the cure of these cases is followed by amenorrhea, but this is not inevitable. Pfahler and McGlinn reported a case in which, at exploratory operation, it was found that removal of the fibroid would mean sacrifice of the uterus—an operation not expedient under the circumstances. The exact position of the fibroid having been determined, the abdomen was closed, the *x*-rays were confined to the fibroid area, the ovaries being protected, and the tumor was removed completely. At no time did the patient cease menstruating or have any menstrual disturbance. At the proper time the patient was allowed to become pregnant, and gave birth to a full-term, healthy, normal child. When the exact location of the fibroid is not known, or when it is so large that it overlaps the areas of the ovaries, this cannot be done, and amenorrhea must be expected if the tumors are to be treated with success. The treatment extends over a period of from four to six months, and the series of doses cross-firing upon the diseased area are given once a month. During the first month there is little change. During the second month there is generally a diminution in the size of the tumor, and a marked reduction in the menstrual flow. Often the second period is absent. Generally the third is absent. The treatment is usually continued even after amenorrhea has been produced for the purpose of destroying the tumor tissue. These results can be produced without placing the patient in the hospital, and generally she can be allowed to go about her duties.

XXXVIII. ELECTROTHERMIC METHODS IN THE TREATMENT OF NEOPLASMS AND OTHER LESIONS, WITH CLINICAL AND HISTOLOGIC OBSERVATIONS

(Dr. William L. Clark did me the favor to write this article for me.[1])

It is evident that one who depends upon a single method in the treatment of malignant disease can achieve only a limited degree of success.

Operative surgery, electrothermic methods, radium, and *x*-rays are all to be considered as factors in treatment.

Knowledge concerning electrothermic methods is not so general as it should be.

Experience has demonstrated the importance of electrothermic methods. In some cases these methods are superior to all others.

In order that the terms used may be clearly understood certain definitions must be given. Desiccation and coagulation are particularly considered. Thermocautery, galvanocautery, and electrolysis are not discussed.

Two definite tissue changes, produced by high-frequency currents, will be described. These are called desiccation and coagulation, respectively.

The *desiccation method* is one by means of which benign or malignant growths of small or moderate size may be destroyed by the utilization of heat of just sufficient intensity to desiccate, or dehydrate, the tissues. The heat is produced by a monopolar high-frequency current of the Oudin type, the current being conducted to the lesion by means of a steel needle or other pointed metallic applicator. A single spark gap is employed in the circuit. The desiccation effect, as originally described, was produced by a high-tension static current transformed into a high-frequency current of suitable quality by means of Leyden jars of sufficient capacity, and a resonator supplying the proper inductance. However, since the advent of the modern transformer type of high-frequency machine, it has been found that desiccation can be satisfactorily produced with this latter apparatus. The principal disadvantage of the former lies in the fact that static currents, being influenced by atmospheric conditions, are often not available in humid weather. High-speed static machines are also expensive, and occupy considerable floor space. Modern high-frequency apparatus is, on the other hand, compact, comparatively inexpensive, and uninfluenced by weather conditions.

The effects produced by desiccation and by coagulation are quite different. The Oudin current, by which desiccation is produced, is of relatively high voltage and low amperage; whereas, the d'Arsonval current, by which coagulation is produced, is of lower voltage and higher amperage.

A milliampere meter cannot be used to accurately measure a monopolar current. The proper current strength necessary to destroy growths of different types and sizes can be learned only by experience. The desiccation effect may be produced in the tissues by delivering the current through a short air space, by just touching the surface, or by inserting the needle more or less deeply, depending upon the degree of destruction desired.

The desiccation method is used advantageously when the lesion is localized and when good cosmetic results are not only desirable but essential.

It is subject to such perfect control that an exceedingly small growth even on the cornea may be successfully treated without impairment of vision by the subsequent formation of scar tissue; a small growth on the vocal cords may, likewise, be destroyed without impairing phonation. The comparatively slight trâuma to the tissues, and the mild secondary inflammation, explain, from an histologic standpoint, the slight scarring and the success obtained in treating these delicate structures.

Other conditions successfully treated by the desiccation method are localized benign growths of the larynx, bladder, and rectum. Equally good results are obtained in lesions as refractory as corneal ulcers, pterygium, and trachoma. Minor gynecologic conditions, such as cervical erosions, urethral caruncles, etc., yield readily to desiccation treatment. Moles, papillomata, angiomata, nevus pigmentosus, leukoplakia, lupus vulgaris, and erythematosus further exemplify the great variety of pathologic conditions for which this method may be successfully used. The desiccation method is also an important factor in the treatment of malignant lesions of the skin and mucous membranes.

It is further desirable to give special mention of this method in the treatment of hemorrhoids and infected tonsils. In the case of hemorrhoids the patient is prepared in the usual manner. A ½ of 1 per cent. solution of procain is used for local anesthesia,

[1] Dr. J. Douglas Morgan and Dr. E. J. Asnis are thanked by Dr. Clark for helpful notes.

by standard technic. The sphincter is then dilated and the hemorrhoids pulled down by means of tenaculæ and clamped in the direction of the muscle fibers, as in the clamp and cautery operation. The desiccation current is then used to destroy the hemorrhoids. Because of the deeper sealing of the hemorrhoidal veins, hemorrhage is practically eliminated. The minor trauma to which the tissues are subjected induces but a mild local inflammation; hence, little postoperative discomfort and no unpleasant sequelæ, such as contracted cicatrix with subsequent stenosis. This method has, in our experience, simplified the treatment even in the most extensive and severe cases of hemorrhoids.

Surgical tonsils in adults, in which there is some constitutional contraindication to surgical enucleation, can be very satisfactorily treated by the desiccation method. Electrocoagulation should not be used in the treatment of infected tonsils.

Coagulation is produced by a bipolar high-frequency current of the d'Arsonval type, utilizing a multiple spark gap. It is more penetrating and intense than the desiccation method and, in accessible locations, is utilized to destroy larger growths, even those involving bone.

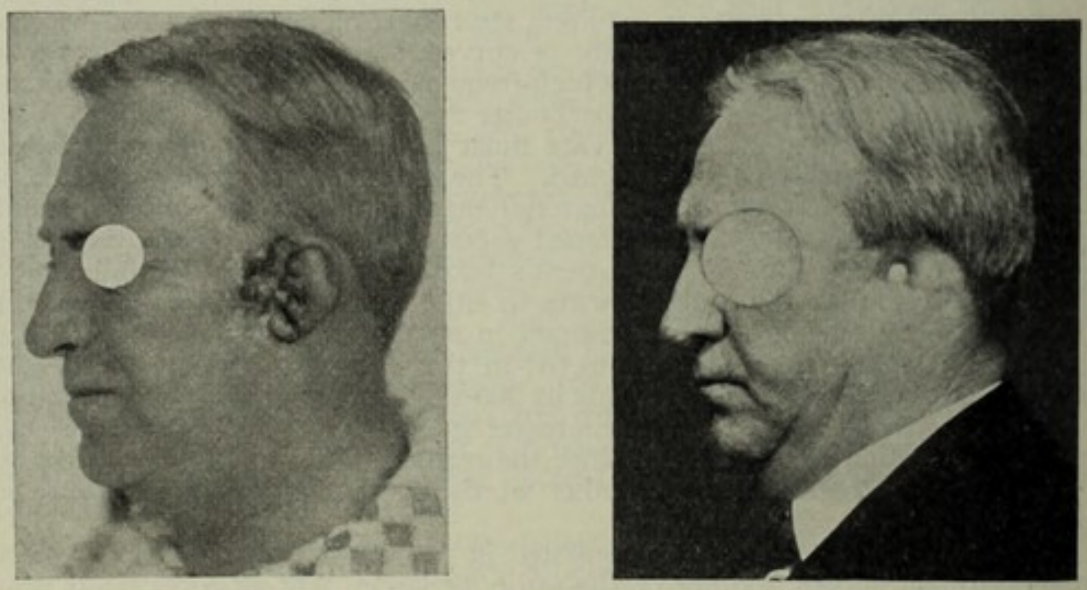
There are many variations of technic in the application of this method to suit the requirements of the individual case. These cannot very well be described, but must be learned from practical experience. It may be stated, however, that the active electrode should always be pointed. Steel sewing needles of various lengths may be employed; if still greater length is required, steel knitting needles, or stiff wire cut to any length, may be used, either straight or curved, so as to be adapted to particular anatomic locations. Since the effect of high-frequency currents is entirely thermic, and not electrolytic, it matters not what particular metal is used. As it is impossible to thoroughly insulate these electrodes, care must be taken that only such tissues as are undergoing treatment shall be touched. The indifferent electrode, which is necessary in this method, may be of any material that will conduct electricity, such as a metallic plate, or, preferably, a moistened asbestos pad. This should be placed in close contact with the skin of the patient's back. Both the active and indifferent electrodes are connected by insulated wires to either side of the d'Arsonval winding of the high-frequency machine. Good contact in all the circuit connections is of great importance. A meter should be connected in this circuit as a guide to the current strength employed, which varies from about 200 to 2500 milliamperes, according to the size of the growth to be treated. The meter is, however, not an infallible guide in estimating the action of the current, since the reading is also influenced by the size of the patient under treatment, or, in other words, by the amount of resistance in the circuit.

Doyen's method of coagulation consisted in the use of a blunt metallic electrode upon the growth, and of another of the same, or larger, size, at some point near the growth. It has been found, however, that the control by this technic is imperfect, and experience has taught us that the pointed active, and the larger passive, electrode is a superior method of application. While the current is passing, the needle may either touch the surface of the growth, or be inserted into it, depending upon the depth of destruction desired. In pedunculated growths, a metal snare may be used to advantage as the active electrode. As already stated, the d'Arsonval current, by which coagulation is produced, is of relatively low voltage and high amperage. If a short air-space intervenes between the growth and the needle, the current will be conducted to the tissue in the form of convective sparks which sometimes approach the intensity of a flame, depending upon the frequency of the oscillations in the current. Under such circumstances the coagulation will be superficial. On the other hand, if the active electrode remains in contact with the growth, heat will be generated in the tissues without the production of sparks. Under these conditions the tissues will be deeply coagulated, the actual depth depending upon the duration of the application. Better control of this can, however, be accomplished by inserting the needle into the tissues to the desired depth. Unlike the heat generated by these high-frequency currents, that produced by the actual cautery is comparatively superficial in action. The former is generated within the tissues by their resistance to the current, while the latter is merely transmitted by contact.

Whether employing the desiccation or the coagulation method, the aim should be to destroy the growth at a single operation. The devitalized tissue should, as a rule, be immediately removed either by excision or curettage, which may usually be accomplished without hemorrhage. If necessary, the base may then receive further treatment. When, however, the mucous surfaces are involved, owing to the greater

danger of secondary hemorrhage in these localities, the destroyed tissue is, with few exceptions, allowed to slowly separate. Bone which has been treated will sequestrate in about six weeks if a current of sufficient intensity has been employed. If important blood-vessels are implicated, it is wise to ligate them as a preliminary.

In dealing with localized, benign or malignant, lesions, the superiority of the electrothermic methods over radiation treatment is shown by definite histologic changes, and by comparison of permanent clinical results. By electrothermic methods the diseased tissue only is destroyed, the vitality of the surrounding normal structures being unimpaired. Subsequent treatments, should they be necessary, offer equally good prospects of success as though the tissue had not received previous treatments. On the other hand, with radiation treatment of sufficient intensity to influence a malignant growth, it is impossible not to lower the vitality of the surrounding normal tissue to a certain extent, and, in case of recurrence, little more can be hoped for from further radiation treatment, owing to the resulting fibrous changes. This is a fact well known to radiologists. Owing to these resulting changes radiation treatment should not be used in conjunction with electrothermic methods in localized lesions, benign or malignant. There are many cases in which electrothermic methods are not applicable and where radiation treatment is preferable, but electrothermic methods alone should be used in the lesions mentioned.



A *B*

FIG. 1194.—*A*, Basal-cell epithelioma involving the ear and surrounding tissues, the mastoid bone, also the ear canal almost down to the tympanum. *B*, The result of one desiccation operation. Both facial nerve and hearing were conserved. (Wm. L. Clark.)

High-frequency machines, as devised by different manufacturers, vary greatly in construction; hence, there is a corresponding variety in the quality of the currents produced. The thermic intensity is often too great or too little, and an undesirable faradic effect, producing shocks and contraction of the tissues, is experienced when improperly constructed machines are used. This want of standardization is unfortunate, since, to produce the desiccation or coagulation effect under the best conditions, a very accurate balance must be maintained between the voltage and the amperage, and also between the capacity, inductance, and the resistance. Thus different operators, employing different types of apparatus, may obtain different results. A machine giving a satisfactory therapeutic current may not be suitable for good surgical work. It is necessary to have machines constructed according to definite specifications. The difficulty of application lies principally in the acquirement of a proper technic. Much harm can be done by an operator without practical knowledge of the various factors involved.

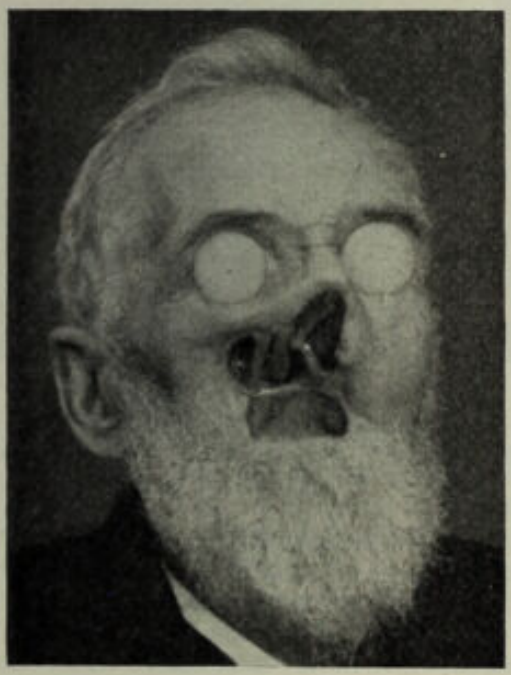
Electrothermic methods can be best practised only by those who have had surgical training and experience. They are quite as surgical in practical application as operative surgery, requiring the same precise knowledge of anatomic landmarks, and the same surgical judgment, that every good operator must have. The probable reasons for the apathy that exists in regard to these methods are, that many surgeons do

not realize their potency, and that persons who use them without surgical accomplishments frequently fail in their practical application.

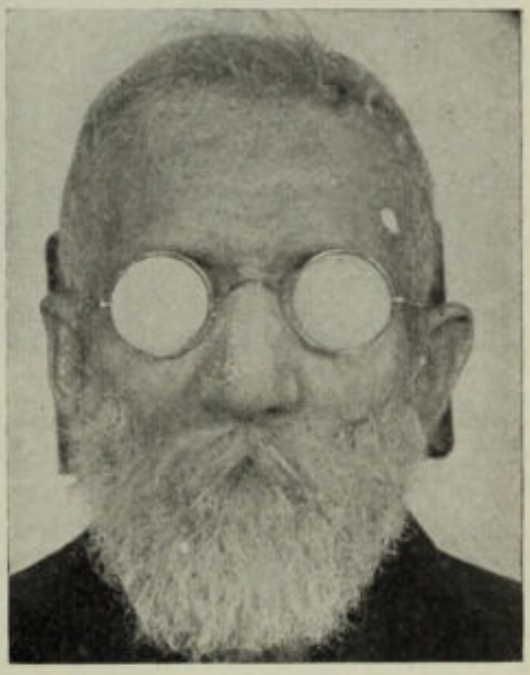
The efficiency of these methods is increased in some cases by the judicious combination of operative surgery, especially of preliminary arterial ligation. The electro-



A



B



C

FIG. 1195.—*A*, Epithelioma involving upper lip, antrum, septum, nose, alveolus and hard palate, of three years' duration. One electrothermic coagulation and desiccation for two slight recurrences. *B*, Final result, with no recurrence in over eight years. *C*, Reconstructed features by the sculpture method executed by Major R. Tait McKenzie of Philadelphia and Mrs. Alan Chesney of Baltimore. A plaster cast was made and the lost features built out in clay. A copper plate of suitable thickness was deposited on the cast by electrolysis and then silver plated. This plate was painted to match the tint of the skin, the mustache added and the plate attached to the rims of the glasses. (Wm. L. Clark.)

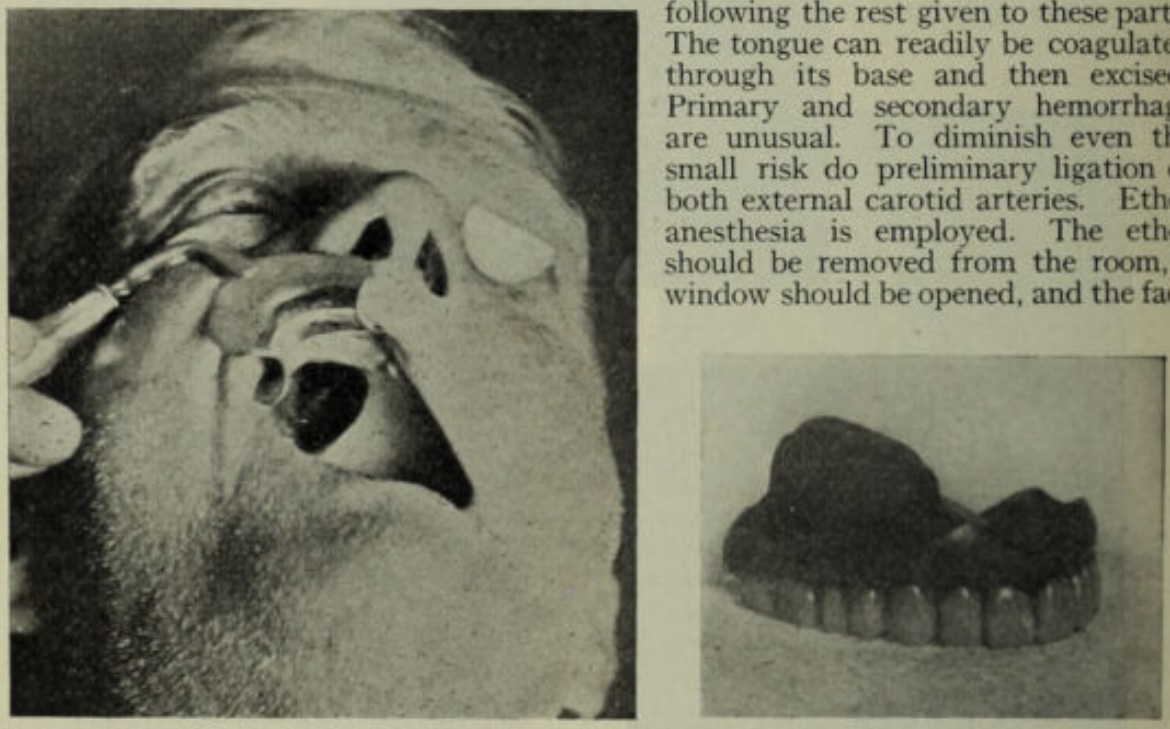
thermic methods should be used alone only in localized tumors of a type which do not tend to metastasize. The basal-cell type of epithelioma occurring on cutaneous surfaces, such as the face, eyelids, etc., even though extensive, and with involvement

of bone, may be so thoroughly treated by the desiccation or coagulation method that recurrences are infrequent.

In localized squamous-cell epitheliomata on cutaneous surfaces or mucous membranes the results obtained are almost as good as in the basal-cell type. However, when the growth is no longer localized and metastasis has occurred, other methods must be used in addition. A certain measure of success is obtained even in these cases.

Electrothermic methods are peculiarly adapted to the treatment of localized malignant growths occurring in any part of the oral cavity. In the treatment of growths of the urinary bladder, larynx, etc., suitable endoscopes must be employed to render the growth accessible for treatment. The choice between local or general anesthesia is governed by the same principles as in operative surgery.

As an example of an operation by the coagulation method, amputation of the tongue will be described. If the case is far advanced with considerable emaciation, it is proper to do preliminary gastrostomy. This has several advantages, namely, it permits of the building up of the patient's strength, relieves the pain incident to swallowing, and frequently results in a considerable reduction of the swelling and induration in the tongue and pharxyn following the rest given to these parts. The tongue can readily be coagulated through its base and then excised. Primary and secondary hemorrhage are unusual. To diminish even the small risk do preliminary ligation of both external carotid arteries. Ether anesthesia is employed. The ether should be removed from the room, a window should be opened, and the face



A *B*

FIG. 1196.—*A*, Result frequently obtained in carcinoma of the hard palate, alveolus, and antrum by the coagulation method. *B*, Denture, preventing food from entering the antrum and assuring normal speech. (Wm. L. Clark.)

should be fanned when the patient is fully anesthetized and before applying the current, else the vapor might ignite. Should the operation be unusually prolonged and the patient show signs of regaining consciousness, it may be temporarily discontinued as often as required, while ether is being again administered. As a rule, the operation is of such short duration that the use of ether a second time is not necessary. Scopolamin, gr. 1/100, and morphin, gr. $\frac{1}{4}$, may in some instances be used hypodermically one hour before the administration of ether. Less ether will then be necessary and the immediate postoperative discomfort will be minimized. After separating the jaws with a mouth-gag, a heavy silk suture is passed from side to side through the tip of the tongue, by means of which the organ is drawn well forward. The coagulation needle is then brought in contact with the dorsal surface of the tongue as far back as is necessary and the current turned on either by the operator, by means of a foot control, or by an assistant, on signal. The needle is then moved across the tongue and carefully inserted into it at different points, allowing coagulation to take place as it moves. This having been thoroughly accomplished, the tip of the tongue is elevated by means of the suture and a straight, sharp sewing needle, of proper length, is substituted for the curved knitting needle previously used. The frenum is then coagulated and the needle inserted between the tongue and the floor of the mouth. When

coagulation is again completed, curved scissors may be used to cut through the coagulated areas on both surfaces, and the tongue is then separated from its attachments. After-treatment consists of simple antiseptic mouth washes and the application, two or three times daily, of Dakin's solution, or one of its modifications, which sterilizes, deodorizes, and tends to keep the slough firm and free from maceration. Care should be taken not to remove the slough prematurely, else secondary hemorrhage might occur. Such a major electrothermic operation should be performed in a well-appointed operating-room, using the same preparatory technic as in any surgical operation.

In addition to the desiccation or coagulation of the affected tissues, and the sealing of blood and lymph channels, the heat penetrates beyond the area totally destroyed and devitalizes malignant cells, without permanently impairing the healthy tissue, thus lessening the likelihood of local recurrence, or metastasis, and conserving the maximum amount of normal tissue. Malignant cells, especially those that are least differentiated, are more vulnerable to heat, and are devitalized at a lower degree of heat than are normal cells. This thermic sensitiveness to the action of the digh-frequency current has often been observed clinically and demonstrated histologically. The success obtained in the treatment of malignant disease by the desiccation and coagulation methods is explained by the fact that all the malignant tissue was, when possible, destroyed with one radical treatment. The practice of intentionally treating a malignant lesion by a series of desiccation or coagulation operations is decidedly reprehensible and must be discouraged. It is quite as irrational to do this as to expect success by surgically excising a cancerous growth in a series of operations.

Pathologic Studies.—The appearance of the cells submitted to desiccation and coagulation is entirely unlike that of those submitted to radium and to the *x*-rays.

Clinically summarized, the aim of the electrothermic methods is to destroy malignant cells, to seal blood and lymph vessels, and obtain a healing wound with the least amount of scar formation.

The cells submitted to desiccation treatment become shrunken and shrivelled, and their nuclei condensed and elongated, with a suggestion of cell outline, the whole having a mummified appearance (mummification necrosis). The blood-vessels are thrombosed and there are no evidences of hemorrhage. In the case of coagulation the cell outline is entirely lost, and the affected tissue elements are fused into a structureless homogeneous mass presenting an appearance not unlike that of hyalinization.

The electrothermic methods are dependent for their results upon the resistance of the tissues to the current, which manifests itself in the formation of heat.

In the case of desiccation, the current being of comparatively low amperage, only a moderate degree of heat is produced; it is of sufficient intensity, however, to cause complete evaporation of the water content of the cells, hence their mummified appearance. Since the mode of cell death is associated with very little degenerative change and scant disintegrated material, there is but a small amount of fibrous tissue as an end-result, hence the good cosmetic results and, incidentally, the neighboring healthy tissues are spared the devitalization resulting from the formation of abundant contractile fibrous tissue. The coagulation method, requiring a higher amperage, induces a more intense heat, so that it not only dehydrates the tissues, but causes coagulation of the cell protoplasm. This greater degree of destruction results, as we have learned to expect, in a proportionately greater amount of fibrous tissue formation.

See William L. Clark, J. Douglas Morgan, and E. J. Asnis in "Radiology," April, 1924. Paper by same authors in "Atlantic Medical Journal," April, 1924. William L. Clark in "Jour. Amer. Med. Assoc.," Oct. 26, 1918.

XXXIX. RADIUM AND COMBINED METHODS OF TREATMENT

(Dr. William L. Clark did me the favor to write this article for me.[1])

History.—The discovery, in 1896, by Becquerel, of the spontaneous emission by uranium salts of rays of a peculiar character attracted the attention of Pierre Curie and his wife. In 1897 Madame Curie undertook an investigation of this phenomenon. As a basis for measurements she used the conductivity produced in the air by the rays (ionization). Her experiments proved that the intensity of the radiation of a uranium compound is proportional to the quantity of uranium contained therein, and that it depends neither on conditions of chemical combination nor on external circumstances, such as light or temperature ("Pierre Curie," by Marie Curie, 1923). During the course of her investigations of certain radio-active minerals she observed that some of them

[1] Dr. J. Douglas Morgan and Dr. E. J. Asnis are thanked by Dr. Clark for helpful notes.

showed more radio-activity than could be accounted for by the uranium or thorium present. In conjunction with her husband she devised "a new method in chemical research based on radio-activity. It consists in inducing separation by the ordinary means of chemical analysis and of measuring under suitable conditions the radio-activity of all the separate products" (Curie, Ibid.). In this way she discovered in 1898 the existence of polonium and radium. In 1902 she was able to demonstrate the spectrum of the new element, and determined its atomic weight to be 226. In 1907 she obtained radium in the state of metal.

The principal radium-bearing ores are pitchblende and carnotite. Pitchblende consists for the most part of uranium oxid. It has been found in Czecho-Slovakia and in smaller quantities in other European countries. It has also been found in various sections of the United States, more especially in Colorado. At the present time radium is being produced principally from ores recently discovered in the Belgian Congo.

Chemically, carnotite is a uranyl-potassium vanadate occurring in large quantities as an ore of lost uranium content and carrying a correspondingly small quantity of radium. It occurs chiefly as a yellow incrustation covering the grains of a particular sandstone. Most of the world's supply of radium has come from carnotite mined in Colorado and Utah.

The extraction of the radium is accomplished, commercially, by treating the crude mineral with nitric acid which dissolves the uranium, iron, etc., and leaves the insoluble radium and barium sulphates, etc., in the residue, or "tails." By combined boiling of the "tails" with soda ash, filtering, and then treating with pure hydrochloric acid, the radium and barium are obtained in soluble form. These are precipitated by adding sulphuric acid in slight excess, and the crude sulphate again converted to the chlorid. It is now ready for further concentration of the radium by a process of fractional crystallization which is the only known method by which the separation of the radium from the barium may be accomplished.

Physics.—For equal weights radium emits a radiation more than a million times more intense than uranium, but the quantity contained in the uranium minerals is scarcely more than 30 mgm. of radium to a ton of uranium. Radium continually produces helium gas (Ramsey and Soddy, 1903). This furnished the first example of a transformation of atoms. According to the theory of radio-active transformations as proposed by Soddy and Rutherford, a radio-active atom can transform itself in two ways: it can expel from itself an alpha particle, or, in other words, a positively charged atom of helium, which is thrown off with a speed of 20,000 miles a second, or, instead, it can detach from its structure an electron, whose mass is 1800 times smaller than an atom of hydrogen, and which carries a negative electric charge. These form the beta rays. When an atom of radium has expelled a positively charged atom of helium what remains constitutes an atom of gaseous emanation. Gamma rays, which are formed at the moment that a beta particle is expelled, are transmitted across the ether with the same velocity as light, but are known to have a much shorter wave length.

The spontaneous disintegration of radio-elements follows a fundamental law, called the exponential law, according to which the quantity of a given radio-element is always diminished by one-half in a definite interval of time called the half-decay period. This means that the rate of change for each element remains constant and that the amount disintegrating in a given time is proportional to the quantity of the substance present. The fraction of the total changing per second is known as "the radio-active constant." Thus, for the emanation of radium this has a value of 1/481,250, *i. e.*, this fraction of the total amount of emanation in existence changes per second. It has been found that the average period of the life of the atom of a radio-active substance is simply the reciprocal of the radio-active constant. Thus, the average life of radium emanation is 481,250 seconds, or 5.5 days. The time required for the half-value period to occur bears to the period of average life a fixed ratio, the latter being always 1.45 times the former.

The causes that determine the transformation are still a mystery to us.

Therapy.—Radium therapy really began in 1901 when Becquerel developed a severe inflammatory reaction of the skin underlying a pocket of his waistcoat in which he carried a tube of radium for several hours. Curie also made some experiments on his own person and proved that radiation was capable of producing an inflammatory reaction in the skin. Hearing of these reactions, and knowing the early results of *x*-ray therapy, Besnier suggested the use of radium as a therapeutic agent.

Radium therapy, known in France as Curie therapy, developed more slowly than

did Roentgen therapy largely because the substance was enormously expensive and, at first, difficult to obtain. Great strides have, however, been made in the science in the past few years, and radium therapy is now on a solid foundation. A great deal of experimental work has been done in an effort to determine the action of radium rays on elementary substances. Chemical changes are produced, but the actual physical process is atomic as well as molecular, and is apparently brought about through the process of ionization (McKee). A number of investigators have shown that radium possesses the property of modifying the production and the action of some enzymes and ferments. Considerable experimentation has shown that the protozoa and organisms of this type are resistant to radiation, the lethal dose being a large one. Large doses of soft beta rays will kill bacteria in culture to a depth of about 2 mm. of gelatin.

The earliest visible histologic changes in irradiated tissues are inflammatory and appear to consist of a dilation of the vessels throughout the cutis. There is also an infiltration by lymphocytes, accompanied by an intracellular and intercellular edema. If the reactions are profound all these changes are accentuated and, in addition, we see vacuolization, loss of prickles, poor staining qualities, loss of nuclei, and disorganization of the basal cell layer (McKee). This is followed by erosion, even to complete disappearance of the epidermis.

As radium and its emanation are the source of the same products of decay which emit the beta and gamma rays, either may be employed therapeutically. Radium usually in the form of a sulphate is used in plaques, capsules, or in needles. Several of these latter may be placed in a capsule for surface application or for use in one or other of the body cavities. Plaques or flat applicators are used mostly for treating cutaneous affections. They vary in size from 2 to 4 cm. and in shape from round, oval and oblong, to square. In the United States a "full strength" flat applicator has 5 mg. of radium element equally distributed over each square centimeter of surface.

Capsules.—The radium is placed in a tube of thin soda-glass having a diameter of 2 to 3 mm. and the length depending on the amount of radium salt contained. This is then placed in a silver container with a wall thickness of $\frac{1}{2}$ mm. This, in turn, is placed in a brass capsule having a wall 1 mm. thick; 10, 25, 50, and 100 mg. tubes are the ones commonly used.

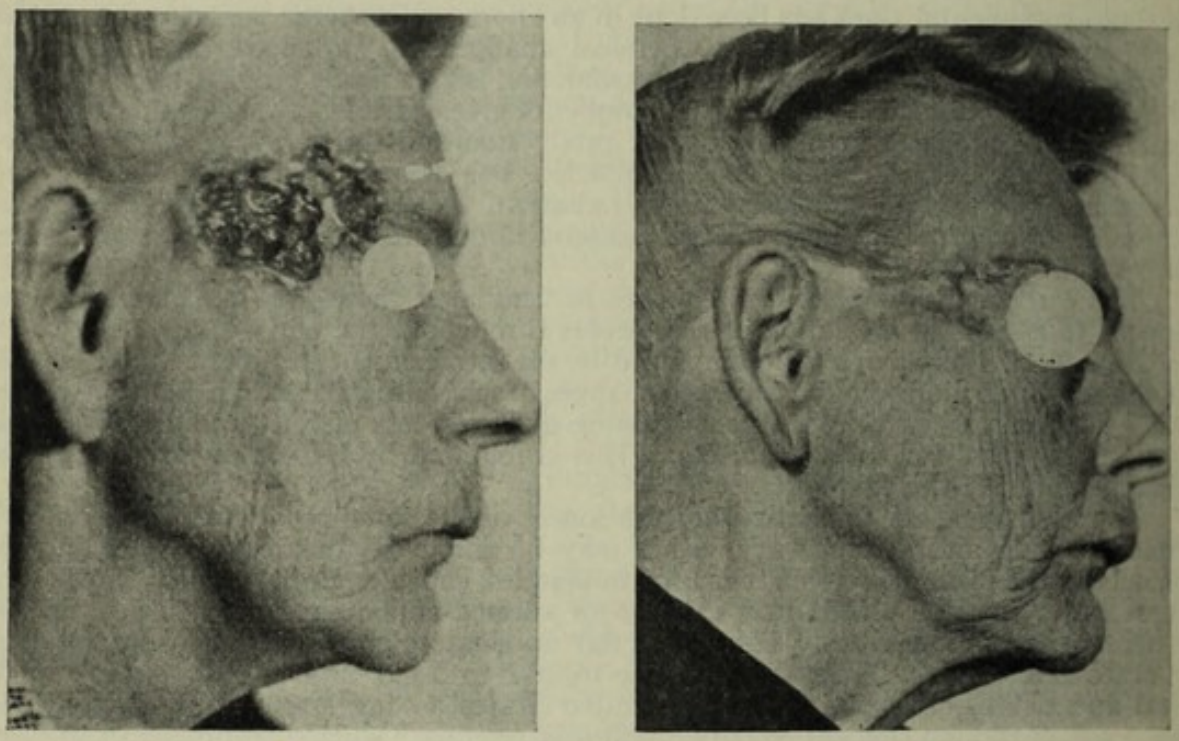
Needles vary in size depending on the amount of radium they contain. They are commonly made of steel, but, preferably, should be of platinum or platinum-iridium alloy with walls $\frac{1}{2}$ mm. in thickness. They may contain from 3 to 25 mg. of radium. It is important that this be distributed evenly along the whole of the shaft of the needle. A glass capsule containing emanation may be placed in the hollow needle instead of the salt.

Emanation from 1/5 to 1 millicurie is used in bare glass capillary tubes. From one to any number of these, depending upon the size of lesion under treatment, are buried, about 1 cm. apart, in the diseased tissue and are allowed to remain permanently. The chief objection to this method is the sloughing and fibrosis which often result from the hyperirritation of the unfiltered beta rays. It now seems better to use the emanation in platinum tubes or needles thereby screening out these undesirable radiations. In this country it is customary to express the dose in milligram hours when using the element, or in millicurie hours when using the emanation. In Europe the dosage, when using emanation, is estimated in units of millicuries destroyed or decayed. To obtain this factor the value of the emanation at the end of the application is subtracted from its value at the beginning. As the "average life" constant of the emanation is 5.5 days (133 hours), we may find the equivalent of this factor, in millicurie hours, by multiplying it by 133.

Radium or one of its derivatives can be used in two essentially different ways: (1) It can be taken into the body by mouth, hypodermically, or intravenously, as any other soluble drug. There seems to be little question that certain forms of gout, rheumatism, chronic arthritis, neuralgia, and high blood-pressure may be helped by its use. It has pronounced effect upon the hemopoietic tissues (Burnam). It has, also, a wide field of usefulness in dermatology. (2) It can be applied in sealed tubes or other container, either externally, in body cavities, or buried in the tissues through an incision.

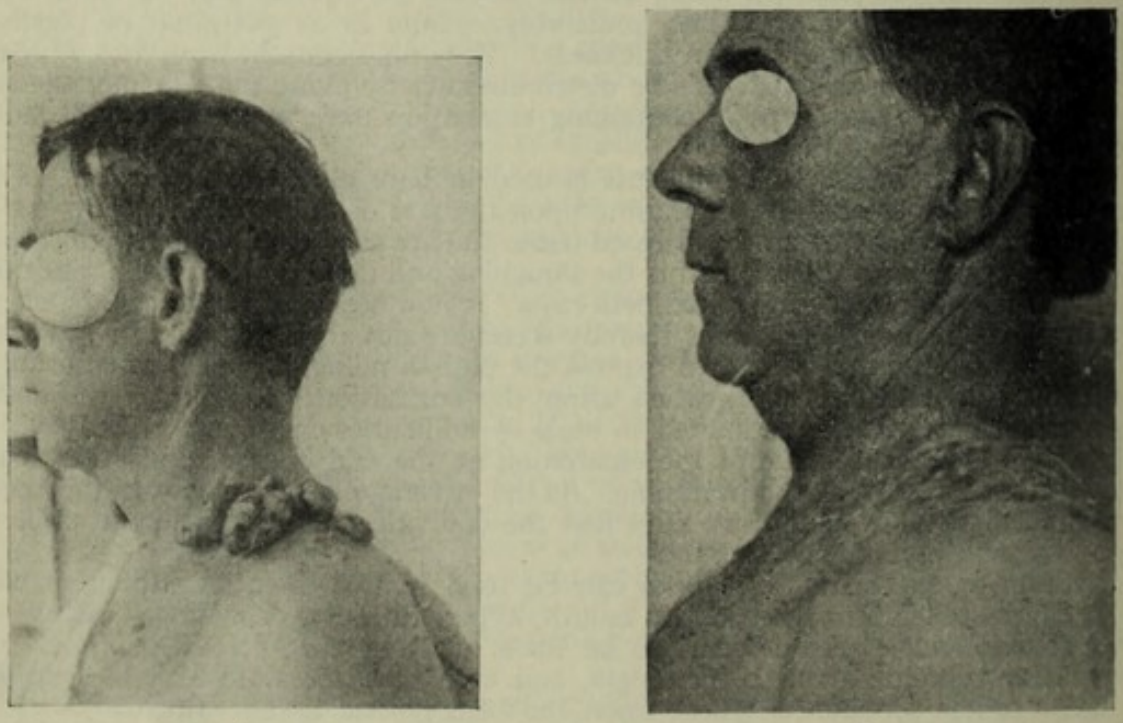
Radium is of distinct value in the treatment of malignant disease, employed alone or in combination with other measures. The use of combined methods in the treatment of cancer has been shown from clinical experience to be sound practice. The physician who employs only one plan to the exclusion of all others, while he may

have limited success with certain types of cancer, cannot obtain such brilliant results in a wide range of cases as he who uses various methods judiciously combined.



A *B*

FIG. 1197.—*A*, Basal-cell epithelioma adherent to the bone, of twenty years' duration, which had been unsuccessfully treated by radium and *x*-rays. *B*, Result of one electrocoagulation treatment. Patient died one year later of pneumonia, but without recurrence of the epithelioma. (Wm. L. Clark.)



A *B*

FIG. 1198.—*A*, Mixed-cell sarcoma, recurrence after two surgical operations. *B*, Result of combined desiccation and radium needle treatment. There has been no recurrence in four years. (Wm. L. Clark.)

Notwithstanding the potency of radium, it is better not to temporize unnecessarily with cancer. If the lesion is localized and can conveniently be immediately and

entirely destroyed by some method, such as the knife, electrodesiccation, or coagulation, it is recommended that it be employed in preference to radium as the primary agent, provided there is a chance of eliminating the disease at one operation; otherwise the growth will be stimulated. Preference is given to electrodesiccation or coagulation, since the destructive action may be accurately confined and the blood and lymph channels sealed, rendering local recurrence less likely. This may be followed by radium applied to the site of the operation as an additional safeguard, if this appears necessary.

Operative surgery is of the greatest importance in cancer involving deep anatomic structures, to ligate blood-vessels, if necessary, and when there is extensive bone involvement. The use of electrothermic methods, radium, *x*-rays, or a combination of them, directly applied immediately after operation, will reach malignant cells inaccessible to the scalpel with results that cannot possibly be obtained by surgery alone. It is therefore concluded in the light of experience that the greatest success in the treatment of malignant disease in its various manifestations lies in the complementary action of surgery, electrothermic methods, radium and *x*-rays, judiciously selected or combined to meet the particular requirements of the individual case.

XL. INJURIES BY ELECTRICITY

(Dr. William S. Wadsworth, Coroner's Physician of Philadelphia, did me the kindness to write for the eighth edition this section.)

Electricity.—The surgeon meets four types of injury by electricity: (1) from currents applied for therapeutic purposes; (2) from industrial currents; (3) from lightning; (4) from radiant discharges—as *x*-ray burns.

To understand fully the effects one finds in the body would require not only a complete knowledge of the physics of electricity, but an equally extensive knowledge of laboratory and clinical physiology. In the past both fields have been so crowded with controversy—in large measure due to the overvaluing of some minor part—that even at present it is hardly safe to express sane conclusions on the subject; but, as the surgeon cannot wait for the specialists to settle their disputes, he must accept conclusions as soon as they are sane.

While nothing is to be ignored, there are certain things which must always be kept in mind. *Electric potential*, or *charge*, is produced by a vast number of processes in living bodies and *electric polarity* is found generally where metabolism is active. Whenever produced there is an equal amount of positive and negative electricity and these charges tend to go together and to neutralize each other.

In metals and other good conductors this reunion takes place readily, but in organic tissues we find insulation preventing the equalization, in fact, most of the best insulating materials are organic bodies, and this is not accidental.

We find then the body developing potential and polarity and at the same time insulation in the general tissue masses, and we find specialized properties of insulation and conduction in the nervous system. We also find the blood acting as a good conductor.

All the active tissues of the body are converters or transformers of forces, and heat and electric potential are the indices we have for measuring metabolism.

We know that in any apparatus where electric potential is produced we can produce effects by passing in an artificial current in the direction opposed to that naturally produced.

We know that the action of the heart is accompanied by electric currents and we are not surprised that experimenters have been able to show conclusively that moderate currents passed into the heart disturb its action, causing it to cease its regular beat and pass into *fibrillation* and finally to stop entirely. We know that all muscular and nerve action is accompanied by electric phenomena, and are not surprised that common experience and laboratory tests show that electric currents produce profound effects on both nerves and muscles.

We know much about the effects of electricity on nerves and muscles, a little about its effects on the blood, but almost nothing about its influence on the other tissues of the higher animals.

We are forced to limit our considerations largely to the effects on nerves, muscles, and blood, not because such effects constitute the whole, but because of the present limitations of science. Unfortunately, serious blunders have occurred in the surgical

use of electricity because what was already known of normal and abnormal tissue potential and of the response to artificial potentials and currents by normal, abnormal, and repair tissues had not been utilized.

Specially sad have these blunders been in *x*-ray work. It should be remembered that the human body is a vast collection of histologic units each of which is a sort of battery having its minute electric qualities of charge, resistance, and effect.

While bodily currents and potentials are small, industrial currents are relatively very large, so that, aside from the great outside insulator (the skin), they readily overcome the internal resistances and, forming for themselves paths, cause very considerable damage to the tissues.

This damage becomes strikingly apparent when it affects some organ on which life immediately depends, as the heart and central nervous system. It is quite sensibly apparent when we get a shock. It is clinically important when we find the result of an apparently slight contact lasting as a painful and incapacitating neuritis, or as a large sloughing area about a slight burn. To understand the effect of artificial currents on the body we must clearly grasp the significance of the *skin as an insulator.* When the skin is dry it offers a high resistance, which is raised by natural or other oils. If, however, the skin becomes wet by water, or any other fluid of lower resistance, such as perspiration or saline solution, the power of resistance of the skin will be greatly diminished—so that very low currents will readily enter the body. This diminution in skin resistance is not so common after a superficial wetting as it is when the fluid has penetrated deeply into the cuticle. Denudation or wounding also aids in destroying insulation. Currents on entering the body find paths through the tissue or, more readily, along blood channels and along nerves. A few minutes' testing with a "medical" battery will give one much valuable insight into these matters. If the current finds a path through large veins to the heart it tends to produce marked disturbance leading to fibrillation or death by complete arrest of that organ. This is true of low voltage industrial currents whether direct or alternating.

Very high voltage direct and very rapidly alternating currents appear to have less effect on the heart—which explains why cases of survival after exposure to very high voltage as well as *deaths from low voltages* have been reported.

In general, *low voltage alternating currents* are more dangerous than direct currents of the same voltage, but as the rate of alternation increases the danger appears to become less until no fatal results follow when the rate of alternation mounts to the hundreds of thousands per second.

We have spoken of potential or charge and flow or current. There are two other very important groups of electric phenomena, those of *induction* and *radiant discharge.*

Wherever there is either stationary charge or current there is an influence capable of inducing in near objects secondary electric charges and currents.

Where the currents passing through the body are barely powerful enough to get through we may, as a rule, ignore the *induced currents* because these are less than the primary, but where the currents or charges are very large, as in lightning, the effects may be very great, in fact, may result from currents which pass not through the body at all, but only near it.

As a rule low currents find paths rather than make them, while high currents often make actual holes not only in the skin but in the tissues, in the walls of blood-vessels, and in the case of very high currents, as lightning bolts, through bones. Every current, no matter how small, tends to open the path so that it flows more readily after such path has been established.

Currents require substance along which to travel in their paths. They also carry substances along such paths. On this principle depends *cataphoresis*, and we find that in serious industrial accidents there is, not rarely, a metallic impregnation of the tissues. This must be remembered in considering the burn which, in so far, becomes a poisoned one.

Currents produce heat, but the burns are usually the result of the arc produced at the point of contact rather than by the heat directly resulting from the passage of the current. Currents also produce *electrolytic* or *chemical changes*—the direct current being regarded as most effective, but in the tissues there are changes which must be recognized even though we must wait for their explanation—such as are found in the blood.

The effects are, in general, proportional to the amount of current and, with qualifications, also proportional to the voltage. The time or duration of the flow is a very important factor in all electric cases.

In considering electric action it is necessary to magnify the time, for great results take place in such extremely short periods that we can hardly conceive of them as they occur unless we do so magnify them. Otherwise we will not properly realize the complex nature of an occurrence which takes but the minute fraction of a second, such as a stroke of lightning. Nor shall we properly appreciate that *electricity possesses no sense of geometry*, but seeks its path under laws of attraction and repulsion as truly as does the trickle of water in a rain storm.

Injuries by therapeutic currents are generally to be studied by the damage done to the nerves and are usually of a trophic type—rarely we have severe thermal or mechanical injuries. Unfortunately we can say but little of the injuries to the tissues themselves owing to the dense ignorance of the whole subject. Very severe damage has been done by the substances forced into the tissues by the cataphoretic process—even fatal results have occurred; fortunately the recklessness in this matter has largely subsided.

Injuries by Industrial Currents.—During the past few years the enormous increase in the use of electricity for domestic and industrial purposes has brought with it a very large number of accidents which demand the attention of the surgeon. In spite of all precautions and safeguards this class of cases is still increasing. In the past they were added to by reason of the ignorance and stupid assurance of the so-called practical electricians; this is fortunately being corrected.

While these injuries are most frequent among those employed about electric appliances, they are not confined to this class. The private citizen in his bath may touch with his wet and soapy hand a charged metal light socket, the butcher in his refrigerator, the confectioner making ice cream, the lad at play, the pedestrian on the public highway, the domestic in the kitchen or laundry, the stenographer in the office, the fireman at a fire, may come in contact with a deadly current. These and other similar cases have occurred with serious results in our own experience.

Most industrial currents are produced by dynamos, and any metal or other conductor connected either purposely or through accident may become dangerously charged and cause serious or fatal accident. *Nearly all industrial currents are dangerous*, as no current of 50 volts or over is safe. Formerly it was supposed that the resistance of the human body was very high, but, after a sad list of fatalities had occurred, it was concluded that under certain conditions the skin resistance rapidly disappeared. Then fatal cases from low currents were recorded as due to heart disease. If the charged metal be connected with the earth—"grounded"—the current will seldom leave it to enter the body; this suggests the procedure of grounding a charged wire where the current cannot be cut or the person removed from contact with it. It, however, should be remembered that this is a dangerous procedure. Usually the person receives the current in one of two ways, either he touches both wires, or conductors, and then makes a double contact, or, as is more usual, he is in contact with one wire and is grounded by touching some uncharged conducting material.

With low voltages full contact is necessary, as such currents will not overcome the resistance of the air; but with high voltages the current may jump or spark.

Ordinarily the skin resistance is sufficient to withstand currents up to 200 volts, but with skin damp with perspiration or saline solutions the ordinary lighting currents of 110 volts are dangerous and it is surprising how little grounding is necessary to produce fatal results. We daily see the repair men on the trolley lines handling live wires, but they are insulated from the ground. So too we know that firemen come in contact with live wires, but their rubber boots save them from serious results, though they are frequently severely shocked. Fortunately the first effect of the current is to cause violent muscular contractions; at times these throw the man some distance, breaking the contact, thus saving his life. Reports from the large industrial plants show that recovery is to be looked for if first aid be promptly rendered and artificial respiration quickly instituted and persistently kept up.

At the point of contact one may find evidences of the passage of the current, such as minute punctures—holes or wounds—burns, or simply marks. The effect may vary from pallor due to vasomotor spasm to redness, from whiteness, as of cooking, to actual charring and, at times, may show a film from vaporized metal.

It is usually stated that constant or direct currents produce shock at opening and closing only, but it should be remembered that, owing to muscular action and other factors, these currents often practically act differently and that burning and electrolysis may be severe. There is some debate as to the cause of respiratory failure resulting from severe electric shock, but it is quite certain that asphyxia follows the arrest of

respiratory action by reason of spasm of the muscles, also that this spasm produces fatigue which persists often for a considerable time, and that we actually do find true nervous respiratory paralysis in cases. It is therefore necessary in treating such cases to continue the artificial respiration long enough to allow for recovery of function in either case, and to give over only when it becomes clear that such recovery is no longer to be hoped for. The hemolytic action of electric currents must be remembered, especially after prolonged contacts, and the sequelæ of such hemolysis expected and treated when developed. The injuries to the peripheral nerves may be very serious and may long resist treatment and must be considered as traumatic lesions. These so often complicate severe burns that they should be expected and the treatment should be adjusted accordingly. The path taken by the current cannot be readily diagnosed from the position of the contacts, but something may be judged from these contacts. If both contacts are on the same leg, one would expect the heart to escape; if the current passed from one hand to the other the chances are that the heart has suffered. In hand to leg contact there is uncertainty, but from one hand to the leg of the opposite side the chances are less favorable. If one of the contacts is on the head, the chances are usually bad. With higher voltage the danger to the central nervous system increases rapidly.

It must always be remembered that the person seldom receives the full charge from the wire or conductor—this is more apt to be the case if the skin be still intact after the exposure.

It must further be remembered that high-power currents may force a path through indifferent tissues avoiding the vital organs. Then we may hope for recovery, but we must expect serious local effects along this path with delayed recovery of the part affected. Usually high-power currents acting continuously give fatal results, and the exceptions which have been featured in the literature seldom show insuperable obstacles to careful analysis of cause and effect. The sequelæ depend on the duration, intensity, type and amount of current, and on the location of its application and its path in the body. Usually the burns are slow to heal, tend to become infected, and often show the trophic changes due to nerve lesions. The nerve lesions give rise to all degrees of anesthesia, paralysis, and trophic changes. When of moderate degree we often find profuse local sweating, vasomotor disturbances, pain and various forms of paresthesia, such as tingling, formication, etc. Local effects naturally vary with the parts affected, being unusually serious about the eye. The eye also suffers from the exceedingly bright light of the arc, and "flash blindness" is quite common in electric plants.

Treatment.—If a person be in contact with a live wire, the first thing to do is, if possible, to shut off the current. If it be not possible to shut off the current, catch a portion of the clothing of the victim and pull him away from the wire, but do not touch his body with the bare hand. If a pair of rubber gloves can be obtained, the subject can be moved with impunity and the wires can be safely cut. If it be not possible to drag a person away from electric wires, an individual can wrap his hands in dry woolen material and safely lift the portion of the body in contact with earth or wire, and thus break the circuit and permit removal of the body.[1] A dry cloth can be pushed between the body and the ground, and the body can then be removed from the wires. It may be possible to push the wires away by means of a dry piece of wood, or to cut them with shears which have wooden handles and which are perfectly dry, or to push or draw the body away from the wire by the employment of sticks of dry wood. Spitzka warns us to be careful in using shears "as the momentary arc formed between the separated ends may blind the rescuers." Raise the head a little, draw the tongue forward, and tickle the epiglottis. If the patient does not breathe, place him prone and make artificial respiration by Schäfer's method. Artificial respiration may be carried out with the patient supine by Meltzer's method of tracheal insufflation or by the pulmotor (see "Report of the Commission on Resuscitation from Electric Shock," June, 1913. Always apply external heat and massage over the cardiac region. If facilities are at hand and the victim is apparently dead, inject at once adrenalin and salt solution into a large artery or into the heart (see pages 422, 1208). While any heart action remains there is a chance of resuscitation. When heart action and respiration are present the prognosis is good. Very severe burns may be caused. The author has dressed many electric burns with hot fomentations of salt solution during the first few days. This facilitates the separation of the sloughs and seems to aid the weakened tissues in resisting microbic invasion; after sloughs separate, the part is dressed with dry sterile gauze. Antiseptic

[1] See the directions in "Med Record," Dec. 28, 1895, from "Med. Press."

dressings can be used from the beginning, but they often fail entirely to arrest the sloughing. Iodoform produces much irritation and should not be employed. Ointments are very unsatisfactory. When the dressings are changed, the part should not be washed with corrosive sublimate, as this agent produces irritation; peroxid of hydrogen should be employed, followed by warm normal salt solution. Sharpe removes sloughs by applying the following mixture: 2 parts of scale pepsin, 1 part of hydrochloric acid, U. S. P., 120 parts of distilled water. This mixture is washed off after two hours with peroxid of hydrogen. The same surgeon treats necrosis of bone by injecting every few hours a 3 per cent. solution of hydrochloric acid, using every second day the pepsin solution, and when necrotic areas come away, packing with gauze. When repair begins, the raw surface should be covered with silver-leaf. Skin-grafting by Reverdin's method or Thiersch's method is rarely successful. In some regions it is possible to slide a large flap in place to cover a raw area which will not heal. In a very severe case amputation or resection may be necessary.

In New York, Pennsylvania, New Jersey, and several other states electricity is employed to execute criminals convicted of capital offenses. The infliction of death by electricity is popularly spoken of as *electrocution*. It is beyond doubt, in the words of Dr. E. A. Spitzka, "the most humane method of executing criminals." The first electrocution in New York was in Auburn Prison in 1890, and since then over 150 criminals have been executed by electricity in New York State alone. Dr. Spitzka witnessed 36 electrocutions and made autopsies on 27 of the victims ("Jour. Med. Soc. of New Jersey," 1909). The apparatus used is "an alternating dynamo capable of generating 2000 volts, a 'death-chair' with adjustable head-rest, binding straps, and adjustable electrodes." (At Trenton a 2400-volt current is taken from the public service wire and lowered to the desired tension by a rheostat.) The notch to control the current is in the death-chamber and the dynamo is in another apartment, communication being had by electric signals. The prisoner (usually without fetters) walks in when everything is ready and sits down in the chair, and his arms, legs, head, and chest are strapped to the chair. An electrode moist with salt solution is fastened to the head and another to the bare calf of the leg. The head need not be shaved.

"The application of the current is usually as follows: The contact is made with a high potential—1800 volts—for five to seven seconds, reduced to 250 volts until a half-minute has elapsed; raised to high voltage for three to five seconds; again reduced to low voltage until one minute has elapsed, when it is again raised to the high voltage for a few seconds, and the contact is broken. The ammeter usually shows that from 7 to 10 amperes have passed through the criminal's body.

"A second or even a third brief contact is sometimes made, partly as a precautionary measure, but more to abolish completely reflexes in the dead body.

"The time consumed by the strapping-in process is usually about forty-five seconds and the first contact is made a few seconds later. In all, about sixty to seventy seconds elapse from the moment the convict leaves his cell until he is shocked to death" (Spitzka, Ibid.).

After electrocution the temperature of the body rises and may reach 129.5° F. Dr. Spitzka finds that after removing the brain the temperature in the vertebral canal is often over 120° F. The brain shows capillary hemorrhages, arterial anemia, and venous congestion. In some of Spitzka's cases sections of the pons, oblongata, and spinal cord showed areas resembling gaseous emphysema, which were perhaps caused by "electrolytic liberation of gas."

In electrocution there is no pain, consciousness is at once abolished, death is certain, and resuscitation is impossible. The lurid stories about criminals being killed by the necropsy and not by the electric current are nonsense.

Injuries by lightning occur mostly in the summer months and are more frequently met with in rural districts than in cities. The number of deaths per year in this country is as follows: The Surgeon-general of the Public Health Service, Dr. H. S. Cumming, gave to Dr. Keen the following figures as to deaths from lightning in the the United States: In the registration area in 1923 there were 461 fatal cases. It is estimated that in the whole United States there were 541 fatal cases. It is impossible to say how many are actually injured but not killed, because no statistics are available. From such experiences as the great storm in Gettysburg during the militia encampment in 1908, when 3 were killed outright, 28 were reported as seriously shocked, but recovered, and scores were more or less seriously affected; and from the records of many other instances giving similar proportions, we conclude that at least 5 are injured to 1 killed.

Lightning, which is the discharge of atmospheric electricity, varies enormously in phenomena and effects. We have little accurate knowledge regarding the amount of electricity contained in such discharges, but we have every reason to believe it is very great as compared with all other forms of electricity. The discharge or "bolt," which passes from a cloud to the earth usually appears to be a direct disruptive spark like that from an induction coil of large capacity.

On closer study we find this simplicity is only apparent. The matter is highly complex. Lightning does not follow straight lines, but seeks out a path with relation to conductors and the attraction of other primary and induced charges in many objects. Further, the effects are not limited to the direct line or actual path of the discharge, but extend to a very considerable distance by producing powerful induction effects in proportion to the enormous potential of the bolt. In order to understand the action of lightning we must recall how static charges not only accumulate on the surface of conductors, but how they seem to sink into the substance of non-conductors or become occluded as if they spread over the multiple surfaces of the component particles, as they certainly do in such objects as hair, fur, and clothing. The discharge is not over surfaces alone, but goes through substance also.

We then can realize why animals become sources of danger during storms, for the dry hair offers an enormous surface for electric accumulation, and as soon as it becomes damp enough to conduct electricity the animal becomes more dangerous than an equal amount of metal. In a similar way masses of damp hay become conductors of electric potential and are often struck.

Trees with a corky bark which offer an enormous surface become more dangerous when such bark becomes damp than smooth barked trees. This has given rise practically to a popular belief that the beech is safer than the oak in a storm.

We must not rest content with classing the variations of lightning as freak performances, but must study the effects in the light of scientific accomplishment. Thus the effects on the clothing are often most startling, being usually described as explosive in type; yet when we recall how vast is the surface of the component fibers and how hydroscopic such fibers are and how conduction increases with dampness and how partial conductors develop heat in proportion to the current, we are no longer surprised at the effects, but are enabled to judge of the nature and path of the discharge with some degree of certainty. This will help us greatly in our diagnosis and prognosis of the injuries to the body. It will also help us to understand why two persons subjected to the induction effects of the same bolt will show very different markings.

We must never forget that electric discharges are extremely sensitive to the attractions and repulsions of electric charges and that they induce such charges. It must further be recalled that what we observe in the sky on a large scale takes place in the body on a small scale, and that as one discharge is thick, intense, and straight, another is notched or branched. So in the body we find markings corresponding to all the types seen in the sky. So, too, do we find the discharge from the body meeting that from the sky. In one case the mass of the discharge is so great that it is uninfluenced by minor object charges, but crashes through all obstacles; in another case a smaller charge wanders about from object to object, entering a window or door and playing pranks of the greatest variety. So in the body the heavy charge smashes through skull, pulpifies brain, rushes straight down and out, while the milder bolt is influenced by conditions, wanders, and may leave with only local effects. In this way cases of actual stroke have recovered. Usually direct strokes are fatal when they pass through the body, and only those passing through a part or those going over the surface or those passing near furnish the cases of recovery. I have seen a recovery after a direct stroke. The man was burned and wounded from his left shoulder to his left heel. His clothing was scorched, keys and money in his pocket were fused, and his shoe was torn from his foot. When death occurs it is usually instantaneous, so that when any sign of life remains there is hope, but, even in the apparently hopeless cases, treatment should be persisted in.

Persons struck while in open fields or on roads are apt to show burns indicating that the bolt passed from head to foot. Persons struck while under trees often show induction effects only, but may show that the bolt or part of the bolt jumped from the tree to the body. Arborescent markings are purely discharge phenomena and are generally due to induction charges.

What has been described as return stroke and has been supposed to be due to secondary or readjustment discharge, appears generally to be due to the discharge of induction charges immediately following the primary discharge. The cause of

death, from its instantaneous nature, must necessarily be due to the effects on the nervous system, probably destructive effects and not unlike those produced by high voltage artificial currents. Tissue effects are found wherever the bolt has passed, and these may be mechanical, consisting of various sized holes or considerable wounds, or they may show the explosive type indicating the sudden production of gases or vapor. Very frequently we find burns, generally superficial, but not rarely severe, and at times very severe. Often we find a combination of all types—burning, denudation, actual wounding, and markings. The eyes often suffer, at times being burned, and at others, the optic nerve being affected. We may find only a temporary flash blindness.

The sequelæ include nerve lesions similar to those found after industrial injuries. The brain is more apt to be permanently injured, but may exhibit anything from coma to intense excitement. Usually unconsciousness is only brief, but may last for hours.

Treatment should be persisted in long after apparent death, for cases of late recovery are recorded. It is essentially the same as for injuries by industrial currents (see page 1480) and includes artificial respiration in the prone position with care to have the head bent well back so as to free the throat; maintenance of body temperature; combating of shock and heart failure and, some say, the guarded use of electricity. In cases apparently dead intracardiac injection of adrenalin should be tried.

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